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**IMPROVEMENT OF OVERALL THROUGHOUT EFFECTIVENESS
OF FOOTWEAR MANUFACTURING**

Case:- Peacock Shoe Manufacturing Industry

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This is to certify that the thesis prepared by Tadessew Erana, entitled: “Improvement of Throughout Equipment Effectiveness of Ethiopian Footwear Manufacturing (Case, Peacock Shoe Manufacturing Industry) and submitted in partial fulfillments of the requirements for the degree of Master of Science (Mechanical and Industrial Engineering) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

IMPROVEMENT OF OVERALL THROUGHOUT EFFECTIVENESS OF
ETHIOPIAN FOOTWEAR MANUFACTURING

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DECLARATION

I hereby declare that the work which is being presented in this thesis entitled “**Improvement of Throughout Effectiveness of Ethiopian Footwear Manufacturing**” is original work of my own and has not been presented for a degree of any other university and all the resources of references used for the thesis have been duly acknowledged.

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This is to certify that the above declaration made by the author is correct to the best of my knowledge.

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Abstract

Due to the changes in customer(s) demand, technology, lifestyle, and especially the increasing of competitors in the market and their outcomes; so the manufacturer has to be adopted more reliable methods of improvement. The major problems of the case manufacturing are related with lower values of equipment, line, stage OEE metrics and Overall throughput effectiveness result. In all section, the equipment and lines OEE metrics values are below the world-class value. And from the all section the most affected metric was performance metrics. Due to the entire dependency of the manufacturing, there is propagation of loss and up and down stream effect. The major causes of losses are external and internal factors. The purpose of this study is to improve OTE; by identify the factors generate the loss of OEE metrics at of each individual and throughout manufacturing. The taken the necessary action plans were according to the founded loss at each section on the OEE metrics and the propagation of losses and up and down steam effect is also considered. To achieve the objective, the most appropriate method were:- AM, Heuristics algorithms for the sequence of processing, dispatching rule, Attribute Control Chart by (IBM:-SPSS –v20), cause and effect diagram for screen out the factors of loss and pareto chart for prioritization of factors affect metrics are applied at different levels. The necessary data for the analysis were collected from each section from their daily output, direct observation and stopwatch recorded was under taken.

To identify the root causes of factors affect OTE; the analysis of metrics has been done in all section; during that system metrics values and loss factors, the frequencies of breakdowns occurrences were identified and the quality characteristics factors are known. When analyzing and interpretation, the bottlenecks stage and section are identified and major effectiveness losses are identified. The improvement areas with associated challenges and their root causes has been investigated; then the AM implementation frame work, batter makespan is developed by heuristics algorithms, corrective actions, counter measures and action plans has been suggested as strategy for improvements.

Finally, an improved OTE system was proposed; where metrics are improved at equipment, line, stage level respectively. From the result the OTE of the system were increased from 8.92% - 23.06% to 20.83% - 42.80% through the months. Therefore, the achieved results in the proposed method and algorithms can be easily adapted after implementation and the company's targets can be achieved and profitability, competitiveness is improved significantly.

Key words: - OTE entire, OTE system, OEE metrics, Heuristics, NEH, AM frame work, makespan

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List of abbreviations and Acronym

A:-availability

Ae:- entire availability

ANNS :-artificial neural networks

CAP : control action plan

CDS:-Campbell Dudek Smith

CUBES:-capacity utilization which focused on the bottleneck efficiency system

EFI= Ethiopian footwear industry

FIS:-fuzzy inference systems

FMEA :-failure mode and effects analysis

FSP:-flow shop scheduling problem.

HMLV :-high-mix-low-volume

IEA:- industrial engineering application

IP: in process

ME:-material efficiency

MTBF:- mean time between failure

MTTR:-mean time to repair

NEH:- Nawaz–Enscore–Ham

NWT:- Not working time

NWT:-Not working time

OAE :-Overall Asset Effectiveness

OCAP:-Out control action plan

ODT:-Order down time

ODT;-Order down time

OEE= over all equipment effectiveness

OEEE :-Overall Environmental Equipment Effectiveness factors,

OEEE:- Overall Environmental Equipment Effectiveness

OEQCL: overall equipment and quality cost loss

OFE :-Overall Factory Effectiveness

OLE :-Overall Line Effectiveness

OLE: Overall line effectiveness

OME:- Overall manufacturing effectiveness

OPE:-Overall Production Effectiveness

ORE :-Overall resource effectiveness

OTE:-Overall Throughout effectiveness

P e:- entire performance

P:- performance

Pa:- is the amount of products produced by equipment during the total observation time,

PEE:-Production Equipment Efficiency

PFSP:- permutation flow-shop scheduling problems

PFSSP:- Permutation Flow Shop Scheduling Problem

Pg:- is the amount of the qualified product,

PLT:-Performance time losses

PSMI:Peacock Shoe Manufacturing industry

Ptha:-is the theoretical output of one single device

Pu:- is the amount of unqualified product.

Q e:- entire quality

Q:-Quality

Ract:- is the actual processing speed of equipment,

Rth:- is the theoretical processing speed of equipment,

SBT:-Standby time

SBT:-Standby time

SMED:-Single-minute exchange of die

SMI:- Shoe Manufacturing industry

SW :-standardized work

Td:-is the downtime,

TEEP:-Total Equipment Effectiveness Performance

TP;- is the production time of equipment,

TPM:-Total production maintenance

TT;- is the planned running time or total observation time of equipment,

TU;- is the uptime of equipment or actual processing time,

UNIDO:- United Nations Industrial Development Organization

VSM :-Value stream map

WIP:-Work in process inventory

CHAPTER ONE

1. INTRODUCTION

More than recently, today improvement is vital for the future existence of manufacturing. That is due to the changes of customer(s) demand, technology, lifestyle and especially the increasing of competitors in the market and their outcomes. Therefore the manufacturing have adopted more reliable methods to promote sustainable performance and delivering quality from their manufacturing (Gujar et al., 2019). In agile manufacturing age the organizations are no longer survive without seeking improvement(A. Pandey, 2019).The overall output of the manufacturing affected by internal and external factors.

Beside internal:- equipment failure, setup and adjustment, idling and minor stoppage, reduced speed, defect in process, yield loss(Tsarouhas, 2018) and power off and no light are external. And the measure area of improvement is attractive when started from the entire and it focuses on the pulling of the manufacturing by answering the customers question through the resource utilization. To say the occupied improvement is equitable for the all manufacturing, when it concern on the overall entire manufacturing system. And that is called Overall Throughout equipment effectiveness (OTE).

The concept of OTE has to be considerable and also necessary; because it creates a competitive advantage for the manufacturing in developing models of production system to facilitate the improvement ways and area (He et al, 2018). OTE presents several benefits for the manufacturing and customers. It uses for the utilization of working time, machine and labor and to deliver quality products for the customers through clarifying the level of where; beside the settled and figure out the cause of losses in the direction of affected metrics.

OTE attained imagination after the application of Overall Equipment Effectiveness (OEE) is generating improvements for equipment(s) and OTE applicable for the improvement of throughout manufacturing system by stages. And OEE is merged by Nakajima in1960 with the total productive maintenance (TPM)(Nilmani sahu1 and Sridhar k, 2013). OEE is measuring and improvement indication tools for the specific individual equipment through its metrics. The metrics are Availability (A), performance (P) and quality (Q)(A. Pandey, 2019).

Where Availability is defined when the machine can run perfectly i.e. there is no cause of downtime. Quality is said when the qualified products are produced during the running time.

And Performance defined by the number of pieces produced during that running time with respect to the predefined capacity.

The improvement is based on the types of the manufacturing and factors generating the effect of the OEE metrics. OTE is the expanded concept of the OEE and it is used as a measurement tool of system and improvement indication for the production process which production type; may be product(s) continuous type, job shop and flow shop(He et al., 2018).

The way of measuring the OTE is depend on the arranged of production system. The production system may be series, parallel and mixed type. For the shoe manufacturing, production type is flow shop and the arrangement is mixed type. During this like type, it based on the process type, and the production system classified in to stages to facilitate the computation ways of OTE. The OTE is derived from the OEE(Huang, 2017). To derive OTE from the OEE, the procedures are measure the OEE for each individual equipment or line. And bottleneck line or equipment is considered(Gujar et al., 2019) and promote to compute the OTE entire according to relationship of the between and OTE of the system is inclusive about the downstream effect on the quality metrics(He et al., 2018). The OEE is applicable in any types of manufacturing at equipment level. The benefit of OEE for the manufacturing at equipment level to is measuring and analysis, to reduce the equipment losses to zero and has been attained recognition as basic necessary for organizations(Anil S. Badiger* and R. Gandhinathan 2008).

In worldwide OEE shows how well a company is utilizing its resources, which include equipment, labor and the ability to satisfy the customer in terms of delivering quality products(Praveen S et al ,2014). In other words, OEE is a "best practices" way to monitor and improve the effectiveness of manufacturing processes(Gholizadeh, 2019). According to (Eldridge et al., 2005 and Kumar et al., 2014) state, OEE application was developed to performance measurement approach that has been widely used in industry by controlling and monitoring the equipment's performance. And it also uses as indicator and driver of process and performance Improvements as cited by(Jose Arturo Garza-Reyes, 2015) when production follows sequence form.

OEE offers a measurement tool to evaluate equipment corrective action methods and ensure permanent productivity improvement through it three metrics(N. Sahu, 2013). The OEE metrics are availability, performance and quality(Zeny Fatimah Hunusalela*, 2019). It is difficult to imagine what the time was like when shoe were discovered yet. However everything is founded at the time of need is raised and demanded to fill the vacancies.

A leather footwear manufacturing was started almost before 5 million years ago during the ice age period and is a widely traded commodity among the leather products (MOIEk, 2015 and.mulu, 2019). In case of Ethiopia, the footwear industry started manufacturing in 1939 year ago. The Leather materials are used worldwide especially for shoes.

The beneficiary of this sector at the current time is increased like in; East nations, in particular China, India, North African countries and the Central and Eastern European countries(Tesfaye G, 2009 and Cherkos T, 2011). But the usability of tanner for manufacturing industry was differ from country to country and especially in Africa the footwear manufacturing industry grow slightly(Addis.S, 2019) Behind of the existed resource of tanner in Africa especially in Ethiopia, the sectors need more attention to invest on the leather footwear manufacturing.

According to the finding of (Cherkos T, 2011, Tesfaye G, 209 and Addis S, 2019) as the Ethiopian footwear manufacturing industry need sustain and strategic improvement of OTE. Apart from dozens of issues, the factors affect quality are carelessness of operators, yield loss machine failures and related problems have been identified as the major obstacle for performance of the in the shoe manufacturing industry in terms of quality metrics(Addis S, 2019). In EFI there is Inefficient utilization of resources (machine, labor and material)(Cherkos T, 2011). The OTE metrics of manufacturing is affected by Breakdown, Set-up and adjustment, Small stops, reduced speed, Production start-up reject, Production reject and production type(Abele, 2015; Ibrahim, et.al, 2018; Marcello Braglia, 2019; Marcello Braglia, Marrazzini, & Civile, 2019; Vijay Lahri and Pramod Pathak, 2015). To improve the OTE of the shoe manufacturing, the organization has to take necessary action on the improvement of OEE metrics in all section as per as the specified possible output found in the each section. The possible specified in the section with respect to output are and cutting section:-leather cutting and insole cutting, stitching section:-stitching on conveyor one (C1) and stitching on conveyor two (C2), moccasin and ironing and the last is lasting section: - lasting conveyor one (C1) and lasting conveyor two (C2).

The purpose of this study is to improve OTE; by identify the factors generate the loss of OEE metrics at of each individual and throughout, when it based on the real logical of production type and formed bottleneck. And it is through by determining the OTE at both of the entire and system. Take the necessary action plan according to the founded loss at each section on the OEE metrics and the propagation of loss and up and down steam effect is considered. And by using autonomous

maintenance(AM) frame-work in all section for improve all metrics and eliminate the stream effects, Heuristics algorithms for the sequence of processing, dispatching rule, Attribute Control Chart by (IBM:-SPSS –v20),cause and effect diagram for screen out the factors of loss and pareto chart prioritization of factors affect metrics at any levels.

The Heuristics algorithms are comprehensive and have different types which use for developing almost optimum and near to optimum makespan, $\max C_j$, $\min \max C_j$, $j=1 \dots n$. and total tardiness and flow time. And according to their ways of developing make span there are various type of heuristic algorithms. The suitable heuristics algorithms depends their function and behavior manufacturing, Palmer, Cambel-Duck Smith (CDS) and Nawaz Ensore Ham (NEH) are selected. Each of them has individual ways of computation for make span optimization; the best method is will choose after the result from each. And disputing rule has no more different idea from the heuristics algorithms and it also uses for the developing optimum make span by following the disputing methods. Attribute Control Chart is a quality control mechanism when the quality controlling is based on the attribute checking and wither it pass or fail and SPSS-v20 is a data analyzer tool and can easily analysis the collected data. The tested data is varied from day to day and at that time the data analyzing is P-chart. And C and E diagram and Pareto chart analysis uses for the filtering the hidden cause of the occurrence of OEE metrics loss factors and uses to prioritize according to the 20% for 80% factors of loss respectively. From the view of the starting time and its transformation plan tanner manufacturing, especially in Ethiopian footwear industry (EFI) still there is no satisfied change, resource utilization and there is chronic problem on the quality of shoe (Ashebre M et.al, 2013). Exceptionally, with compare to the other shoe manufacturing industry, according to the UNEDO report the Peacock shoe manufacturing industry, the daily average output pair person is minimum one. The output of any manufacturing is depend on the level of it OEE metrics at individual and through the sequence. Generally the reason of the minimum output is caused from break down of machine, part, connection loss of line, power off no light, careless ness of employees, lack of training, shortage of raw material, sequencing of job, over processing and the others, so to improve the OTE, applying the above stated methodology bring the vital change in the manufacturing throughout improving the individual OEE metrics.

1.1 Problem Statement

OEE is containing the compressed requirement of both customers' organizational profitability. And it was obtained in terms of availability machine, performance of producing the required amount within the given operating time and to producing quality product as the requirements of customers. Therefore, it is one of the measurements tools of the organization performance by the above three metrics. As well as uses as the indicator of improvement area for the eliminating of the factors affect the three metrics; for brings continuous improvements in any manufacturing. In peacock shoe manufacturing there was stoppage at different section, minimum output during running time and unqualified shoes. Since the manufacturing was flow process, the above factors affects OEE at each level and these losses were propagated in terms of up and down effects and the factors affects the OEE at both entire and system level. Availability metrics affected stoppage, the second metrics Performance metrics minimum output during running time and third metrics is quality; it is affected by defect and yield loss.

As Eshetu B, (2017) states the quality problems affect country Footwear industry as it is not globally competitive due to the reason of the problem attack the total performance measurements of manufacturing. Again as Addis S, (2019) states the quality related problems are the main issue of productivity decline of PSMI due to the rejected product within the production process.

According to (M.H.M. Ahmed, 2020) the world-class values of the OEE metrics, for the sections, line or equipment were settled between the value of: - Availability = 90.0%, Performance = 95.0% and Quality = 99.9% and then products of them brings, OEE=85.0%. Nevertheless, currently, an OEE value of Peacock Shoe Manufacturing industry (PSMI) was varied between **10% to 25%** and OEE metrics values also below the settled values due to the above stated reasons. The improvement of OEE is attained from the cumulative improvement of OEE of the individual; it may be in the form of single equipment or line. The improvement techniques are depending on the formed loss of the metrics. And Gujar et. al. 2019 and Sivakumar and Manivel, 2019) take the OEE improvement through, the work study and time study.

Garza-reyes and Jose Arturo (2015) focused on the TPM implementation for eliminating the factors affect the OEE metrics. Faisal Umar et al, (2018) focused on the cause of OEE losses by production process analysis and the main wastes generate OEE metrics losses. In addition, according to eliminating factors of OEE metrics (R. Pandey et al., 2019) focused on unutilized resource generate impact on metrics and STPM implementation is chosen. Again for improving the OEE (Hegde M, 2009 and

Marcello Braglia, 2019a) uses lean and 5s's as a major tool. In whatever production system, secret of founded improvement is the specific affected OEE metrics and the propagation of loss.

All of the stated researchers are considering different types of losses as identified. Most of them focused only the six major losses of OEE metrics as well as they use the different categories of methods and tools for the improving. However, in this research the major losses classified in to seven major by including the sequencing losses. Sequence problem can be briefly described as follows: there are a set of m machines and a set of n jobs. Each of the n jobs requires m operations and each operation is too be performed on a separate machine and due to lack of preparing better sequence of for the flow shop there is un utilization resource in the manufacturing and output performance of the manufacturing affected by maximum total flow time of job as well as the machine idling formed. Therefore from the manufacturing system the improvement is about the OTE rather than OEE since OTE measuring of the flow production system and OEE laid to equipment measurements. During this type, the arrangement relationship of line and equipment is considered to eliminate propagation of loss and up and down stream effect. Therefore, to improve the OTE, selected appropriate approach are AM framework, heuristic algorithm, attribute quality controlling and developing control action plan based on the analysis result from the cause and effect and Pareto and at final the compressive improvement mechanic by diagram is developed based on the result of analysis.

The basic Research questions of the thesis are: -

- 1) What are the root causes of each major OEE metrics losses at each section?
- 2) From the heuristics; what are the preferable algorithms for the developing the better makespan?
- 3) How the system OTE metrics were indemnified in each month for generate improvements of the bottleneck metrics?

1.2 Objectives

1.2.1 General objective

To identify the factors affect the Overall throughout Effectiveness (OTE) of Peacock shoe manufacturing industry (PSMI) for improving of the OTE metrics of the system.

1.2.2 Specific objectives

To identify root cause of the factors and minimize' which generate the major losses of OEE metrics in each section.

To develop a better makespan for the sequence of job from heuristics algorithms; where the optimum makespan of the sequence of job among the computation of heuristics = $(\max C_j = \min \max C_j^n_{j=1})$

To optimize the bottleneck metrics depend on the formed among delayed metrics with in each month.

1.3 Scope and limitation of the study

OEE is measurement and improvement tools for all types of manufacturing and OTE is drive from the OEE of the individual machine and when the manufacturing type is follow the continuous processing and flow shop type. But the OEE is targeted to the single machine metrics measurement tool and improvement indication; however because of the manufacturing count output per the section, the metrics of OEE, OTE entire and OTE system is also computed as section; To analysis all metrics of OEE, OTE entire and OTE system all data information is need in accurate; from the each section regard on the metrics but in the cutting and stitching section there is no quality control mechanism and no data of quality failed raw materials and In process (IP) product and for this both section the quality level is taken as 99.9% to 100% qualified. To take data for the C and E it is so difficult due to the COVID-19 pandemic; however for the research direct observation and recording the root cause were done in addition to interview by following COVID-19 protection rule. The research is only focused on the PSMI of its three section regard on the OEE, OTE entire and OTE system.

1.4 Significance of the research

Improvement is the vital for both manufacturing and customers. And to bring improvement the essential is measuring the existing level of the manufacturing metrics and then take the necessary improvement methods accordingly; in this research it is specified for each metrics for all section. Show how to incorporate sequencing and scheduling in the flow shop for the improvement performance metrics. Bottleneck of the machine is minimalized; both customers and organization are satisfying. For further researchers it promotes the sequencing and scheduling application in the flow shop manufacturing for improving the performance metrics.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Overview of Overall Equipment Effectiveness

Measurement is the basic principles in any manufacturing for understood the performance level and to control it. Overall Equipment Effectiveness is the measurement tool and enhancement mechanism for the performance of Overall Equipment Effectiveness by using alternative method like analyzing, comparing the actual with world class. Improving Overall equipment effectiveness (OEE) is a concept where the bottleneck operations of a particular process are reduced. And it is very important because to identifies the gap between the actual, optimal and expected performance. So; Overall equipment effectiveness (OEE) is performance measurement tool that measures different types of production losses through its metrics and indicates areas of improvement is needed (Muchiri & Pintelon, 2008). OEE monitors the actual performance of equipment relative to its performance capabilities under optimal behavior (Shekhar .S et.al , 2015).

OEE is not only directed to equipment itself but includes effects of the metrics of equipment too (Rooda, 2005). The OEE application and determining mechanism are allowed for any plant of the manufacturing organization (Dewi Nusraningrum & Zaenal Arifin, 2018). When deal with the performance of OEE in the production system; it includes like materials, environment, motion, management system and etc. are the determinant; however not for all manufacturing organization.

As mentioned, the purpose of OEE for the manufacturing organization in particular, the OEE of the line that will provide a useful guide to aspects of the production process was computed (Panagiotis T., 2018). This based on the production system for minimize the OEE metrics losses generated by machine breakdown in case of input output production. And the reality of such like production there is no propagation of losses from where since no sequencing of jobs; and the necessary improvement is also specific area oriented and the OEE consideration was a system as the single. In the manufacturing system the most focused OEE losses metrics are classified as six major losses. However upon on the manufacturing the losses are varies (Harsha G. H.et.al., 2009) the problems of machine breakdowns, low performance, quality of machine due to Vibration, Coolant Leakage, Operator Awareness, not well

trained are the OEE losses. Waste of materials in manufacturing are categorized under OEE crisis (Jose Arturo Garza-Reyes, 2015a).

The equipment output alone did not give full meaning of the OEE measuring; due to the materials quality and motion has impact on the equipment. In case of productivity by performance of OEE all factors have to be obtaining attention based on their priority and behavior of production type. Equipment failure, defects and rework and industrial accidents are factors affect the OEE; whereas it solved by autonomous and TPM which resulted leakage of shots, breakdown minimized (Badiger et al., 2008). The OEE the losses are differ from production to production. As Badiger et al. the losses are only six major losses and it can be solved by TPM. Nevertheless, when the production system was not in put out put, the tools of solving is changed and also the loss categories may be changed. As mentioned (Praveen S et al., 2014) the OEE losses are dependent on the manufacturing types and need different solving mechanism for the improvement.

The performance of OEE were also affected by different attack like CO₂ emissions, high operational costs, quality costs with regard manufacturing (Rosario D and Sergio A, 2015). The sustainability of production and Environments are additional metrics of OEE. And call as the Overall Environmental Equipment Effectiveness (OEEE). External variability and internal variability generate the uncertainty problem on the production delivery time and non-value added activity was the critical to waste of OEE. To fix it applications of the OEE which is call the fuzzy set and lean thinking taken as major tools (Roessler. M.. and Abele. E, 2015) to solving the manufacturing problem associated with OEE metrics losses.

Basically the Six majors losses are like stoppage losses, namely breakdown or equipment failure, setup and adjustment, idling and minor stoppage, reduced speed, defects in the process, and reduced yield are the categorized losses for the factors of OEE minimizers regard on the manufacturing types (Nafis A et al., 2017 and Hamzeh S et al 2018). Such like huge manufacturing problems are propagated however has rare consideration. The losses were taken as single machine dependent which selected by outer observing. However the manufacturing system is not in put output process of single machine.

The un necessary manufacturing motion, poor resources planning and arrangements are cause of OEE losses (Ali-Asghar Dadashnejad & Changiz Valmohammadi, 2017) which identified as value-adding and non-value-adding activities to deliver product(s) to customers, which consume the same resources along the process' mainstream.

As(Swapnil Raut and Niyati Raut, 2017) the OEE of the manufacturing was affected by machine breakdowns, downtimes and low quality of products are the major factors. In different manufacturing type the Overall Equipment Effectiveness (OEE), is affected as the manufacturing types like, Not working time (NWT), Standby time (SBT) Order down time (ODT), Performance time losses (PLT)(Marcello Braglia et al., 2019) they focused on the combined of task which non-value adding activity and equipment waste call equipment losses are incorporated in the major six losses. In OEE losses consideration (Rahul P and Sridhar K, 2019)Overall Resource Effectiveness (ORE) addresses various kinds of losses associated with manufacturing system like readiness, changeover efficiency, availability of material and availability of manpower are under the Overall Equipment Effectiveness. In a manufacturing firm there has been studied and analyzed different mechanisms of improving OEE (Nilmani S and Sridhar K, 2013) while eliminate the six major losses.

2.1.1 Efficiency, effectiveness and productivity

Confusion exists as to whether; OEE has indeed been an effectiveness or efficiency measure. The traditional vision of TMP referred to Overall Equipment Efficiency while now it is generally recognized as Overall Equipment Effectiveness. The difference between efficiency and effectiveness is that effectiveness is the actual output over the required reference output. Efficiency is the actual input over the require reference input. The Equipment Efficiency refers thus to ability to perform well at the lowest overall cost and Equipment Efficiency is then unlinked from output and company goals(Iannone & Nenni, 2013).

Hence the concept of Equipment Effectiveness relates to the ability of producing repeatedly what is intended producing that is to say to produce value for the company. (Riyadil Jinan et. al., 2018) the increased effectiveness in manufacturing industries related to production support equipment. Effectiveness is indicating total result of the manufacturing company like in ways of total equipment effectiveness performance, production equipment effectiveness, overall factory effectiveness, overall plant effectiveness, and overall asset effectiveness(P. Muchiri and L Pintelon, 2008). For all manufacturing process the produces outputs by transforming inputs(Praveen S et.al , 2014) the value expected and output referred the OEE.

Productivity: - is defined as the actual output over the actual input.

The effectiveness: - of the installation is the actual output over the reference output.

The efficiency: - this is the actual input over the reference input.

The productivity can be influenced not only by changing the effectiveness but also by altering the efficiency; this is the actual input over the reference input.

Productivity is the term which represents the degree of effectiveness of industrial management in utilizing facilities for production(Shekhar S, 2015) by incorporating both efficiency and effectiveness of manufacturing.

2.2 Feature of overall Equipment Effectiveness

Overall Equipment Effectiveness was emerged by Nakajima in 1988; which packed with in the total productive maintenance (TPM). Increasing overall equipment effectiveness (OEE) is achieved through implementation of TPM (Swapnil R and Niyati R, 2017) by increase machine availability, performance & process quality. It is gradually developed to the small industry (Swapnil R and Niyati R, 2015). Overall Equipment Effectiveness(OEE) is the metric that best correlates to continuous improvement success (Atul Pandey.et.al., 2019) and it is expended to the Overall Resource Effectiveness (ORE). (Jose Arturo Garza-Reyes, 2015) is a manufacturing performance measurement system that has been developed with the objective of providing a more inclusive evaluation than OEE, of a machine or process performance.

ORE is merged to obtain best way of; OEE evaluation of the overall performance of a machine or process based; expanded to availability (A), performance (P), quality (Q), essential elements the material efficiency (M), process cost and material cost variations are included. Currently, the OEE was growing from the machine performance measurement to the input factors consideration of the organization (Rahul P and Sridhar K, 2019) ; states OEE was developed to the Evaluating the performance of plant from the single machine evaluation.

Eventually it is developed to working procedure of machines to enhance their Overall Equipment Effectiveness from the relative(Subhankur D and Ajoy Krishna D, 2016). And also developed from machine study to the agile manufacturing system to eliminate the production wastes and the effect of improvements identified through VSM on the overall equipment effectiveness (OEE) metric(Ali-Asghar D and Changiz V, 2017). (Mahsa F and Soroush A, 2019) explain that OEE and overall line effectiveness (OLE) are became smart techniques systems with fuzzy inference systems (FIS) for measuring OEE using FIS, and measuring OLE using FIS and artificial neural networks (ANNs).

It also developed to the process waste optimization through the deep process chart study(Gujar et al., 2019b). OEE become the improving operation of the production line and reliability and reveals the hidden costs associated with the efficiency of the equipment(Panagiotis T, 2018).

OEE expand using the time study to improve the productivity of assembly lines(R Sivakumar and R Manivel, 2019). It is a tool and measuring mechanism which is essential to identify and indicate place of problems and necessary tools of improving the manufacturing; where identify bottleneck and hidden losses (Vijay L and Pramod P, 2015). From this the implicit is use and serves as tool and digging tools as well as improvements methods. It also uses for labor cost decreases and improved OEE in a manufacturing industry resulted increase in availability, better utilization of resources, high quality products and also raised employee morale and confidence(Jayaswal and Rajput, 2012). A tools would be beneficial for future projects focused to improve the effectiveness of machines which have low OEE by implementing the TPM technique and setup time reduction by using different TPM metrics like MTBF, MTTR(mean time to repair) (S. Nallusamy et.al , 2018) from this rested for the future work for enhancing the OEE.

Overall Equipment Effectiveness has become the major concern of modern manufacturing technology and serve as the mediator in the limited empirical knowledge available through assess the relationship between fit manufacturing(lean manufacturing, agile manufacturing and sustainability and business performance for the business excellence(*Raghd I et al.*, 2018). OEE, one of the most important and widely used manufacturing performance metrics(Ratapol W, 2016). Also it can to evaluate the effectiveness of urban freight transportation Systems to reduce overall costs and increase revenue; this operation fulfilled through new methodology for evaluating the effectiveness of urban freight transportation systems using the OEE metric depend on economic development, quality, performance and availability which is called partial rates of the OEE; and optimize the OEE metrics and the profitability of a transportation system(A. Munoz-Villamizar et al., 2018).

From this excellence of, the OEE application was developed from the manufacturing organization to the service organization and to optimize certain crucial metrics of every production system, such as performance, quality, availability and capacity utilization by considers the six major losses as follows.

	Classic OEE	New Methodology
Quality losses	Defects Start-up	Orders not delivered within time windows
Performance losses	Reduced speed Abnormal production Minor stop losses	Reduced speed Traffic jams
Availability losses	Process failures Equipment breakdown Setup/adjust	Unloading times Waiting time to delivery within time windows

Figure 1:-Definitions of OEE concepts in terms of service sectors Source(A. Munoz-V et. al, 2018).

Overall Equipment Effectiveness (OEE) metric is identified as the Overall Environmental Equipment Effectiveness (OEEE), and OEEE incorporates the concept of sustainability based on the calculated environmental impact of the complete product life cycle(Rosario D and Sergio A, 2015). From this the OEE effectiveness was the basic concept and the losses and metrics are also added which emerged from the sustainability and agile the manufacturing and seeking the improvement area for management. Performance evaluation is the most important aspects in the field of continuous improving of the production process and for this overall equipment effectiveness (OEE) is one of the justified performance evaluation method(Chowdury M. and M. A. Hoque, 2014).

(Marcello B et.al., 2019b)Identify the losses beyond the six major losses the Overall Task Effectiveness was emerged from the OEE by the concept of new lean metrics through the task times study and to identify the hidden losses that account for most of the recorded time. the overall equipment effectiveness (OEE) concept is developed to the comparing among dissimilar type of machines those have different capacity and different process parameters such as production capacity, cost of material and quantity of the operator. And also expanded to quality cost minimization which termed as overall equipment and quality cost loss (OEQCL) (Hossain and Sarker, 2017).(Ki-young .J and Don T p, 2001) deals OEE application system is developed and expanded to the capacity utilization which focused on the bottleneck efficiency system (CUBES) from the machine state studies.

Generally, under the more emphasis the application of OEE and enhancing the organization performance currently it is expanded to the Total Equipment Effectiveness Performance(TEEP), Production Equipment Efficiency(PEE),Overall Factory Effectiveness (OFE), Overall Production Effectiveness (OPE), overall resource effectiveness (ORE) and Overall Asset Effectiveness (OAE) are the more targeted area which derived from the OEE(Garza-reyes, 2015; Hossain and Sarker, 2017; Iannone and Nenni, 2013; Marcello B, 2019; Shekhar et al., 2015; Vijay L, 2015 and Hamzeh S et.al , 2018).

Currently the implementing OEE in high-mix-low-volume (HMLV) factories remains a challenge, as both part and process properties are continuously changing but it was applicable(J.M. Jauregui B et al , 2015). Overall Equipment Effectiveness serve as mediation of relationship between Business Performance and Fit Manufacturing as manufacturing to ensure the reliability of the production operations which enable firms to satisfy their customers and end users(Raghed I et al., 2018).

Therefore, the analyzing of the OEE metrics losses swelled from the machine situation to the motion losses, uncertainty losses environmental losses, quality cost losses and opportunity losses are the loss categories beyond the machine state. However, none of them still consider the scheduling of sequencing loss over the OEE and this research mainly focused on the sequencing and in production quality loss to eliminate it addition to the identified six major losses of the equipment.

2.3 Metrics of Overall Equipment Effectiveness (OEE)

Overall Equipment Effectiveness (OEE) metrics are the determinant factor of level of the manufacturing organization like; of availability, performance and quality of product deliver to costumers. And depend on the current OEE definition and emerged its metrics as well as losses it can represent the performance level of manufacturing organization in all direction. The OEE was determined by availability, performance efficiency, and quality rate(Hamzeh S et.al, 2018).

OEE is broken down into three measuring metrics of Availability, Performance, and Quality and these metrics help gauge your plant's efficiency and effectiveness and categorize these key productivity losses that occur within the manufacturing process(Praveen S et.al , 2014). (Rosario D and Sergio A, 2015) the OEE is a known measure of equipment utilization, which includes the metrics of availability, quality and performance of each production step, in addition to these Overall Environmental Equipment Effectiveness factors, the **OOEE** incorporates the concept of sustainability of the product development as the additional OEE metric.

The Overall Equipment Effectiveness(OEE) is the metric that best correlates to continuous improvement success(Pandey A et al, 2019). And because of it is the competent metrics for the organization and the result of OEE improvement is obtain from loss elimination.(Mahsa F and Soroush A, 2019) OEE is an important metric for measuring OLE (Overall Line Effectiveness).Generally as possible to understand from the above illustration the OEE the most well-known OEE metrics are Availability, Performance and Quality are the major. And this research also has no other metrics of OEE rather focuses on the ways of analyzing those metrics and the losses in in more inclusive way. The OEE was currently rampant too for measuring the ORE, OME, and etc. of manufacturing organization.

To enhancing the Overall Equipment Effectiveness, it is more important focusing on the OEE metrics losses. The OEE metrics losses of the manufacturing organization are almost different from manufacturing to manufacturing. To empathize and identifying losses types it is determined by the knowing the manufacturing types and proses as well as having the skill to understanding the OEE means. And by this research this there are identified seven major losses which affect the OEE metrics of manufacturing specifically.

2.3.1 Formulas and terminology of OEE metrics

Most of many scholars are categorized the OEE metrics in three major categories and of course in this research it is as it is. Each of them has their own formulas in mathematical and the mathematical formulas were updated from time to time based on the manufacturing processing types which is emerged from the obtain areal values of the identified losses of the metrics. Therefore the calculating system of OEE metrics is depending with metrics losses. Basically, the OEE was in figurative way.

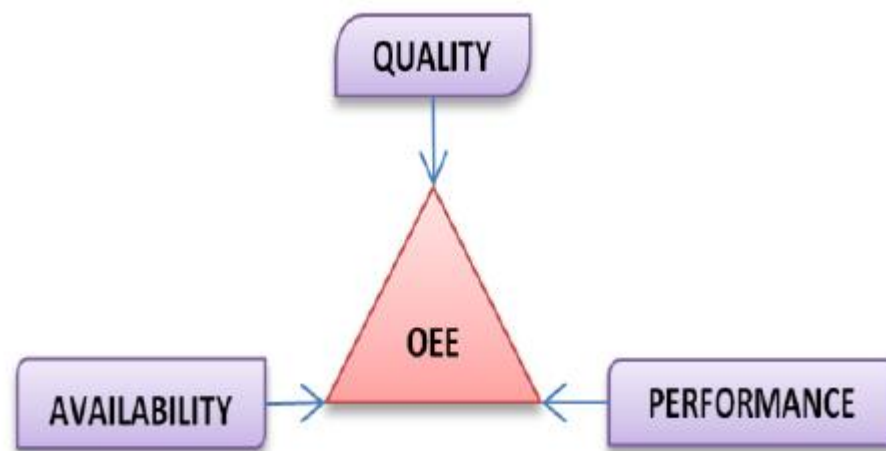


Figure 2:-The triangular of OEE metrics source (Vijay Lahri & Pramod Pathak, 2015)

OEE metrics is classified into three: -

- Availability
- Performance
- Quality

Availability: -This metric describes how actually the machine is available for production. Availability accounts with down time losses. The Availability Metric is a pure measurement of Uptime that is designed to exclude the effects of Quality, Performance, and Scheduled Downtime Events(Dewi Nusraningrum&Zaenal Arifin, 2018; Juan M. Jauregui Becker , Jesper Borst, 2015; Marcello Braglia,

2019a; Vijay Lahri and Pramod Pathak, 2015; Wudhikarn, 2016). According to the Nakajima the availability formula was give as follows and (Anil S. Badiger* and R. Gandhinathan, 2008)

$$\text{Availability} = \frac{\text{operating time}}{\text{planned production time}} \dots \dots \dots \text{Equation 1}$$

When; planned production time is calculated by subtracting the planned downtime from shift time hours where planned downtime includes all planned machine downtime events like Operator breaks (lunch, tea, etc.) and planned maintenance.

$$\text{Planned production time} = \text{Shift time} - \text{Planned downti} \dots \dots \dots \text{Equation 2}$$

$$Pt = Tst - Pdt$$

$$\text{Operating time} = \text{planned production time} - \text{unplanned downtime} \dots \dots \dots \text{Equation 3}$$

$$Ot = Pt - UPdt$$

Performance: - the Performance portion of the OEE Metric represents the speed at which the Work Center runs as a percentage of its designed speed(Rahul Pandey &. K Sridhar, 2019).

And it is calculated as by multiplying the output during the operating time by the theoretical standard cycle time and then dividing it by the running time: -

$$\text{Performance} = \frac{\text{uotput} * \text{theoretical cycle time}}{\text{running time}} \dots \dots \dots \text{Equation 4}$$

Where:

Output = the output during operating time is the amount of output the machine produced during its operating time.

Theoretical standard cycle time = it is the amount of output that should be produced during a certain time frame (unit of time/output)(Anil S. Badiger* and R. Gandhinathan, 2008).

Quality rate: - is calculated by subtracting the output during the running time by rejects (including reworks) and then dividing by the output(Anil S. Badiger* and R. Gandhinathan, 2008):

$$\text{Quality} = \frac{\text{output-reject}}{\text{output}} = \frac{OPt-RPt}{OPt} \dots \dots \dots \text{Equation-5}$$

2.4Introducing Overall Equipment Effectiveness and Throughput (system) Equipment effectiveness

The manufacturing equipment's are needed to be kept idle for a variety of reasons, including machine setup, breakdown, maintenance and raw material supply delay. Moreover, due to machine or human

errors the production system may not produce 100% quality products(Hossain & Sarker 2017) for the customers to win the market. Productivity was measured through the OEE and it's the packed with full of both customers and organization wants are included with in it. The intentional implication of OEE was time and product which contain resource utilization by hidden meaning. In a lot of organization OEE was known as single machine metrics measurement and in spite of that most researchers are did not consider about the propagation of losses where the production was output input. The difference of OEE and OTE was at terminology and as well as differ in the loss consideration. The OEE uses to determine the metrics at the individual equipment level and OTE uses to determine the OTE metrics at the entire and system level by consider the propagation of losses and arrangements of the production system.

Overall Equipment Effectiveness(OEE) can represent as overall throughput effectiveness (OTE) metric based on the idea of comparing actual productivity to maximum attainable productivity(Sarker& Hossain, 2017) OEE is mostly uses when single machine dependent and the production system were continuous. The OTE is the same metrics consideration with OEE. However they are differing by loss consideration in terms of propagation means.

AS(Sarker& Hossain, 2017) states the application of OTE in the manufacturing industries are serve as to identify the productivity, bottleneck and opportunities for improvement quantitatively.

System OTE, which is the performance of the whole system and can be defined as the performance of the bottleneck equipment in the given production system(Iannone & Nenni, 2013) and (Cesarotti.et.al , 2015) it serve to eliminating excluding manufacturing measurement.

Performance evaluation is the most important aspects in the field of continuous improving of the production process and Overall Equipment Effectiveness (OEE) is one of the justified performance evaluation methods that is popular in the manufacturing industries to assess the machine's effectiveness and performance(Chowdury M. L. Rahman & M. A. Hoque, 2014).

Overall equipment effectiveness (OEE) is measuring the performance effectiveness of individual equipment or entire processes(J. A. Garza-Reyes, 2015).Both OEE and OTE are the selective tools for measuring and indicating the improvement area of the manufacturing (Harsha G.et.al , 2009). In manufacturing organizations both OEE at equipment level and OTE at entire and system improvement were implemented through different tools and pillars of the TPM pillars, 5S and other mechanisms are the preferable(Harsha G et.al, 2009).

Effectiveness of equipment plays a major role in modern manufacturing firm to achieve the goal (Binoy B & Jenson J, 2013). Overall through effectiveness (system) is the measuring of the manufacturing performance through the metrics by considering the propagation of losses depend on the behavior of manufacturing system.

2.4.1 Derivation of OTE from OEE

When the manufacturing system flow sequence type and the final outputs were obtained after process; the manufacturing measurement level is known after through computation of equipment, line, stage and system. Therefore to improve the overall manufacturing system, it is needed to drive the inter relation according to their relation to measure it and identify the factor affect metrics at specified possible site.

The derivation of OTE is based on the OEE formulas and system arrangement categories maybe series, parallel and assembly system. From listed system, Peacock shoe industry contains both series and parallel connection system. According to(Fei He et.al, 2018 and Huang, 2017) the derivation of OTE and metrics of availability(A^{system}) performance(P^{system}) and quality(Q^{system}) and for the entire OTE and metrics are as follows.

$$OEE = A * P * Q \dots \dots \dots \text{Equation 5}$$

$$A = \frac{TU}{TT} = \frac{TT - Td}{TT} \dots \dots \dots \text{Equation 6}$$

$$P = \frac{Pa}{R_{th}TU} = \frac{TPR_{act}}{TUR_{th}} \dots \dots \dots \text{Equation 7}$$

$$Q = \frac{Pg}{Pa} = \frac{Pa - PU}{Pa} \dots \dots \dots \text{Equation 8}$$

When the above equations are merged bring the equation of:

$$OEE = \frac{TU}{TT} * \frac{Pa}{R_{th}TU} * \frac{Pg}{Pa} = \frac{Pg}{TTR_{th}} = \frac{Pg}{p_{tha}} \dots \text{Equation 9}$$

From the equation (13), the essence of OEE is the ratio of the quantity of qualified output to theoretical output.

And(He, Shen, Lu, & Tong, 2018) states this concept is applied to the OTE of a production system, which is considered as a separate device in theory. The essence of OTE is therefore the ratio of qualified output (actual output, Pg (F)) to theoretical output (P (th) a (F)) of the entire line measure of throughput but not system OTE; and is defined as follows:

$$OTE = \frac{Pg(F)}{P_{a(F)}^{(th)}} \dots \dots \text{Equation 10}$$

In the case of zero losses the theoretical output of the i^{th} equipment's stated as:-

$$P_{a(i)}^{(th)} = Rth(i) \times T_T \dots \dots \dots \text{Equation 11}$$

From the reality of production, the theoretical outputs of equipment are determined by the equipment with the lowest theoretical output in the production system and equation (12) uses for determining the system theoretical output.

Therefore the theoretical output of the entire system or stage derived as below equation (12).

$$P_{a(F)=\min_{1,2,3\dots n}}^{th} (R^{th(i)} \times T_T \dots \dots \dots \text{Equation 12}$$

In the line production system, the actual output of the all system is determined by the equipment with least qualified output and which is affected by downstream equipment.

Theoretical output of this parallel production system is as follows:

$$P_{a(F)}^{(th)} = \sum_{i=1}^n (Rth(i) \times T_T) \dots \dots \dots \text{Equation 13}$$

During the system production of in a series, the minimum output of qualified product is calculated as follows:

$$P_{g(F)=\min\{ \min_{i=1,2,3\dots n} \{ P_{g(i)} \times \prod_{j=i+1}^n Q(j) \}, P_{g(n)} \dots \dots \dots \text{Equation 14}$$

To calculate the OTE of the series system, substituting equations (15) and (17) into equation (14), the OTE of a series system can be stated as follows:

$$OTE^{series} = \min\{ \min_{i=1,2,3\dots n-1} \{ OEE_{Rth(i)} \prod_{j=i+1}^n Q(j), OEE_{(n)} Rth_{(n)} \} \dots \dots \dots \text{Equation 15}$$

In the series production system $OEE_{Rth(i)} \prod_{j=i+1}^n Q(j)$ in equation (18) describes the qualified output per unit time of equipment is affected by the next equipment. Therefore the minimum result of this equation is the entire qualified output per time of the series production system.

In parallel manufacturing system, the actual output of the system is calculated as follows:

$$P_{g(F)} = \sum_{i=1}^n (OEE(i) \times Rth(i) \times T_T) \dots \dots \dots \text{Equation 16}$$

By substituting equation (17) and (20) into equation (14) the parallel manufacturing system of the OTE calculation formula can be defined as:

$$OTE^{parallel} = \frac{\sum_{i=1}^n (OEE(i) \times Rth(i))}{\sum_{i=1}^n (Rth(i))} \dots \dots \dots \text{Equation 17}$$

Most of the manufacturing systems are contain integrated systems like series, parallel and mixed type and the Peacock shoe manufacturing industry is a mixed type of system i.e. parallel, parallel series and parallel connection manufacturing system. Whatever the system types it is possible to find the system Overall Throughout Effectiveness based on the Overall Throughout Effectiveness of the entire manufacturing system and according to the classified stage of the system. During the system is mixed type the formula use is as follow:

$$OTE^{(s)} = \frac{\min\left\{\min_{i=1,2,\dots,n-1}\{OTE(1) Rth(i) \prod_{j=i+1}^n Q_j\}\right\}}{\min_{i=1,2,\dots,n}\{Rth(i)\}} \dots \dots \text{Equation 18}$$

From the quality control mechanism of the peacock shoe manufacturing industry the quality rejected products are found only at the end i.e. The there is no more quality related problems in the cutting and stitching section and the quality problems are found in the lasting section of lasting processing.

So from this view the quality rate is equation: $Q = \frac{Pg}{Pa} \dots \dots \dots \text{Equation 19 for the lasting section of lasting process.}$

During computing the derivation of the three metrics in the separate units/stages/ the calculation formula can be modified with reference to the OEE and three metrics of one single component. In theory, the production system the total amount of output of the system is depend on the bottleneck machine production cycle time.

To calculate the OTE of the system; separately the OEE metrics value; A, P and Q rate of each five stages of operations are compute.

To determine the A (i), P (i) and Q (i) the entire system should be followed as below:

$$A(i) = \frac{\sum_{r=1}^p A(r,x) Rth(r,x)}{\sum_{r=1}^p Rth(r,x)} \dots \dots \dots \text{Equation 20}$$

$$P(i) = \sum_{r=1}^p \frac{P(r,x) Rth(r,x)}{\sum_{r=1}^p Rth(r,x)} \dots \dots \dots \text{Equation 21}$$

$$Q^{(s)} = \frac{Pa(y) - \sum_{j=y}^n pu(j)}{pa(y)} \dots \dots \dots \text{Equation 22}$$

For the OTE, of the system the metrics of the overall manufacturing system is as follows

- I. The availability rate (A) of a production line or production process equals the availability rate of the entire system of that bottleneck machine.

$$A^S = A_{bottleneck} \dots \dots \dots \text{Equation 23}$$

- II. The performance rate (P) of a production line or production process equals the performance rate of the entire system of that a bottleneck machine.

$$P^S = P_{bottleneck} \dots \dots \dots \text{Equation 24}$$

- III. The quality rate of the manufacturing is depend on the two conveyors of lasting machine of total output minus total number of defect from both conveyors divide by total amount of output.

$$Q = \frac{Pa(total) - \sum_{i=1}^2 Pu}{Pa(total)} \dots \dots \dots \text{Equation 25}$$

All derived formulas are from (He et al., 2018 Huang, 2017; Naik, Raikar, & Naik, 2015; Tsarouhas, 2018)

Terminology

RUN TIME (Availability Metric) - The total production time that the machine has been running and producing parts.

SETUP TIME (Availability Metric) - The period of time on the machine required for an operator to perform all the necessary tasks to produce the first good part.

DOWN TIME (Availability Metric) - The period of time the machine is not available for production due to maintenance or breakdown.

TOTAL TIME (Availability Metric) - The total accumulated machine time of Run Time + Down Time + Setup Time

TARGET COUNTER (Performance Metric) - the number of parts or cycles that should be completed at a particular point within the shift, day, or production run.

TOTAL COUNT (Performance & Quality Metric) - The total number of parts, good and bad, that are produced on a machine.

GOOD COUNT (Quality Metric) - The input count for any part produced to manufacturing specifications on the machine.

AVAILABILITY = Run Time / Total Time

PERFORMANCE = Total Count / Target Counter

QUALITY = Good Count / Total Count(Vivek B. P et.al, 2014).

2.4.2 Factors Affect OTE metrics

According to Nakajima, 1988 the OEE metrics losses are classified in to the following: -

Equipment failures/breakdown losses are the time losses and quantity losses caused by defective products.

Setup and adjustment losses are defined as the time losses resulting from downtime and the defective products that occur when the production of one item ends and the equipment is adjusted to meet the requirements of another item.

Idling and minor stop losses occur when the production is interrupted by a temporary malfunction or when a machine is idling.

Reduced speed losses refer to the difference between the equipment design speed and the actual operating speed.

Reduced yield losses occur during the early stages of production, from machine startup to stabilization.

Quality defects and reworks are the losses in quality caused by the malfunctioning of production equipment. Six Big losses are those activities which consume input and resources without giving any valuable output in terms of monetary value(Lahri & Pathak, 2015).

The six categories losses are attain different focused base on their impacts (Anil S. Badiger and R. Gandhinathan, 2008) equipment failure, defects and rework and industrial accidents are the losses identified. Machine breakdowns, low performance, quality of machine Vibration, Coolant Leakage, Operator Awareness, not well-trained Operating Procedure are considered as the major losses of OEE metrics(Harsha G. Hegde et.al , 2009). Again (Hamzeh S et.al , 2018) listed that the OEE metrics losses are classified in to six but they identify main causes such as; speed losses, excessive breakdowns and high levels of defective products of manufacturing.

(Nafis A et.al, 2018) states the OEE metrics losses are identified Six major stoppage losses, namely breakdown or equipment failure, setup and adjustment, idling and minor stoppage, reduced speed, defects in the process, and reduced yield in the initial; however there is no consideration of losses propagation. In wide manufacturing the OEE metrics losses are may be differing from section to section. (Braglia et al., 2019a)Not working time (NWT), Standby time (SBT) Order down time (ODT), Performance time losses (PLT) are the identified metrics losses. (Ali-Asghar Dadashnejad & Changiz Valmohammadi, 2017a) unnecessary motions in the productions are identified as main effect of the OEE metrics through increasing the production cost and eradicating products quality.

The CO₂ emissions, high operational costs, quality costs are the OEE metrics losses (Rosario Domingo and Sergio Aguado, 2015). As (Markus Philipp Roessler and Eberhard Abele, 2015) the uncertainty problem in the shop floor, which generated from the external and internal variability and none value added activities are the critical waste of OEE losses.

And OEE waste was due to the affected of the OEE metrics. “downtimes” (Chowdury M. L. Rahman & M. A. Hoque, 2014) are identified as the major losses of OEE metrics.

The OEE metrics losses are interrelated to the ORE losses those are unplanned downtimes, ideal, operating cycle times and volume of defects (Jose Arturo Garza-Reyes, 2015), however only the six metrics losses are highlighted.

According to (Swapnil Raut and Niyati Raut, 2017) mentioned the machine breakdowns and downtimes and product quality problem as well as lateness of delivery date, waste is due to operators, maintenance personal, process, tooling problems and non-availability of components in time, other forms of waste include idle machines, idle manpower, break down machine, rejected parts etc. are the identified.

There is propagation of losses from metrics to metrics and it show the occurrence of factors are the determinant (Pandey Atul et.al, 2019 & Rahul Pandey & K Sridhar, 2019) breakdowns of machines and pour quality of products are studied metrics losses. Working conditions, thermal expansion and flow process (A. J. Gujar et.al, 2019) are stated the major losses of metrics. The “error of shrinkage, operator pause and water-cooling machine” (Faisal U. et.al, 2018) are identified. Machine running without job, Idle, Setting, Inspecting the dimensions, Left the machine, Went to supervisor room and Went to supervisor room are the most which affect the OEE metrics (Nilmani S & Sridhar k, 2013).

The failure of the Equipment (Panagiotis Tsarouhas, 2018) can generate quality problems and performance and the losses are propagated to the left two metrics. (S. Raut & Raut, 2017 & R. Sivakumar & R. Manivel, 2019) machine idling; breakdown and lack of quality specifications are the OEE metrics losses in which can widely propagate. And (Sowmya K & Chetan N, 2016) bottlenecks, downtime and cost of quality are which directly and indirectly affect the metrics of Overall Equipment Effectiveness. Downtimes, Setup hours, Scrap are the major identified the Metrics losers (J.M. Jauregui Becker et.al., 2015 & A.F. da Silva et al, 2017). The deterioration rate compared to expected design rating identified beside the availability, performance and quality losses in manufacturing (Idriss El-Thalji & Erkki Jantunen, 2012 & Purba H et.al, 2018).

Any problems with the manufacturing affects the metrics (Daniel A et.al, 2018, S. Nallusamy et.al., 2018 & Mahsa F and Soroush A, 2019).

The OEE of the manufacturing organization associated with the physiological, biomechanical, chemicals and musculoskeletal condition; Floor area not Clean, Fatigue of operators, Inconsistent of operators in working, Harmful chemicals, Accident and deaths, Sudden breakdown due to electrical faults and Rejection of goods are listed impact of metrics and productivity of the organization(Sahu* *et al*, 2016& Rajat S Sen *et.al*, 2019) and this reason occurring of due to the high lead times.

The OEE metrics are affected like ways as follows in the transport service; (A. Munoz-Villamizar *et.al*, 2018) Orders not delivered within time windows and; Reduced speed Traffic jams and Unloading times, Waiting time to delivery within time windows are minimized the quality, performance and availability respectively. Specially As(Muchiri & Pintelon, 2008) finding the losses are categorized in to the seven major losses such as Major stoppages, Changeover, cutting blade loss, Startup and shutdown losses, Minor stoppages, Speed losses and Quality losses.

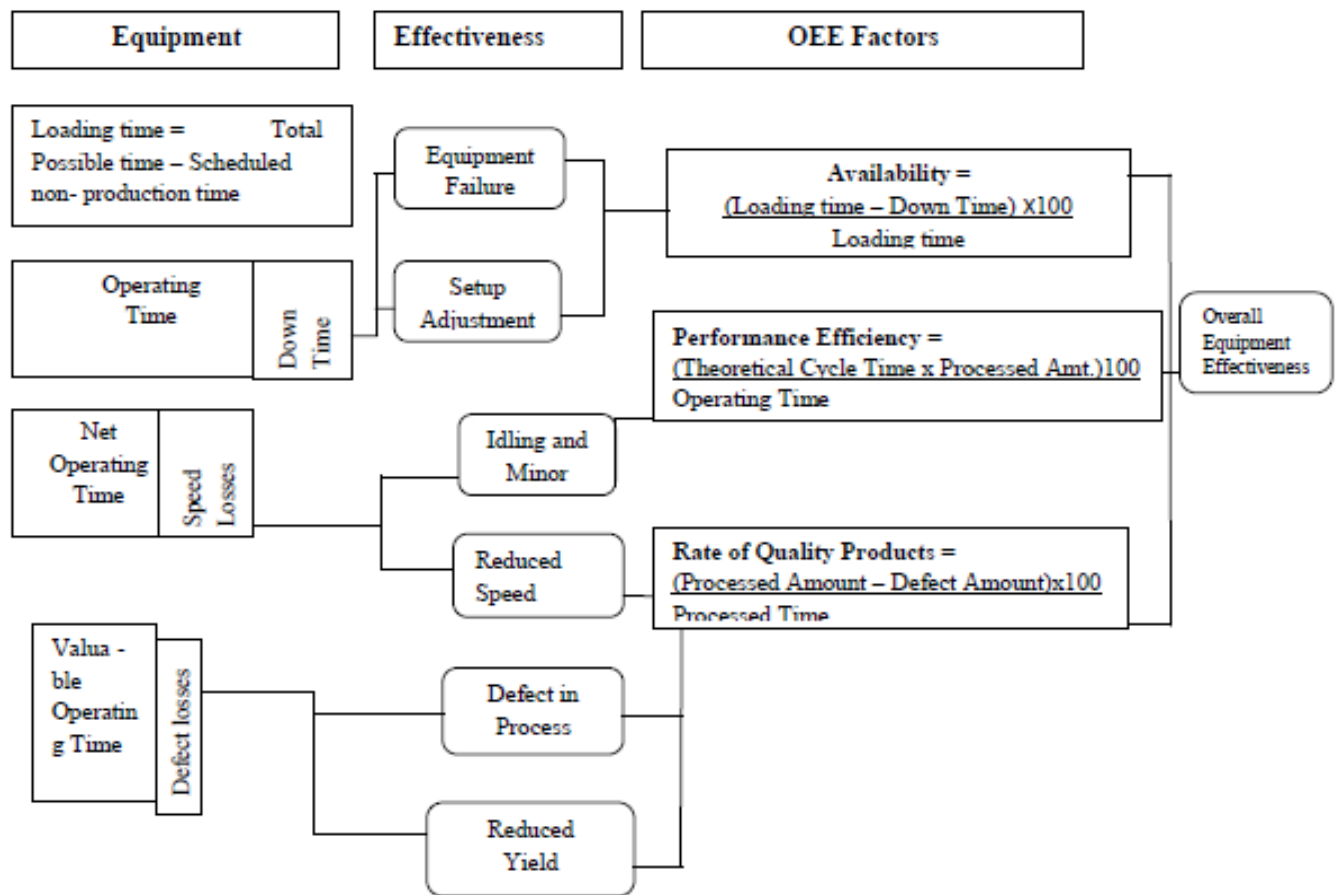


Figure 3: Diagrammatic of OEE losses. Source (Pratesh J & Hemant S, 2012)

Generally, from the above referred literatures the scholars are identifying the OEE metrics losses in different ways in different organization. And as possible to understand from the different manufacturing organization and case company, the losses are followed by types of Industry (like service and manufacturing industry), manufacturing (like continuous, follow shop/ job shop/, mass), product, environments, management and input resources are can be the reason of losses.

2.5 Improvement of Overall Equipment Effectiveness and Overall through effectiveness (OTE)

2.5.1 Method and tools of improving Overall Equipment Effectiveness (OEE) and Overall through effectiveness (OTE)

In manufacturing / service/ industry there are different methods and tools of improving the OEE of the organization depend on the factors affects the OEE metrics to keep it at the maximal values and at least to the world class value. Below the method and tools of improving are as shown.(Harsha G et.al, 2009)Through systematic approach method of using the fishbone diagram and pareto analysis and tools of TPM and 5S techniques implementation ways the OEE was improved from 43 % to 72 % in addition the total saving per annum due to increased effectiveness was around Rs 4,53,000/.

The OEE implementation system, analyzing, measuring of the exist OEE for managing the time losses and using the autonomous and TPM tools are can minimize leakage of shots, breakdown and increased OEE from 51.35% to 73.77%(Anil S. Badiger* and R. Gandhinathan, 2008). Throughout implementation of Total Productive Maintenance (TPM) and using pareto the OEE metrics are improved(H Soltanali et al., 2018). By too examines factor of losses and applied Kaizen and using the appropriate tools of TPM pillars Pareto analysis, WWBLA work sheet, and cause-and-effect diagram, the measurement of OEE was from 75.09 to 86.02%, productivity was improved by 23.93%, and production of defective items was reduced by 49.50%(Nafis Ahmad et.al, 2018). (Dewi Nusraningrum and Zaenal Arifin, 2018) by using descriptive quantitative approach with value analysis methods and incorporating fishbone diagram and using 5W1H, the performance of the company's is changing for the better and as well as on the other machine.

Through "observations, and in analogy with other similar works" and lean tools implementation then task losses are minimized and manufacturing performance was increased(Braglia et al., 2019b).

By VSM and OEE value were assessed, compare and contrasting the values before and after the through the structured questionnaire and by help of by the lean production it is possible to eliminating losses and decreasing lead-time then the OEE was improved to 76 to 83%(Ali-Asghar Dadashnejad & Changiz Valmohammadi, 2017).

By improvement in sustainability the total cost of production was minimized from 1.999 ureo 1.875(Rosario Domingo and Sergio Aguado, 2015) also by techniques of Systematic analysis of manufacturing processes, lean production and green manufacturing system the OEE was motivated. (Atul Pandey et.al, 2019; Rahul Pandey and K Sridhar, 2019; Swapnil Raut and Niyati Raut, 2017b) improved that through the total participation of organization in the company and sampling, analyzing, and creating an improvement roadmap methods and as well as by using tools of TPM pillars implementation system in the manufacturers organization, the OEE were can be improved by reducing cycle time as well as possible to attained the business excellence effectiveness and utilization of the available resources.

By particular disciplined of OEE analysis at manufacturing processes on the shop floor with in corporate function of production planning for process optimization and manipulated by applications of the OEE, the fuzzy set and lean thinking can increase both transparency, reliability of production plans and performance of the organization(Markus Philipp Roessler* and Eberhard Abele, 2015).

By the conceptual of mathematical development of the ORE measure, Empirical and simulation-based investigations and applications the key performance indicators are enhanced(Jose Arturo Garza-Reyes, 2015). As (A. J. Gujar et.al, 2019 and Sivakumar and Manivel, 2019a)work study, time study method and production process improvement can also help to reach towards three metrics and improve OEE from 79.57% to 89.12% and 50% to 70%. Use of Six Sigma methodology and statistical analysis helps to improve the OEE performance(Hassani and Hashemzadeh, 2015a). By proper analysis and implementation of total productive maintenance system the overall efficiency of the industry was increased when losses are minimized and overall equipment effectiveness has been increased between 5 to 8%(Soo-Fen Fam et.al 2018 and Rajat S Sen et.al, 2019).

As (Mahsa F and Soroush A, 2019) to decrease some weaknesses of OEE and OLE methods by exploiting intelligent system techniques, such as fuzzy inference systems (FIS) and artificial neural networks (ANNs). (S.F. Fam et.al, 2017) the five lean manufacturing tools namely single-minute exchange of die (SMED), standardized work (SW), takt time, value stream mapping (VSM) and Kaizen are able to reduce waste and increase the OEE.

The TPM pillars implementation like Focused improvement and Planned maintenance as pioneering and using the control chart analyzing tools the OEE losses are totally minimized (Manjunatha B et.al, 2018 & Soo-Fen Fam et.al, 2018). The OEE was (Ratapol W, 2016) improved through the OEE calculation under help of arena regression analysis. (Vittorio Cesarotti and Vito Introna, 2016 and Zeny Fatimah Hunusalela et.al, 2019) show that regression analysis, through failure mode and effects analysis (FMEA) and using fuzzy logic in addition to the TPM implementation factors of OEE metrics losses are minimized.

From the above stated methods, tools and ways of eliminated or minimized the factors affects the metrics of OEE and manufacturing performance. The OEE improvement was very differ from organization to the organization according to the manufacturing system. It alters on the level of understanding of problems and having the application of IEA. Depend on the manufacturing and processing system this research focused to improving the OEE of the manufacturing Organization applying the sequencing and scheduling principle in addition to total productive maintenance (TPM) are the selective tools.

2.6. Sequence and Scheduling

2.6.1 Scheduling

Scheduling is (A Irman et.al, 2019) defined the process of allocating resources over time to perform a collection of tasks within a certain period of time. Production scheduling is defined as the way of allocating resources or machines to process a set of tasks within a certain period. Flow shop production system requires scheduling to set up a job priority (Yusraini Muharni et.al, 2019). Effective scheduling deals with the faster movement of goods and services through a facility for (Jatinder N. D. Gupta et.al, 2019). It serves for utilizing the allocated resources.

In manufacturing taking the schedule decision generate several important like minimize idle time, total set up time, work in process inventory, and for maximize the machine utility through developing better makespan (David A et.al, 2019). And this is realized by developing the better scheduling when the WIP and idling of machines are improved. This is use for the initiation of the worker moral and capability.

And also(Wenzhu Liao & Yanxiang Fu, 2019) scheduling model is established by taking both the robustness of total completion time and the tardiness of production into consideration simultaneously. (Feng Liua et.al, 2018) is to determine the sequence of groups and the sequence of jobs to minimize the makespan. The relation of sequencing and scheduling is sequencing is indicating the order of job to be processed and scheduling is scheduling plus time table by considering job/task/ activity objective on the machine for the optimum or near to the optimum makespan. Proper scheduling involves sophisticated algorithms that seek to maximize the utilization of these scarce resources in the form of the optimization (Pedro Alfaro-F et.al, 2020).

2.6.1.1 Flow shop scheduling

Flow shop scheduling problem (FSP) is of wide application and plays an important role in the manufacturing systems(J.-J. Wang & L. Wang, 2019). Flow shop scheduling is the methods of planning, allocating controlling and executing the assigned Jobs according to permitted machine for executing it without affectation the machines order but to obtain the better make-span the aim is to exchanging the jobs for the benefit of the company in terms of resource utilization. As cited by(D Setiawan et.al, 2019). In flow shop scheduling, n job available will be processed on m machine with the similar sequence for every job. (Kewal K et.al, 2019) minimize the makespan helps the organization to produce mass volume with in the given production time.

(Win-Chin Lina et.al, 2017) flow shop scheduling is effective to minimize the total tardiness. It focused on the when both jobs are available and as well as machines are too.

In flow shop production it involves production scheduling problems, particularly in determining the efficiency of the work sequence that will be done to produce small makespan values so that the production capacity can be larger and the production cost were minimized(Yusraini M et.al, 2019). Then the OEE metrics of performance which determine the output amount perfectly increased through the minimized make span and increasing production capacity.

(Hong-Yan Sang et.al, 2015) scheduling is optimization criterion and the minimization of the maximal job completion time or makespan (or C_{max}) which corresponds to the time at which the last job in the sequence is finished on the last machine in the shop and interring chance of the following job is high for obtaining additional finished products. And the quality metric are considered and affected by the amount of output.

In case of flow shop scheduling (J. N. D. Gupta et al., 2019)“flowshop scheduling considered each of n jobs from a set $N = \{1, 2, \dots, n\}$ is processed on a set $M = \{1, 2, \dots, m\}$ of m machines in the same technological order as given by the indexing of machines”. In Heuristic flow shop scheduling problems, the developing minimum makespan methods have been widely applied for permutation flow-shop scheduling problem (PFSP), and it is classified as follows

Campbell Dudek Smith (CDS) heuristic method proposed by Campbell, Dudek, and Smith

And he Nawaz–Enscore–Ham (NEH) heuristic method proposed by Nawaz, Ensore, and Ham(Wenzhu Liao & Yanxiang Fu, 2019).

2.6.1.1.1 Permutation flow shop scheduling

A Permutation flow shop scheduling problem (PFSP) with makespan criterion is a problem consists in scheduling n jobs on machines $M_1 \dots M_m$. In that order, without interruption and Machines can process at most one job at a time and the processing order of jobs is the same on all machines(Jan Gmys et.al, 2020). (R Sanjeev Kumar, 2016) state it allows “ n ” jobs to be processed on “ m ” machines. As (Wenzhu Liao & Yanxiang Fu, 2019) the permutation flow-shop scheduling problems (PFSP), which is viewed as a simplified version of the FSP. In case of permutation flow shop scheduling an FSP with m machines $M = \{M_1, M_2, \dots, M_i, \dots, M_m\}$ and n jobs $J = \{J_1, J_2, \dots, J_j, \dots, J_n\}$ is presented. J_j is composed of m operations and performed by consecutive machines.

O_{ij} refers to the operations performed by M_i for J_j and its operation time is p_{ij} . The operation sequence of J_j is $(O_{1j}, O_{2j}, \dots, O_{mj})$ (Wenzhu Liao and Yanxiang Fu, 2019).

And again, the Permutation Flow Shop Scheduling Problem (PFSSP) refers to the problem of running n jobs on m machines sequentially and on the same permutation with the objective of minimizing the makespan and it can be characterized by the following main points:

Each job j_k can run on each machine only once where $k = 1, \dots, n$

Each machine i_h can process only one job at a time where $h = 1, \dots, m$

Each job j takes a time to be processed on each machine I namely, the processing tempts

The processing time of each job is changed depending on the machine as each job will run on machine 1 to m orderly.

The processing time of each job includes the set-up time plus the running time on a machine.

It is assumed that the start time is zero

Each job has a completion time C to finish its processing in a machine that takes two parameters $C(j_k i_h)$ as it is the completion time of job j on a machine

Pre-emption of jobs is not permitted.

The objective of PFSSP is to find the best permutation of jobs that minimizes the makespan C^* which is defined as the completion time of the last job on the last machine (M. Abdel-Basset et al., 2018) & Nailwal et al., 2019).

2.6.1.1.2 Heuristics flow shop scheduling

NEH heuristics is as cited by (M.K. Marichelvam et al., 2020) is a constructive heuristic algorithm was developed by Nawaz (1983) to solve the n jobs and m machines permutation flow shop scheduling problems to minimize the makespan and NEH heuristic is used to generate one of the initial solutions through the sum of processing time for all the jobs at every stage is calculated, and then the NEH heuristic is applied. As (G. Deng, Q. Su, Z. Zhang et al., 2020) the Nawaz–Enscore–Ham (NEH) based heuristics for flow shop scheduling are extended in no-wait job shops.

The NEH heuristic consists of three steps:

- I. All the jobs are sorted according to the descending sums of their processing times, giving a sequence of jobs.
- II. The first two jobs from the sequence are taken and the two partial possible schedules are evaluated. Then, the better sequence is selected as a current sequence.
- III. Job i , $i = 3, \dots, n$ is taken and find the best schedule by placing it in all of the possible i th positions in the sequence of jobs that are already scheduled are found then the best partial sequence is selected for the next iteration (M.K. Marichelvam et al., 2020).

2.6.1.1.3 Campbell Dudek Smith (CDS) algorithm

The CDS algorithm is the development of Johnson's rule. It is (David Arohman et al., 2019) basically, a method can solve the problem of two machines of flow shop by dividing the m machine into two groups, then by sorting the job from both of machines which used algorithm Johnson; then after obtaining as much as $m-1$ alternatives, there will be selected for the smallest makespan sequence.

- I. Take the first sequence ($k=1$). For all of the jobs, looking for the minimum price of t^*I_1 and t^*I_2 which is the processing time on the first out of the second machines.
- II. If the minimum time can be gain on the first machine (example: $t_i, 1$), then positioning on the beginning sequence, then if the minimum time can be gain on the second machines (example: $t_i, 2$), those jobs can be positioned on the last sequence.

III. Move those jobs only from the list and the sequence. If there are still exist the remnant job, repeat again the first step, otherwise if there are didn't 't exist the remnant job, the sequencing process have been done(David Arohman et.al, 2019).

Take the first and last machine (other machines are considered non-existent), arrange the order using the Johnson's rule. Take machine 1, 2 and machine M, M-1, and then combine the processing time between.

2.6 How scheduling uses to Enhancing OTE and which metrics is directly enhanced

It is stated OEE is best measurement tool and method uses to measure the performance of any industry or organization through its metrics. The metrics was affected by different losses. Improvement mechanism based on the understating of manufacturing system and identifying the factors affects the OTE in the system. The OEE metrics are affected directly and indirectly. From the manufacturing system and current existed problem the lack of developing best makespan through the sequencing is one and major factor affect the OEE metrics and generate the work in process inventory (WIP) which resulted from the bottleneck. To eliminate /minimize/ this chronic problems scheduling is the best alternative.

As stated (Juan M. Jauregui B et.al, 2015) the OEE improvement consider the effective production requires from the during the available equipment to produce the parts in the optimal expected. To utilize the availability resource like machine, materials, space and operators when developing the batter makespan is the best alternative. If batter makespan is developed throughout the computation of heuristic method the completion time of the part is minimize and total tardiness also minimize then the total volume output is increased only by altering the sequence. And the OTE of the manufacturing also improved.And as(D Setiawan et.al, 2019) performance can be measured based on four criteria: minimize completion time, maximize utilization, minimize work-in-process inventory, and minimize customer waiting time. This are the main scheduling objectives by developing better make span.

Among the OEE metrics both Performance rate and quality tare is determined by the well execution of the four stated in above criteria of the scheduling. Scheduling is (Sanjeev Kumar et.al, 2016) the minimization of makespan and total flow time. The implication proper scheduling is keeping the machine in high performance, maximum output and increasing chance of producing quality products. (M. Abdel-Basset et al. 2018) to minimizing the makespan through schedule is reducing the time complexity and minor stoppage and idling time.

And it increases the OEE under the enhancing safety and capacity is utilized. (M.K. Marichelvam et.al, 2020)Makespan is essential for effective resource utilization in terms of output. The performances of OEE metrics are also measured through effective resource utilization of output. As stated the scheduling are very helpful in the manufacturing to improve the OEE metrics and (Wenzhu Liao & Yanxiang Fu, 2019) optimal job sequence that can achieve minimal total completion time in order to decrease the cost of production.

Generally from the definition of both the OEE metrics performance and the scheduling; when good scheduling is developed through the iteration of each heuristics scheduling the performance of the total output is increase and the commutative result implies the OEE increase.

2.7 Maintenance

Maintenance is main tools use for any manufacturing to provide excellent reliability and quality of them equipment at competitive prices and smooth manufacturing processes as well as serve the organization from incurring un necessary cost for machine(Tsarouhas, 2018b). Autonomous Maintenance (AM) is one of the TPM pillar, which proposes a group of actions aimed at involving actors others than the maintainers in the context of equipment maintenance(Marcos A1 and , Antonio C, 2021).

2.7.1 Autonomous maintenance

It the systematic ways of producing the skilled full operators to increase the profitability of the organization throughout the developed maintenance skill(Rajkumar Sahu* et.al, 2016). Is maintenance way uses for developing the operator's skill in multipurpose to increases their confidence and developing them to the owner attitude. According to the(Pratesh J & Hemant S, 2012) when introducing the autonomous maintenance, the operators are responsible for upkeep of their equipment to prevent it from deteriorating. Autonomous Maintenance standards such as cleaning, lubricating and inspection were develop and even perform simple countermeasures in their respective equipment to prevent unplanned machine downtime d(Musa, et.ai, 2014). Autonomous Maintenance, acts on the diagnosis of equipment conditions, optimizing the skills of employees who operate the machines throughout the production shift (Duques A et.al, 2019).

In addition, AM ascertains the roles and tasks of production operators so they can perform easy daily maintenance activities aside planned maintenance(Cesar & Martins, 2021; Duques, 2020; Wakjira & Iyengar, 2018). To be productive in the Autonomous maintenance not only optimizing skill; it fruits is attained by authorizing and the owner zed employees.

This is besides creating intentional sprite motivation by the future hope making. It was by giving incentive, given award on their excellence of, changing their employment type.

Specifically, the AM activities can be divided into seven stages as shown below

- i. Conduct initial cleaning and inspection
- ii. Eliminate sources of contamination and inaccessible areas
- iii. Develop and test provisional cleaning,
- iv. Inspection and lubrication up to standards,
- v. Conduct general inspections autonomously,
- vi. Workplace organization and housekeeping, and
- vii. Fully implement the autonomous maintenance program(MOLENDA, 2016; Shagluf, et.al., 2014)

2.8 Summary of literature and gap

In the previous study different researchers are done on the enhancing and maximizing the OEE and OTE in different manufacturing by considering different factors affecting metrics. During the previous studies as cited in the above, the OEE and OTE use as the measurement tools for the manufacturing through its three metrics levels and indicate the needed improvements area for the metrics and possible improvement methods are employed depend on the identified factors affect the metrics (Muchiri & Pintelon, 2008, Harsha G. H.et.al., 2009, Rooda, 2005, Shekhar .S et.al , 2015, Jose Arturo Garza-Reyes, 2015, Praveen .S et.al , 2014, Rosario D and Sergio A, 2015,Dewi Nusraningrum & Zaenal Arifin, 2018, Panagiotis T., 2018, Nafis A et.al., 2017 and Hamzeh S et.al 2018).

The future of OEE was expanded in two basics ways. One expanded its future was by the measuring applicability is from single equipment to manufacturing and from manufacturing to the service sectors. And the second focused on the factors affects:- the factors affect of the metrics were also attaint consideration from break down of machine up to waste in the manufacturing and as well as method of improvement also from implementation of TPM pillars to VSM and ANNs methods (Swapnil R and Niyati R, 2017, Swapnil R and Niyati R, 2015, Atul Pandey.et.al., 2019, Jose Arturo Garza-Reyes, 2015, Rahul P and Sridhar K, 2019, Subhankur D and Ajoy Krishna D, 2016, Ali-Asghar D and Changiz V, 2017, Mahsa F and Soroush A, 2019 and R Sivakumar and R Manivel, 2019).

To measure the OEE level of the equipment and line the three metrics calculating method are applied and for the measuring the OTE of entire and system the way of measuring were derived from the OEE formula after identifying the production model in terms of arrangement of machine (Dewi Nusraningrum & Zaenal Arifin, 2018; Juan M. Jauregui Becker, Jesper Borst, 2015; Marcello Braglia, 2019a; Vijay Lahri and Pramod Pathak, 2015; Wudhikarn, 2016 Fei He et.al, 2018 and Huang, 2017) and Fei He et.al, 2018; Huang, 2017). The methods of improvement were selected depend on the happened factors of the metrics and the levels of each metrics were also improved (Harsha G et.al, 2009, Anil S. Badiger* and R. Gandhinathan, 2008, Dewi Nusraningrum and Zaenal Arifin, 2018, Braglia et al., 2019, (Atul Pandey et.al, 2019; Rahul Pandey and K Sridhar, 2019; Swapnil Raut and Niyati Raut, 2017 Soo-Fen Fam et.al 2018 and Rajat S Sen et.al, 2019). Generally from the previous study, regard the measuring of the metrics of equipment and manufacturing gradually expanded and ways of bring the improvement also too. Therefore for the case study to bring the necessary improvement the appropriate were selected depend on the manufacturing type and factors of affecting the its metrics through the manufacturing process and the literature gap were also identified in the table form.

Table 1:- list of literature gap.

Authors	Method	Focus Area
Harsha G et.al, 2009	Fishbone diagram and pareto analysis and tools of TPM and 5S techniques implementation	Equipment
Anil S. B and R. G, 2008	Using the autonomous and TPM tools	Equipment
A. Munoz-Villamizar et al., 2018	Statistical process control	Service
H Soltanali et al., 2018.	TPM	Equipment
Nafis A. et.al, 2018	TPM pillars, Pareto analysis, WWBLA work sheet, and cause-and-effect diagram	Equipment
Dewi N and Zaenal A, 2018	Fishbone diagram and using 5W1H,	Equipment
Braglia et al., 2019	Lean tools implementation	Equipment

Ali D & Changiz V, 2017	VSM	Equipment
Rosario D and Sergio A, 2015	Lean production and green manufacturing system	Equipment
Atul P. et.al, 2019; Rahul P & K Sridhar, 2019; Swapnil R & Niyati R, 201	TPM pillars implementation	Equipment
Markus P * and Eberhard A, 2015	Fuzzy set and lean thinking	Equipment
Ratapol W, 2016	Arena regression analysis	Equipment
A. J. Gujar et.al, 2019& Sivakumar & Manivel, 2019	Work study and time study	Equipment
Hassani & Hashemzadeh, 2015)	Six Sigma methodology and statistical analysis	Equipment
Manjunatha B et.al, 2018 &	Focused improvement and Planned maintenance as pioneering and using the control chart analyzing tools	Equipment
Soo-Fen Fam et.al 2018& Rajat S Sen et.al, 2019	Proper analysis and implementation of total productive maintenance	Equipment
Vittorio Cesarotti and Vito Introna, 2016 & Zeny F et.al, 2019	and using fuzzy logic in addition to the TPM implementation	Equipment
Mahsa F and Soroush A, 2019	Fuzzy inference systems (FIS) and artificial neural networks (ANNs).	Equipment
S.F. Fam et.al, 2017	By five lean manufacturing tools	Equipment
He, Sh.et.al, 2018	Statistical analysis	OTE(system)

Source: - from previous study on the OEE and OTE improvement methods and areas of improvements.

By this research in addition to Focused improvement, as pioneering and using the control chart analyzing tools, Fishbone diagram, using Pareto analysis and AM; especially heuristics algorithms were included. In additional the improvements were flow the system focused which is called OTE.

CHAPTER THREE

3 Methodology and background of case company

3.1 Methodology

To doing the research and to bringing improvement of OEE at, equipment, section and OTE at entire and system, it is necessary to identify and understand the required data in proper way; as well as to analysis the research the necessary instruments have to be employed for ultimate goal of the thesis. From the cited reference indicates that there are different ways of solving the problems are applied and it based on the categories of losses affect the OEE metrics and type of the manufacturing system.

Basically, for solving the identified problems, during research the necessary data are collect from each section (cutting, stitching and from finishing section) regard on the machine availability, down time, performance of machine during the available time, processing time each job(shoe) on each machine, categories of shoe based on its model and quality based data of the qualified products based on the acceptable shoe and unacceptable shoe are the necessary data and etc. are the required data for analyzing exist Overall Equipment Effectiveness.

In order to get those data, different data collection methods are will employ. The methods of data collection and doing the overall research are primary and secondary data from organization, literature (like thesis and books), journals and reports. To attain the settled objects; the analyzing tools are:- Pareto analysis for prioritizing, Cause and effect diagram (Microsoft vision), Heuristics (Lekin- software) for job sequential analysis and for developing better make span and Control chart: - (IBM SPSS-v 20) for process controlling of quality problems.

3.1.1 Source of Data

For executing the thesis, the data source is the secondary and primary mainly employed. Primary data: - are data which collect directly by different path and from organization, which did not pass any types of analyzing. Each of them has its own collecting mechanism. The types of data collect by this way are both qualitative and quantitative. Secondary data: - are data which are putted evidence regard on the OEE metrics, scheduling, quality improvement mechanism from any literature, journals, books and reports. It is both types of qualitative and quantitative data.

3.1.2 Data collection Method

Data collection will depend on the nature of data and its possibility to available as it categorized as quantitative or qualitative. For this research primary and secondary data will collect depend on the characteristics of the research.

Primary Data: - it is data collected from the case company regard on the availability of machine, downtime of the machine, performed product during available time, and quality related issues and the make span through direct observation, communication or discussion with factory responsible bodies (i.e. general manager, production and quality manager, shop floor workers and operators) and time study focusing on bottlenecks to get better understanding of the problem area.

- ✓ **Direct Observation**-during visit of the case company necessary data will collect through careful observation of working condition like speed, arrangement material for of work flow, scheduling, working environment, and process of production and Operator attention.
- ✓ **Collecting from different section of each section:** collecting documented data on the daily output of each section from production planning department, qualified and rejected amount. Broken machine and breakdown frequency from maintenance department.
- ✓ **Interviews**-The researcher will conduct interview through discussions with technical mangers, supervisors, production planner. The interview was context free, it will be held for the research; it with these people based on the researcher's main areas of coverage in the title and the objective described like break down of machine, maintenance type and employers holding mechanism.
- ✓ **Time recording:** - with a stopwatch to collect the time taken of each process on each of specified machine for all jobs.

Secondary Data: -Secondary data will use in this research; includes different documents regarding to factory's previous records of daily production reports,

- ✓ **Document review**- to show the existing problems of OEE Metrics losses in the case company the related documents like: - Ramsay, Jamica and Ambessa; about the production daily output and production shop scheduling, are reviewed.
- ✓ **Literature/ journals/:** - compare and contrasting the mechanism of they use to improve the OEE and scheduling mechanisms.
- ✓

3.1.2.1 Literature Survey

Literature survey is done to analyze and deeply understand what is previously done on the topic and also to find out important techniques for enhancing OEE methodologies and improvement. And in addition, helps to identify the gaps of exist on between OEE and OTE of the previous works as well as provide improvement and finding additional mechanism of enhancing over all equipment effectiveness depend on the manufacturing types. From the Literature survey on thesis and journals articles the identified gap were on the method of improvement, area of improvement and OEE metrics losses identification.

3.1.3 Data Analysis tools and improvement methods

The tools will select rely on the research needs and select as suitable tools to deal with the research problems and meet the objective of this study

Pareto analysis (Microsoft word excel): - after the Each losses factors are collect in terms of unit product/ unit time/ in order to prioritize it the pareto principles are followed and this was help to know the in what which losses affect the OEE metrics and be the cause of other losses.

Cause and effect diagram (Microsoft vision): - after prioritize the OEE losses metrics to identify the Couse it the fishbone diagram relationship was developed based on the types of losses. Then depend on the cause of the effects the necessary action was suggested.

Autonomous maintenance: - the current existing maintenance type of the manufacturing was preventive which was done monthly. However the machines were usually broken easily and are needed timely cleaning and aware during operating to eliminate the both break down loss and maximize the employee performance by training.

Heuristics:-by using (lekin- software): are the sequential flow job analyzing method for developing better make span; so depend on the data will collect by stomach unit time of each processing time the two heuristic namely NEH and CDS computation of analysis will be undertake and the bottles neck are identified and minimized.

Control chart (Attribute Control Chart): - (IBM:-SPSS –v20): -from the output units of products the control charts will develop to controlled in both of n-Chart as well as p-charts. During the control chart focused on the assignable and unassignable cause of problems and the western electrical hand book rules are followed.

- ✓ One-point plots outside the 3-sigma control limits.
- ✓ Two out of three consecutive points plot beyond the 2-sigma warning limits.
- ✓ Four out of five consecutive points plot at a distance of 1-sigma or beyond from the center line.
- ✓ Eight consecutive points plot on one side of the center line

3.1.4 Frame work /strategies/ improvement of OEE metrics.

The research structure is developed into a schematic and visualized framework (Figure 5) of the research steps required to achieve the research objective. The process start with the preliminary study and

defining problems, analyzing and ends with conclusions, recommendation and finally

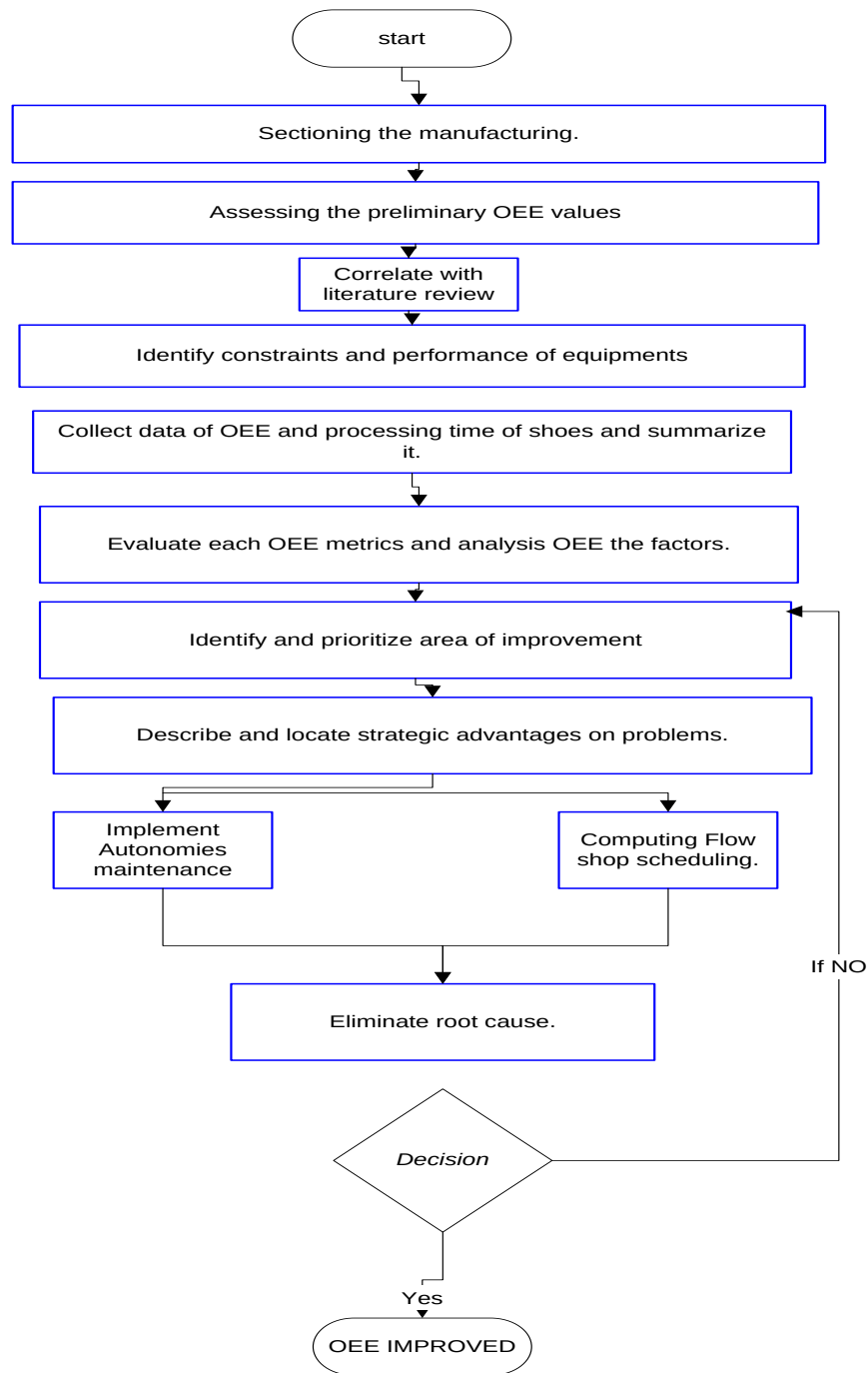


Figure 4:- Research frame work

3.2 Background of case company

The first informal shoe manufacturing facilities of peacock are the 300Sqm old and suffocated facility just behind the Old (Arada) Postal Services Office up in Piazza, right next to the Russian Cultural Centre (Alexander Pushkin Hall), is now dwarfed by Peacock's own three huge, modern and complicated plants and fully runs. In fact, the shoe manufacturing company had started business in a 40Sqm rented room with four employees in 1992. In those days, it used to produce a maximum of 12 pairs of shoes a day only for the local market. More than a year later, it included the relatively bigger facility in Piazza, though its market remained local. For more than eight years, it operated in the same facility, with the same capacity. Peacock is now one of the popular shoe manufacturers in Ethiopia with 157 floor worker employees and 30 office worker and production managers, controllers and etc.; busy the entire working hours at the three huge plants of more than 1,000sqm size each. The three plants house the Cutting, Stitching and Lasting or assembling units of the factory. Peacock shoe factory is engaged mainly in the production of quality dress casual men's shoes. Peacock has a wide range of shoes for in a variety of styles and colors. The shoe factory success has been its dedication to quality. Its significant and vital advantage is having a modern factory with modern and latest machineries. Its products sold in local and export foreign markets. The company exports its products to Italy, Spain, USA, Jeddah and Nigeria, Congo and etc. The vision of the company is to further expand exports,

3.2.1 Products, Customers, Suppliers and Competitors of Peacock

Peacock shoe factory is engaged mainly in the production of quality dress casual men's shoes. The company uses both local and imported raw material. Its local suppliers are dire, Mojo and Ethiopia Tannery for leather products and Kangaroo, Kadisco for foam and some chemicals respectively. The company imports leather and chemicals from China, Italy, Germany and Portugal. The company sells its products both for local and export market. It has its own distributions center for local market in Addis Ababa and in regions. Its distribution centers in Addis are in Piazza, Amade and Merkato. And in regions are Adama, Jimma, Nekemte, Shashemene and Hawasa. It also exports its products to Italy, United Arab Emirates, Jeddah, Jordan, Israel, Spain, Kenya and USA.

The main competitors of the company are Ramsey, Jamaica, Kangaroo, Anbessa, Chinese factories, etc. This competition is vital for the company to produce quality products that can compete in global market. The main model of shoe exported to other country are, Simon, Bead, Bade, Polo, Lexington, Gimmy, Rigato, Marry, Peacock, Greed, Aspen, Peach, Mentero and G-star respectively.

CHAPTER FOUR

Data presentation, Analysis and Findings

4.1 Introduction

In any manufacturing organization; during the production processing time, there is a targeted and actual output of the equipment and through system. The difference is merged from the utilization of the resource. And the occurrence variation determined by performance level of each metrics of the measurement unit with settled world class values.

In manufacturing, the performance metrics level can be 100% when there are no losses. However depend on the existed reality of losses like:- lack of infrastructure, breakdowns, power off, speed loss, minor stoppage, scrap and etc.; the world class values of OEE and its metrics are settled in the below table.

Table 2: The world class value of OEE and its metrics

OEE metrics	World class values of OEE and it metrics
Availability(A)	90%
Performance(P)	95%
Quality(Q)	99%
Overall Equipment Effectiveness (OEE)	85%

Source: From world class values of OEE agreement(M.H.M. Ahmed, 2020).

In the manufacturing organization; the OEE is a measuring tool of performance levels at system and equipment in the factories through its metrics in order to reduce any problems which affect the resource utilization interms of loss of metrics and optimize the productivity of the manufacturing depend on the results of OEE metrics(Gholizadeh, 2019). Depend on the values of OEE metrics, OEE is not only used as an operational measure, but also as a process improvement indicator within the confines of the specified values of metrics for the production system(M.H.M. Ahmed, 2020).

To analyze the existing situation and improve the OTE values of the case study, the necessary data on the machines availability, machines performance, quality related data, models of jobs, processing time on each machine and sequences of processing.

The data include the daily, monthly and year production capacity of the factory in each section and lines of the section are required.

Based on its necessity, the necessary data has to collect from each processing section; from the cutting, stitching, moccasin, insole and lasting. Data about the targeted to process, actual output, designed capacity, machine stoppage and processing time of each brand of shoe from the all specified section. The sequences of processing for the highly demanded, as well as passes on the most common machines.

4.2 System representation and Derivation

As stated in the previous the PEACOCK shoe factory has three main sections mainly cutting section; which only cutting of leather and insole operation based on the specified designed and required models of shoes. Stitching section is a section which stitching operations, moccasin and ironing are processed. And the third section is lasting section is a section with the finishing processing operations are done. The production data from all sections are needed to evaluate the OTE of the factory(Fei He et.al, 2018).and the OTE derivation as follows.

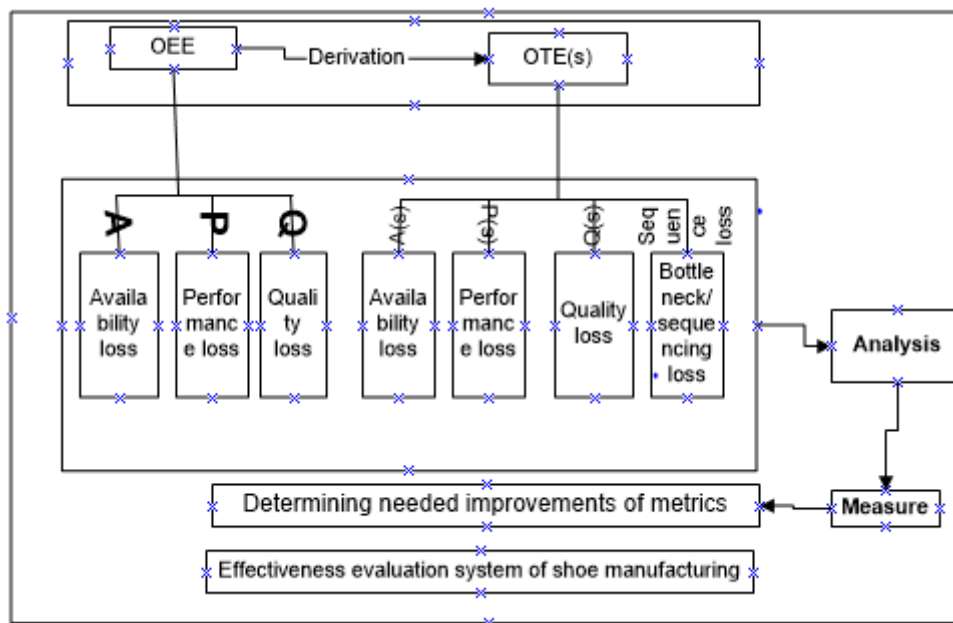


Figure 5:-Effectiveness Evaluation system of shoe manufacturing.

In shoe manufacturing system the final products are obtained after a through different operation on different equipment's. These different operation sequences have the arrangements of, series, parallel and mixing of operation system. And the formulas are derived from OEE to OTE.

The general representation of manufacturing system can be drawn as follow.

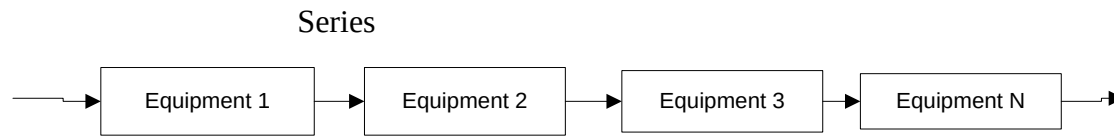


Figure 6:- series manufacturing system representation

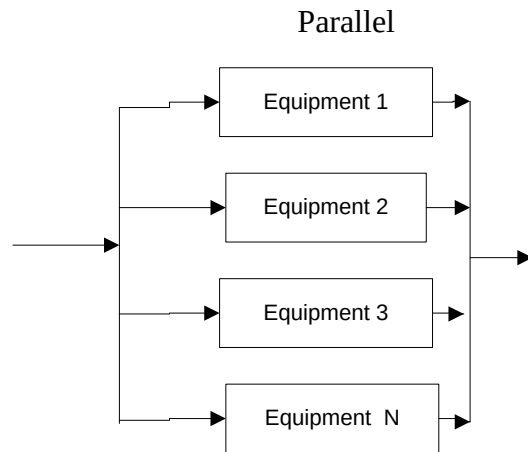


Figure 7:-parallel manufacturing system representation.

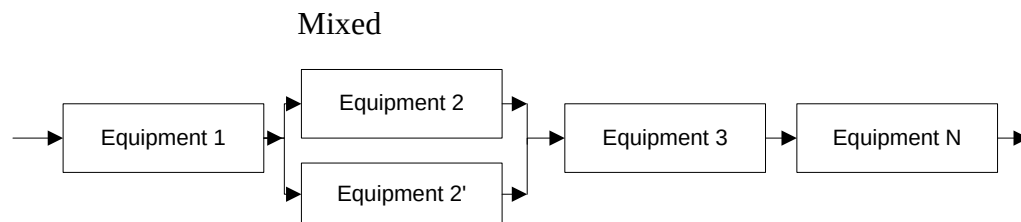


Figure 8:- mixed system manufacturing representation.

From the general representation manufacturing system models, the peacock shoe manufacturing system model drawn as follows. The Industry has three separated manufacturing section. And all products pass through each section to obtain its final product. In actual manufacturing systems, a line or manufacturing system arrangements just series or parallel systems, as there are also hybrid systems. The peacock shoe manufacturing machines configuration was hybrid system which the both cutting leather and insole machines are in series, stitching machines are in parallel, moccasin machines are in series and finally lasting machines are arranged in parallel.

General system representation

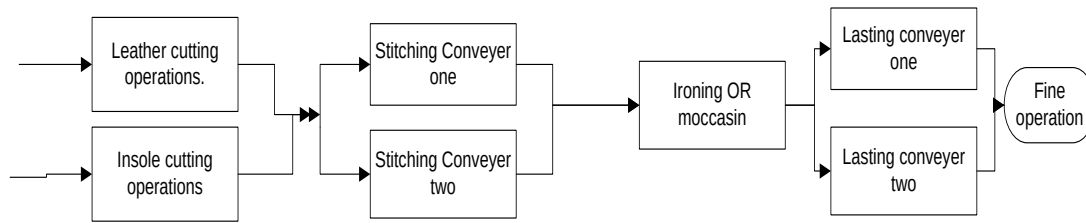


Figure 9:-The Throughout representation of system.

Cutting section

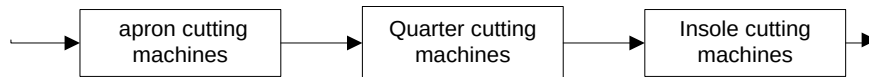


Figure 10:-cutting section

Stitching

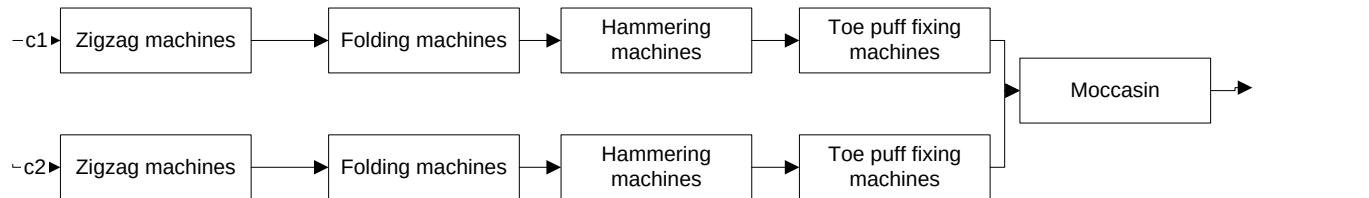


Figure 11:-stitching section

Lasting section

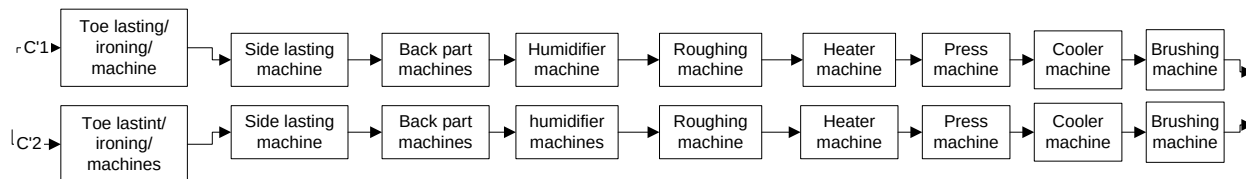


Figure 12:-lasting section

4.3 Data presentation and analysis

All source of the data regard on the manufacturing information which list below is acknowledged from the Peacock shoe manufacturing Industry. The recorded data from the manufacturing is a data uses for analyzing the overall equipment effectiveness (OEE) and the Overall throughout effectiveness (OTE) of the manufacturing system. For that, the daily, weekly and monthly production output as well qualified output and defected amount per week depend on the figure 9. And data on amount of losses in minute and breakdowns frequency is include all figures 10 up to 12.

The categorizing the manufacturing is based the main section and main operation with in the section. This way uses to increase the reality of output results and to minimizing complexity during analyzing and solving the problems. Depend on the above manufacturing system was presented in above; the necessary data are collected from the each of the manufacturing sections. The collected data was contains for ten (10) months of the 2012 EC which its span from September to June. And collecting this much data uses for identify the redundancy of factors affecting the OTE and metrics of manufacturing system and to know system fluctuation on the variation bottleneck among the system.

4.3.1 Monthly production capacity of sections

The monthly production capacity of the manufacturing in all section according the figure 9 classification is collected and below is the summarized from the daily output of the each listed and the daily output found on the appendix one from 1up to 40 weekly production data.

Table 3:- Total monthly production.

DIRE INDUSTRIES PLC. PEACOCK SHOE FACTORY												
WEEKLY PRODUCTION REPORT OF ALL DIPARTMENTS												
DEPT	Month	WEEKLY PRODUCTION										TOTAL
		Septem	Oct	Novem	Decem	Fabr	Janury	March	April	May	June	
CUTTING	LINE	Target	18960	14195	19129	19877	19057	19043	18281	20755	24658	189957
		Actual	11974	6776	11711	13029	14103	14887	14437	17786	17484	131772
		D/ce	7077	9069	11218	10648	7804	7006	3844	3919	7174	6417
STITCHING	C1	Target	10815	6880	10000	10400	9600	8487	6516	8116	11065	93093
		Actual	5405	3178	7248	6426	5564	7984	4243	4890	9400	60700
		D/ce	5040	3702	2752	3974	4036	503	2273	3226	1665	4852
	C2	Target	9754	7039	10100	10525	9675	9700	8100	9700	11720	101207
		Actual	4444	3690	6433	7714	10788	7077	7043	9507	9768	6310
		D/ce	5310	3349	3667	2811	-1113	2623	1057	193	1952	8584
LASTING	C1	Target	9580	7766	11100	7200	6600	6450	5550	7200	12510	14900
		Actual	6454	3970	5139	7718	8899	8156	4663	6536	11066	11832
		D/ce	2820	3796	5961	-518	-2123	-1235	803	-54	1609	3038
	C2	Target	9639	6525	8700	7200	6600	6450	5550	6600	9578	8623
		Actual	5400	2448	5865	5332	5667	7148	5724	9342	9156	6268
		D/ce	3900	4077	2835	1868	933	-698	-174	-2742	422	2355
MOCASSIN		Target	5800	4750	6250	6500	6000	6000	5000	6000	6456	6780
		Actual	3470	3702	4003	5384	3928	4,056	5384	5789	6000	5973
		D/ce	2330	1048	2247	1116	2072	1944	-384	211	456	807
INSOLE		Target	25827	20400	30000	31200	28800	28800	24000	28800	28250	26400
		Actual	10486	2183	4176	12035	12399	17340	10849	14574	28250	16517
		D/ce	13939	18217	25824	19165	16401	11460	13151	14226	28250	9883

Source: monthly target and actual from the organization from production planning department performance report.

All are organized from Appendix ONE; table 1 upto 40

The above data is combined from the sum up of the weekly production report. Except the Sunday and holy days the left days are working days. From the above data some difference values are negative, when the actual output is greater than the target values. And it indicates the equipment and conveyors are running above their target output capacity; however these not indicate the machine and conveyors are running above the designed capacity. From the above table the percentage of actual output from the targeted output is 63.52%, which including the defected products.

4.3.2 Total defective in amount in each month

The data of quality rejected shoes at the lasting section were listed below table's show the defected numbers of shoes within the 37 weeks of production duration and the defect characteristics classified in to total rejected and B-grade. The quality control mechanism of peacock shoe manufacturing industry is a quality checking of each piece of shoes at the end processing on the lasting machine.

Table 4:-A total number of rejected piece of shoes in months.

conveyors	Months	1	2	3	4	5	6	7	8	9	10
	C1	128	137	217	270	265	274	414	376	703	467
	C2	170	262	210	238	200	173	270	226	369	221
	Total Rejected	298	399	427	508	465	447	684	602	1072	697

Source: -summarized from appendix three- A; which is weekly department report of rejected from lasting section

And the defected percentages during the 10 (ten) months production durations was 1.3235% out of the total production. This is very large number. And it is percentagewise excluding about the entire production quality problems. The above table shows the total amount of shoes rejected in the ten (10) months production duration of 2012EC. And it is identified by the attribute quality checking of each piece. As possible to understand from the above the amount of rejected pieces on each conveyor is differ from on to another. And each conveyor is operating parallel and independently.

Table 5:-B-grade pieces of shoes

Conveyors	months	1	2	3	4	5	6	7	8	9	10
	C1	259	1	21	53	52	117	133	128	124	53
	C2	114	21	110	38	91	107	58	89	150	0
	Total B.grade	373	22	131	91	143	224	191	217	274	53

Source: - summarized from appendix A; weekly department report on B-grade quality from lasting section.

Generally the percentage magnitudes of the defected shoes during the 10th month of production were depending on the quality controlling mechanism result and by that both rejected and B-grade were quality failed.

Table 6:- percentage magnitude of defected per months

Months	1	2	3	4	5	6	7	8	9	10
Total defected	671	421	558	599	608	771	875	819	1346	750
Total produced	9365	13055	13023	14877	6031	13650	19989	14039	13457	12346
percent of defected	7.2%	3.2%	4.3%	4.0%	10.1%	5.6%	4.4%	5.8%	10.0%	6.1%

Source:-from production and quality control department

4.3.3 Time losses

In this a manufacturing, losses are the first categories of the obstacle of the profitability and among the losses, the time losses and its categories are listed in the table below, which is summarized from the appendix four.

Table 7:-The summary of Identified time losses.

	Manufacturing sections The unit of loss in minute(s)							
Losses categories	lasting		stitching					Total
	c1	c2	c1	c2	Cuttin g	Insole cutting	Moccasi n and ironing	
Machine breakdown	503	280	555	100	337	265	289	2329
Power problem	3090	470	60	20	34	49	63	3789
Bottleneck	0	0	133	80	0	0	0	213
Material shortage	470	260	540	440	0	0	0	1710
Change line	0	0	155	115	0	0	0	270
Total sum in each section of time loss in minute	4063	1010	1443	755	371	314	352	

Source: compiled from weekly report of the time losses from maintenance and production control department.

4.3.4 Overall Equipment Effectiveness and it's Derivations

4.3.4.1 Design capacity of line and working time schedule

The performance level of the machine is determined based on the theoretical and design capacity with respect to the actual output of the system(s) and equipment(s). The theoretical outputs of the equipment(s) and system(s) are the output which zero loss and without considering any types of loss may be happen in the manufacturing but consider scheduled downtime.

The theoretical output of each equipment and lines are calculated based on the equation 12.

$$P_{a(ith)}^{(th)} = Rth(i) \times T_T$$

Depend on the above formula the theoretical output of the sectioned is as follow in the table seven (8).

Table 8: The design capacity of each separate stages pair day $\left(\text{machine capacity} / \text{day} \right)$

Operation	Cutting	Insole cutting	Stitching	Moccasin and ironing	Lasting
Design capacity/day	5000	1500	1800	1400	2000
Design capacity /hours	714.3	214.3	257.1	200	285.7

Source: From the company machine profiles.

The blow table is schedule on working hours of the organization.

Table 9: Daily information on time

Time breakdown	In hrs	In minute
Net working hours	8	480
Launch breaks	1	60
Working hours	7	420
Shift/s	1/ 24 hrs	

Source: from company, working hour(s).

Any manufacturing organization has guided rule and regulation on the working day(s). And the working day(s) are affected by different factors like holiday(s), peace and security of the country and the entire organization(s) problems. Below table is the summarized working day available in the month(s). In the mathematical analysis knowing the actual working day increases the acceptability of the result(s) because of using real data and it show the real measurements level of the organization performances.

Table 10: Available working day and working hours per month

Months	Available days/month	Working plan hours /month	Networking hours/month	Networking minute/month
1	20	160	140	8400
2	24	192	168	10080
3	25	200	175	10500
4	26	208	182	10920
5	24	192	168	10080
6	25	200	175	10500
7	20	160	140	8400
8	25	200	175	10500
9	26	208	182	10920
10	24	192	168	10080

Source: Summarized from the department daily working report and working time schedule.

4.4 Data presentation and analysis

4.4.1 The theoretical output analysis for each separated operational

The theoretical output of the stage is calculate based on the zero loss in stage and the result(s) are the products of the net working hours in the month(s) times the design capacity of the stage.

The blow table(s) is the theoretical output of the each stage is calculate by their individual design capacity without considering bottleneck(s) and any losses. The computation is depend on the below equation from equation 12.

$$\text{Theoretical output}(P_{a(ith)}^{(th)}) = Rth(i) \times T_T$$

Stage one

The theoretical output of cutting stage

$$P_{cutting}^{th} = Rth(\text{cutting}) \times T_T$$

Table 11: The theoretical values of cutting section of the each month(s)

Month(s)	Net working in hours/month	Design capacity /hour	Monthly theoretical output
1	140	714.3	100000
2	168	714.3	120000
3	175	714.3	125000
4	182	714.3	130000
5	168	714.3	120000
6	175	714.3	125000
7	140	714.3	100000
8	175	714.3	125000
9	182	714.3	130000
10	168	714.3	120000

Source: Calculated theoretical output, depend on the equation 12 with monthly available working day(s)

Stage two

The table below is the theoretical output of the insole cutting stage which is calculated according to the equation 12.

$$P_{\text{insole cutting}}^{\text{th}} = R_{\text{th}}(\text{insole cutting}) \times T_T$$

Table 12: The theoretical values of insole cutting section of the each month(s)

month(s)	Net working hours/month	Design capacity /hour	Monthly theoretical output
1	140	214.3	30000
2	168	214.3	36000
3	175	214.3	37500
4	182	214.3	39000
5	168	214.3	36000
6	175	214.3	37500
7	140	214.3	30000
8	175	214.3	37500
9	182	214.3	39000
10	168	214.3	36000

Source: Calculated theoretical output, depend on the equation12 and theoretical output of insole cutting leather machine, when zero losses.

Stage three

Table below is the theoretical output of the stitching section is and is calculated according to the equation 12

$$P_{\text{Stitching}}^{\text{th}} = R_{\text{th}}(\text{Stitching}) \times T_T$$

Table 13: The theoretical values of stitching section of the each month(s)

month(S)	Net working hours/month	Design capacity/hour	Monthly theoretical output
1	140	257.1	36000
2	168	257.1	43200
3	175	257.1	45000
4	182	257.1	46800
5	168	257.1	43200
6	175	257.1	45000
7	140	257.1	36000
8	175	257.1	45000
9	182	257.1	46800
10	168	257.1	43200

Source: Calculated theoretical output, depend on the equation 12 and theoretical output of stitching, when zero losses.

Stage four

Table below show the theoretical output of the moccasin stage and it is calculated according to the equation 12.

$$P_{\text{moccasin and ironing}}^{\text{th}} = R_{\text{th}}(\text{moccasin and ironing}) \times T_T$$

Table 14: The theoretical values of moccasin and ironing of the each month(s)

Month(s)	Net working hour/month	Design capacity/hour	Monthly theoretical output
1	140	200	28000
2	168	200	33600
3	175	200	35000
4	182	200	36400
5	168	200	33600
6	175	200	35000
7	140	200	28000
8	175	200	35000

9	182	200	36400
10	168	200	33600

Source: Is a calculated theoretical output, depend on the equation12 and the theoretical output of moccasin and ironing, when zero losses.

Stage five:-Table below show the theoretical output of the lasting section and it calculated according to the equation 12.

$$P_{\text{Lasting}}^{\text{th}} = R^{\text{th}}(\text{Lasting}) \times T_T$$

Table 15: The theoretical values of lasting operations of the each month(s)

month(s)	Net working hours/month	Design capacity / hour	Monthly theoretical output
1	140	285.7	40000
2	168	285.7	48000
3	175	285.7	50000
4	182	285.7	52000
5	168	285.7	48000
6	175	285.7	50000
7	140	285.7	40000
8	175	285.7	50000
9	182	285.7	52000
10	168	285.7	48000

Source: Is a calculated theoretical output, depend on the equation12 and the theoretical output of the lasting operations, when zero losses.

The above tables from 11 up to 15 shows the design capacity of each identified individual stages of; cutting operation, insole cutting, moccasin and ironing, stitching and lasting by individual design capacity. However from the flow production principle not only actual output, the actual theoretical output, $P_{a(F)}^{\text{th}}$, of the entire system is calculate depend on the derived equation 13. And this leads system theoretical output to the individual theoretical output; which is bottleneck for the system. Therefore theoretical output of the each equipment and line are determined by the equipment with the lowest theoretical output in the line production system and According to the (table 8) the minimum design capacity pair day among is 200 piece pair hour which is moccasin and ironing operation. And it taken as the bottleneck for the rest and determine the theoretical entire system output of all sections.

$$P_{a(F)}^{\text{th}} = \min_{1,2,3,\dots,n} (R^{\text{th}(i)}) \times T_T$$

4.4.2 Analysis of Overall equipment effectiveness

Overall equipment effectiveness is a both measurement and improvements indicators tool in manufacturing organization and these two major objectives are the critical to show the level of performance and the factors affect the organization in the priority ways. The reason of analyzing of OEE of each equipment's is the OEE of the each equipment(s) are the milestone and stepwise for measuring and analyzing the entire system OTE. According the (Fei He et al., 2018) it is As a well-known measurement method, OEE can fully reflect the equipment condition in the production site, and it is widely used in the manufacturing industry to analyze equipment(s) effectiveness for the improvement remedy. To analysis the OEE of the peacock shoe manufacturing industry; the equipment(s) are classified in to the different seven main sections which are based on the input output.

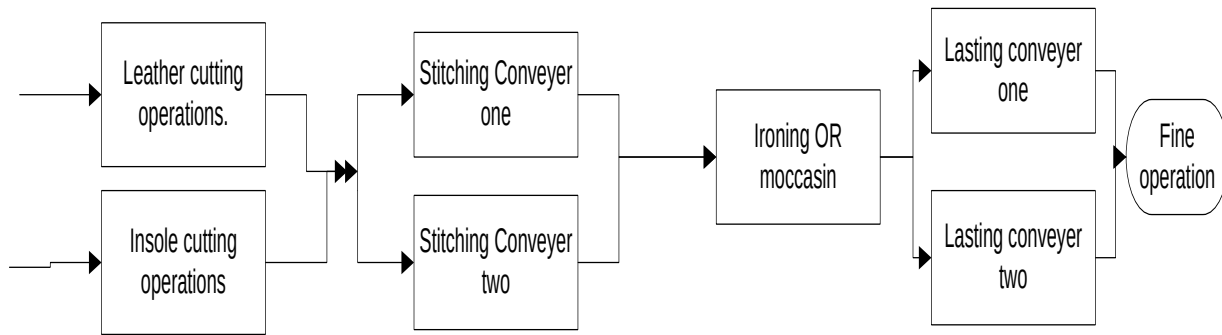


Figure 13:-The seven main operations stage of the peacock shoe manufacturing industry

The Overall equipment effectiveness (OEE) of the peacock shoe manufacturing industry is computed according to the classified section above and the data uses for the analysis are depend on the bottleneck design capacity among the above table 14 classification and it is ironing and moccasin has minimum design capacity, Available networking time schedule from table 10, actual monthly produced from table 2 and include loss like breakdown(s) and power off from the table 6 according to the necessity of data.

$$Availability (A) = \frac{TU}{TT} = \frac{TT - Td}{TT} \quad \text{From equation 6}$$

$$performance(P) = \frac{Pa}{R_{th}TU} = \frac{TPR_{act}}{TUR_{th}} \quad \text{From equation 7}$$

$$Quality (Q) = \frac{Pg}{Pa} = \frac{Pa - PU}{Pa} \quad \text{From equation 8 and}$$

$$Overall\ equipment\ effectiveness\ (OEE) = A * P * Q$$

The quality control mechanism is different from the organization to the organization and this is based on the impact of the quality characteristics on the acceptance of the final products by the customers.

When the manufacturing system is continues system it is interested when the quality control is in the sequence way. In Peacock Shoes manufacturing Industry the quality control mechanism is checking the final products after the final operation(s) each.

However from the manufacturing system this way of quality control mechanism is not allowed. Each step of the separated operation stage(s) has their own quality characteristics. Each of metrics is computed accordingly depend on the upstream effect on the lasting stage quality. To understand the trends of the OEE and its metrics the ten (10) months are considered. And use the output; $P_{a(F)=\min_{1,2,3...n}}^{th} (R^{th(i)} \times T_T)$; in manufacturing when capacity adjusting is formed, the bottleneck machines control none bottleneck machine(s).

And this kind of adjusting machine capacity is useful for the organization to minimize buffering, raw material planning and inventory control and protect from capital punishments and tied up of products

Leather Cutting equipment

1st month

Availability rate (A)

$$A^{cutting} = \frac{8400 \text{ minutes} - 146 \text{ minutes}}{8400 \text{ minutes}} = 98.20\%$$

Performance rate (P)

$$P^{cutting} = \frac{11974 \text{ pcs}}{138.3166 \text{ hr} \times 200 \text{ pcs/hr}} = 43.28\%$$

$$Q^{cutting} = \frac{pa \text{ pcs} - pu \text{ pcs}}{pa \text{ pcs}}$$

$$Q^{lasting c1} = \frac{1197 \text{ pcs} - 47 \text{ pcs}}{1197} = 96\%$$

Overall Equipment Effectiveness (OEE)

$$A^{cutting} \text{ rate} * P^{cutting} \text{ rate} * Q^{cutting} \text{ rate}$$

$$OEE^{cutting} = 98.80\% * 43.28\% * 96\%$$

$$OEE^{cutting} = 40.8\%$$

By follow the above way(s) of computation the rest nine (9) months OEE and its metrics values are in the below table.

Table 16 The OEE values of the cutting stage.

	DIRE INDUSTRIES PLC.									
	PEACOCK SHOE FACTORY									
Stage	month	Oct	Novem	Decem	Feb	Jan	March	April	May	June
Cutting	A	98.2%	97.9%	87.8%	98.8%	97.3%	87.86%	94.8%	94.9%	97%
	P	43.2%	33.53%	35.79%	42.04%	42.53%	51.64%	50.95%	48.26%	28.67%
	Q	96%	99.2%	99.1%	92%	99.6%	99.5%	99.6%	99%	98.7%
	OEE	40.7%	32.5%	31.14%	38.6%	41.2%	44.7%	47.9%	45.3%	27.3%

Source:-calculated from the Cutting stage data.

Insole cutting operation

1st month

Availability rate

$$A^{ins-cutting} = \frac{8400 \text{ minutes} - 109 \text{ minutes}}{8400 \text{ minutes}} = 98.7023\%$$

Performance rate

$$p^{ins-cutting} = \frac{10486 \text{ pcs}}{138.1833 \text{ hr} \times 200 \text{ pcs/hr}} = 37.9423\%$$

Quality rate

$$Q^{ins-cutting} = \frac{10486 \text{ pcs} - 33 \text{ pcs}}{10486 \text{ pcs}} = 99.6\%$$

Overall Equipment Effectiveness (OEE)

$$OEE^{ins-cutting} = A^{ins-cutting} \text{ rate} * P^{ins-cutting} \text{ rate} * Q^{ins-cutting} \text{ rate}$$

$$OEE^{ins-cutting} = 98.7023\% * 37.9423\% * 99.6\%$$

$$OEE^{ins-cutting} = 37.2\%$$

By follow the above way(s) of computation the rest nine (9) months insole cutting OEE and its metrics values are in the below table.

Table 17: The nine months OEE and its metrics of the Insole cutting stage

DIRE INDUSTRIES PLC.										
PEACOCK SHOE FACTORY										
Op/nt two	months	Oct	Novemb	Decem	Febr	January	March	April	May	June
Insole cutting	A	91.7%	86%	89.9%	98%	87%	98.1%	96%	87.7%	92.8%
	P	47.53%	44.24%	33.21%	34.52%	49.71%	49.53%	41.75%	77.61%	49.38%
	Q	99.6%	96.7%	98.7%	99.3%	99.4%	92.5%	98.8%	97.4%	98.9%
	OEE	47.31%	36.8%	29.4%	33.6%	43%	44.9%	39.6%	66.2%	45.3%

Source: - calculated from the insole cutting data

Stitching operation(s)

The stitching operation(s) the of Peacock shoes manufacturing Industry has an independent two main conveyers.

And both conveyer(s) has the same design capacity; however both contain different individual output from the data. And most of the factors affect them are different. These factors and output data imply both conveyers OEE and its metric are differ from conveyor to conveyor.

Conveyor one (C1)

1st month

Availability rate

$$A^{StitchingC1} = \frac{8400 \text{ minutes} - 135 \text{ minutes}}{8400 \text{ minutes}} = 98.392\%$$

Performance rate

$$P^{StitchingC1} = \frac{5405 \text{ pcs}}{137.75 \text{ hr} \times 200 \text{ pcs/hr}} = 19.6188\%$$

$$\text{Quality rate of stitching} = \frac{5405 - 73 \text{ pcs}}{5405 \text{ pcs}} = 98.6 \%$$

Overall Equipment Effectiveness (OEE)

$$OEE^{stitchingc1} = A^{stitchingc1} rate * P^{stitchingc1} rate * Q^{stitchingc1} rate$$

$$OEE^{stitchingc1} = 19.301\%$$

Conveyor two (C2)

1st month

Availability rate

$$A^{Stitchingc2} = \frac{8400 \text{ minutes} - 25 \text{ minutes}}{8400 \text{ minutes}} = 99.70\%$$

Performance rate

$$P^{Stitchingc2} = \frac{4444 \text{ pcs}}{139.583 \text{ hr} \times 200 \text{ pcs/hr}} = 15.918\%$$

$$OEE^{stitchingc1} = A^{stitchingc2} rate * P^{stitchingc2} rate * Q^{stitchingc2} rate$$

$$OEE^{stitchingc2} = 15.869\%$$

The above one month OEE and its metrics realized the values of each conveyor are different from each other. For the left nine (9) months; the OEE and its metrics are computed by using the data based on each actual output and loss categories. By follow the above way(s) of computation the rest nine (9) months stitching operation OEE and its metrics values are in the below table.

Table 18: The two conveyors OEE and its metrics for nine months of stitching operation

DIRE INDUSTRIES PLC.											
PEACOCK SHOE FACTORY											
operatio	lin	mont	Oct	Nove	Dece	Febr	Januar	March	April	May	June
Stitchin g	C1	A	93%	84.1%	88.9%	98.9%	98.6%	98.4%	95.8%	98.5%	96.8%
		P	20.5%	20.7%	17.7%	21%	23%	15.2%	14%	26%	19.6%
		Q	98.6%	97.8%	97.9%	99.3%	98.3%	96.4%	98.7%	97.7%	98.6%
		OEE	18.8%	20.7%	15.4%	20.6%	22.2%	14.4%	13.2%	25%	18.7%
	C2	A	98.5%	89%	90%	97.9%	98.9%	98.5%	94.7%	93.2%	99.7%
		P	11.0%	18.4%	21.3%	32.2%	20.2%	25.2%	27.2%	26.8%	18.8%
		Q	98.6%	97.8%	97.9%	99.3%	98.3%	96.4%	98.7%	97.7%	98.6%
		OEE	10.6%	16.2%	18.8%	31.3%	19.7%	23.9%	25.4%	24.4%	17.7%

Source: Computed from each and individual data of stitching operation.

Moccasin and ironing stage operation

1st month

Availability rate

$$A^{moccasin} = \frac{8400 \text{ minutes} - 121 \text{ minutes}}{8400 \text{ minutes}} = 98.5\%$$

Performance rate

$$p^{moccasin} = \frac{5160 \text{ pcs}}{140 \text{ hr} \times 200 \text{ pcs/hr}} = 18.42\%$$

Quality rate

$$Q^{moccasin} = 5160 - 56/5160 = 98.9\%$$

Overall Equipment Effectiveness (OEE)

$$OEE^{moccasin} = A^{moccasin} \text{ rate} * P^{moccasin} \text{ rate} * Q^{moccasin} \text{ rate}$$

$$OEE^{moccasin} = 17.9\%$$

The left nine (9) months OEE and its metrics are in the below table; the computation of according to the 1st month computation.

Table 19: Moccasin and ironing OEE and its metrics values

DIRE INDUSTRIES PLC.										
PEACOCK SHOE FACTORY										
Operation	month	Oct	Novem	Decem	Febr	January	March	April	May	June
Moccasin and ironing	OTE	16.1%	15.4%	15%	21.2%	16.8%	17.3%	27.4%	24%	23.9%
	A	89.7%	94%	88.1%	97.3%	98.4%	99.55%	95.7%	98.6%	97.8%
	P	18.4%	16.59%	17.27%	22.19%	17.55%	17.48%	28.97%	24.81%	24.90%
	Q	97.6%	99.2%	98.6%	98.2%	97.5%	99.6%	98.8%	98.4%	98.5%

Source: calculated from the moccasin data for OEE and its metrics.

Lasting operation

The same as stitching section, the lasting section of Peacock shoes manufacturing Industry has an independent two main conveyers.

And both conveyer(s) has the same design capacity and individual output from the data. And most of the factors affect them are different. These factors and output data imply the both conveyers OEE and its metric are differ from conveyor to conveyor.

1st month

Conveyor one (C1)

Availability rate

$$A^{lasting\ c1} = \frac{8400\text{minutes} - 420\ \text{minutes}}{8400\ \text{minutes}} = 95\%$$

Performance rate

$$p^{lasting\ c1} = \frac{6454\ pcs}{133\text{hr} \times 200\ pcs/\text{hr}} = 24.26\%$$

Quality rate

As maintained before the quality control mechanism of the peacock shoe Industry is not from operation(s) to operation(s) and not from stage to stage. It is the quality control mechanism was controlled at last operation; the above quality determinations were retrieved from the downstream and upstream effect characteristics of quality. And this mechanism is after all lasting operations are finished and before packed. The quality controlling mechanism is none sample way and it is whole piece checking.

$$Q^{lasting\ c1} = \frac{pa\ pcs - pu\ pcs}{pa\ pcs}$$

$$Q^{lasting\ c1} = \frac{6454\ pcs - 387\ pcs}{6454\ pcs} = 94\%$$

Overall Equipment Effectiveness (OEE)

$$OEE^{lasting\ c1} = A^{lasting\ c1}\ rate * p^{lasting\ c1}\ rate * Q^{lasting\ c1}\ rate$$

$$OEE^{lasting\ c1} = 21.665\%$$

Conveyor two (C2)

1st month

Availability rate

$$A^{lasting\ c2} = \frac{8400\ \text{minutes} - 130\ \text{minutes}}{8400\ \text{minutes}} = 98.45\%$$

Performance rate

$$p^{lasting\ c2} = \frac{5400\ pcs}{137.833\text{hr} \times 200\ pcs/\text{hr}} = 19.58\%$$

Quality rate

$$Q^{lasting\ c2} = \frac{5400\ pcs - 284\ pcs}{5400\ pcs} = 94.74\ \%$$

Overall Equipment Effectiveness (OEE)

$$OEE^{lasting\ c2} = A^{lasting\ c2}\ rate * P^{lasting\ c2}\ rate * Q^{lasting\ c2}\ rate$$

$$OEE^{lasting\ c2} = 18.26\%$$

The rest nine (9) months OEE and its metrics are computed the same with the 1st month values and the values for nine months in the below table

Table 20: The OEE and its metrics values of the lasting operation

DIRE INDUSTRIES PLC.											
PEACOCK SHOE FACTORY											
	line	month	Oct	Novem	Decem	Febr	January	March	April	May	June
lasting	C1	A	85.52%	88.48%	98.04%	99.93%	98.73%	99.46%	98.33%	99.86%	99%
		P	13.66%	16.60%	21.62%	26.51%	23.60%	16.74%	18.99%	30.44%	35.24%
		Q	96.52%	95.37%	95.81%	96.43%	95.20%	88.82%	92.28%	92.52%	95.52%
		OEE	11.40%	14%	20.30%	25.54%	22.18%	14.79%	17.23%	28.12%	33.33%
	C2	A	98.5%	98.04%	98.73%	89.7%	99.36%	89.8%	92.5%	98.4%	97.27%
		P	7.28%	17.09%	14.84%	16.88%	20.55%	20.44%	26.69%	25.15%	19.37%
		Q	88.43%	94.54%	94.82%	94.86%	96.00%	94.26%	96.62%	94.33%	96.44%
		OEE	6.43%	15.84%	13.88%	15.99%	19.60%	19.26%	25.79%	23.72%	17.99%

Source: computed from the gathered data for OEE and its metrics.

The above analysis of the first month and including the table from table 16 up to 20 are the OEE and its metrics of the each equipment's and line of Peacock Shoes manufacturing industry. As possible to understand from the computation of OEE, the OEE and its metrics value of the each equipment and lines in the same month was different from each other; and also for the individual equipment and line, the OEE and its metrics values are differ from month to month. This show, with in the same month each of the operation(s) with in stage was affected by different factors and the individual operation are also affected by different factors at the different month(s); there is up and down stream effect.

4.4.3 Analysis of the entire Overall Throughout Effectiveness

When the manufacturing is a system continues flow shop and the output of the equipment(s) and lines are in put for the next equipment, to obtain the final products in a manufacturing it is impossible to determine the entire Overall Throughout Effectiveness (OTE) and the metrics by individual operation(s) stage of OEE and its metrics; this is due to the bottleneck of the design capacity and each stage of operation(s) are affected by different factors. The maximum entire system output is determined by the minimum individual equipment(s). From the individual values of OEE and its metrics as well as according to the derived equations to analysis the OTE of the entire system, the systems were as the follow of figure below.

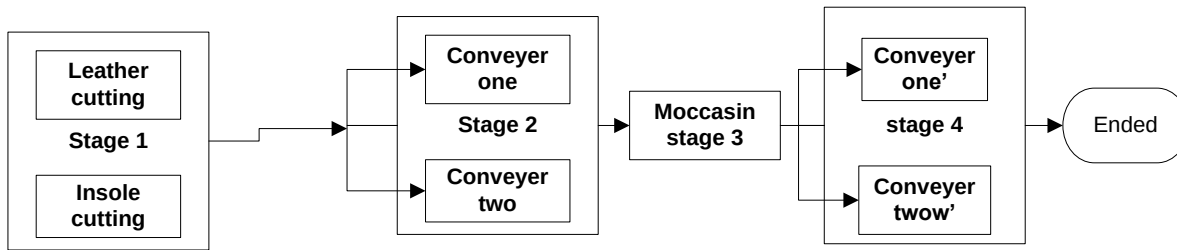


Figure 14: Each Entire system of Peacock Shoe manufacturing industry

Depend on the derived equation (18) the OTE of the entire system is computed from the individual values of OEE and its metrics.

From the above figure 15, the system configuration: - stage one, two and four are connected in parallel and stage three is individual operation in the system.

$$OTE^{parallel} = \frac{\sum_{i=1}^n (OEE(i) \times Rth(min))}{\sum_{i=1}^n (Rth(min))}$$

The OTE of the each stage of the entire system

Stage one

Stage one contains both leather cutting and insole cutting operations and is connected in parallel way. In the parallel system the OTE of the entire system is computed according to the above equation. The $R^{th}_{(i)}$ is the minimum values from all R^{th} which is the actual theoretical output factors and it uses to minimize the buffer. And use data from table (8).

OTE of the first stage and its metrics

1st month

$$\text{OTE of stage one} = \frac{\Sigma((0.4224 \times \frac{200 \text{ pcs}}{\text{hr}}) + (0.3745 \times \frac{200 \text{ pcs}}{\text{hr}}))}{\Sigma(\frac{200 \text{ pcs}}{\text{hr}} + \frac{200 \text{ pcs}}{\text{hr}})} = 39.845\%$$

The OTE metrics; A, P and Q of the entire of this stage is calculated based on the equations (21, 22 and 23) respectively.

$$A_i = \frac{\Sigma_{i=1}^2(0.988 \times 200 \frac{\text{pcs}}{\text{hr}}) + (0.987 \times 200 \frac{\text{pcs}}{\text{hr}})}{\Sigma_{i=1}^2 \frac{(200+200) \text{ pcs}}{\text{hr}}} = 98.79\%$$

$$P_i = \frac{\Sigma_{i=1}^2(0.4328 \times 200 \frac{\text{pcs}}{\text{hr}}) + (0.3794 \times 200 \frac{\text{pcs}}{\text{hr}})}{\Sigma_{i=1}^2 \frac{(200+200) \text{ pcs}}{\text{hr}}} = 40.61\%$$

$$Q_i = \frac{(\Sigma_{i=1}^2 Pa) - (\Sigma_{i=1}^2 Pu)}{\Sigma_{i=1}^2 pa}$$

$$Q_i = \frac{(\Sigma_{i=1}^2 (11974 + 10486)) - (\Sigma_{i=1}^2 (52 + 72))}{\Sigma_{i=1}^2 (11974 + 10486)} = 99.4\%,$$

By stepwise the following above ways, the entire OTE, A, P, and Q of the rest month of the first stage is present by the next table as follows.

Source: computed results of the entire OTE by the above formulas.

From the above table 35 reflects, the OTE of the entire system depend on the all metrics values and the monthly OTE and its metrics are independent to each other.

Table 21:- the entire OTE and its metrics of stitching (stage 1)

stage	month	Septem	Oct	Novem	Decem	Fabr	Janur	March	April	May	June
stage One											
	OTE	39.85 %	26.24 %	38.72 %	34.43 %	38.20 %	46.%	45%	46.23 %	62.82 %	38.84 %
	A	91.%	86%	89.%	98%	87%	98.%	96%	87.%	92.%	91.%
	P	40.61 %	33.95 %	38.89 %	34.50 %	38.28 %	37.12 %	45.20 %	46.35 %	62.94 %	39.%
	Q	97.%	97.%	98.%	95.%	95%	99.%	96%	99.%	93.%	98.%

Source: the computed values of entire OTE and its metrics (stage 1) by above formula(s).

Second stage OTE and its metrics

The second stage on the entire system is the stitching stage and is perform operations by connected in parallel and both conveyors are perform stitching operation; however are independently operated. And the output of the entire values are support each other.

$$\text{OTE entire of 2}^{\text{nd}} \text{ stage of 1}^{\text{st}} \text{ month} = \frac{\sum \left(\left(0.193 \times \frac{200 \text{ pcs}}{\text{hr}} \right) + \left(0.1587 \times \frac{200 \text{ pcs}}{\text{hr}} \right) \right)}{\sum \frac{(200 \text{ pcs} + 200 \text{ pcs})}{\text{hr}}} = 17.575\%$$

The OTE metrics; A, P and Q of the entire of 2nd stage is calculated as follow:-

1st month A, P and Q value(s)

$$A_i = \frac{\sum_{i=1}^2 \left(0.9839 \times 200 \frac{\text{pcs}}{\text{hr}} \right) + \left(0.997 \times 200 \frac{\text{pcs}}{\text{hr}} \right)}{\sum_{i=1}^2 \frac{(200+200) \text{ pcs}}{\text{hr}}} = 99.045\%$$

$$P_i = \frac{\sum_{i=1}^2 \left(0.1962 \times 200 \frac{\text{pcs}}{\text{hr}} \right) + \left(0.1592 \times 200 \frac{\text{pcs}}{\text{hr}} \right)}{\sum_{i=1}^2 \frac{(200+200) \text{ pcs}}{\text{hr}}} = 17.77 \%$$

$$Q_i = \frac{(\sum_{i=1}^2 Pa) - (\sum_{i=1}^2 Pu)}{\sum_{i=1}^2 pa}$$

$$Q_i = 98.6 \%$$

By stepwise the following above the entire OTE, A, P, and Q of the rest month of the stitching stage is present by the next table as follows.

Table 22: the entire OTE and its metrics of stitching (stage 2)

	month	Oct	Novem	Decem	Febr	Januar	March	April	May	June
Stage two	OTE	9.6%	18.5%	18.4%	25.8%	20.5%	19.15%	19.57%	25.3%	17.9%
	A	93%	84.1%	88.9%	98.9%	98.6%	98.4%	95.8%	98.5%	96.8%
	P	10.3%	19.46%	19.5%	26.9%	21.6%	20.15%	20.57%	26.4%	19.2%
	Q	98.6%	97.8%	97.9%	99.3%	98.3%	96.4%	98.7%	97.7%	98.6%

Source: the computed values of entire OTE and its metrics stage 2 by above formula(s).

The value of the OTE is highly pulled by minim values among the metrics; because the OTE entire is the product result.

The OTE and metrics of stage three

The 3rd stage OTE and A, P and Q value(s) of the entire

The operation at stage three is a single and individual. And it is series for the next operation stage. The OEE and its metrics value(s) for each month(s) are the value(s) of the entire system OTE and its metrics.

The 10th month's entire system OTE and metrics values are in the table below.

Table 23: the entire OTE and metrics values of moccasin and ironing operation of stage three

DIRE INDUSTRIES PLC.										
PEACOCK SHOE FACTORY										
Operation	month	Oct	Novem	Decem	Febr	January	March	April	May	June
Moccasin and ironing	OTE	16.1%	15.4%	15%	21.2%	16.8%	17.3%	27.4%	24%	23.9%
	A	89.7%	94%	88.1%	97.3%	98.4%	99.55%	95.7%	98.6%	97.8%
	P	18.4%	16.59%	17.27%	22.19%	17.55%	17.48%	28.97%	24.81%	24.90%
	Q	97.6%	99.2%	98.6%	98.2%	97.5%	99.6%	98.8%	98.4%	98.5%

Source: from a summarized OEE value and its metrics

The OTE and metrics of stage four.

The 4th stage of the entire system is the lasting stage and is perform operation by connected in parallel and both conveyors are perform lasting operation; however are independently operated. And the output of the entire values are support each other.

$$\text{OTE of stage 4}^{\text{th}} (\text{lasting section}) = \frac{\sum \left(\left(0.2167 \times \frac{200 \text{ pcs}}{\text{hr}} \right) + \left(0.1826 \times \frac{200 \text{ pcs}}{\text{hr}} \right) \right)}{\sum \left(\frac{200 \text{ pcs}}{\text{hr}} + \frac{200 \text{ pcs}}{\text{hr}} \right)} = 19.965\%$$

The OTE metrics; A, P and Q of the entire system

1st month A, P and Q value(s)

$$A_i = \frac{\sum_{i=1}^2 \left(0.95 \times 200 \frac{\text{pcs}}{\text{hr}} \right) + (0.9845 \times 200 \frac{\text{pcs}}{\text{hr}})}{\sum_{i=1}^2 \frac{(200+200) \text{ pcs}}{\text{hr}}} = 96.725\%$$

$$P_i = \frac{\sum_{i=1}^2 \left(0.2426 \times 200 \frac{\text{pcs}}{\text{hr}} \right) + (0.1958 \times 200 \frac{\text{pcs}}{\text{hr}})}{\sum_{i=1}^2 \frac{(200+200) \text{ pcs}}{\text{hr}}} = 21.92 \%$$

$$Q_i = \frac{(\sum_{i=1}^2 Pa) - (\sum_{i=1}^2 Pu)}{\sum_{i=1}^2 Pa}$$

$$Q_i = \frac{(\sum_{i=1}^2 (6454 + 5400)) - (\sum_{i=1}^2 (387 + 284))}{\sum_{i=1}^2 (6454 + 5400)} = 94.339 \%$$

By stepwise the following above the entire OTE, A, P, and Q of the rest nine months of the lasting operation stage is present by the next table as follows.

.Table 24: the OTE and metrics values of the lasting operation of the 4th stage entire system

DIRE INDUSTRIES PLC.										
PEACOCK SHOE FACTORY										
	Mont h	Oct	Novem	Decem	Febr	Januar y	March	April	May	June
Stage four	OTE	8.92%	14.92 %	17.09 %	20.77 %	20.89%	17.03 %	21.51 %	25.92 %	25.66 %
	A	92.76 %	93.26 %	98.39 %	99.92 %	99.05%	99.73 %	99.17 %	99.93 %	98.14 %
	P	10.47 %	16.85 %	18.23 %	21.70 %	22.08%	18.59 %	22.84 %	27.80 %	27.31 %
	Q	93.26 %	94.93 %	95.41 %	95.83 %	94.96%	91.58 %	94.84 %	93.34 %	95.86 %

Source: calculated from the OEE of lasting operation.

From the above table 24, the quality metrics value the entire system, the difference from other stage and this is occurred from the entire relationship of up and down stage in the of production system. And ways of quality checking has its individual impact.

Table 25: the summarized entire system OTE and metrics value

DIRE INDUSTRIES PLC.											
PEACOCK SHOE FACTORY											
stage	month	Septem	Oct	Novem	Decem	Febr	Januar y	March	April	May	June
stage one	OTE	39.85 %	26.24 %	38.72 %	34.43 %	38.20 %	46.04 %	45.15 %	46.23 %	62.82 %	38.84 %
	A	91.7%	86%	89.9%	98%	87%	98.%	96%	87.7%	92.%	91.%
	P	40.61 %	33.95 %	38.89 %	34.50 %	38.28 %	37.12 %	45.20 %	46.35 %	62.94 %	39.03 %
	Q	99.60 %	96.7%	98.7%	99.3%	92.4%	92.5%	98.80 %	97.40 %	98.9%	99.6%
Stage two	OTE	17.58 %	10.18 %	19.55 %	19.42 %	26.82 %	21.51 %	20.15 %	20.57 %	26.33 %	18.85 %
	A	93%	84.1%	88.9%	98.9%	98.6%	98.4%	95.8%	98.5%	96.8%	93%
	P	17.77 %	10.28 %	19.46 %	19.47 %	26.88 %	21.56 %	20.15 %	20.57 %	26.38 %	19.20 %
	Q	98.6%	97.%	97.9%	99.3%	98.%	96.%	98.7%	97.7%	98.%	98.%
Stag	OTE	18.41	16.50	17.15	22.17	17.52	16.50	28.83	24.80	24.71	26.66

e thre e		%	%	%	%	%	%	%	%	%	%
	A	89.7%	94%	88.1%	97.3%	98.4%	99.5%	95.7%	98.6%	97.8%	89.7%
	P	18.42 %	16.59 %	17.27 %	22.19 %	17.55 %	17.48 %	28.97 %	24.81 %	24.90 %	26.90 %
	Q	97.6%	99.2%	98.6%	98.2%	97.5%	99.6%	98.8%	98.4%	98.5%	97.6%
Stag e four	OTE	19.97 %	8.92%	14.92 %	17.09 %	20.77 %	20.89 %	17.03 %	21.51 %	25.92 %	25.66 %
	A	98.5%	98. %	98.7%	89.7%	99.3%	89.8%	92.5%	98.4%	97.2%	98.5%
	P	21.92 %	10.47 %	16.85 %	18.23 %	21.70 %	22.08 %	18.59 %	22.84 %	27.80 %	27.31 %
	Q	94.34 %	93.26 %	94.93 %	95.41 %	95.83 %	94.96 %	91.58 %	94.84 %	93.34 %	95.86 %

Source: combined all entire system OTE and metrics values.

4.4.3.1 Overall Throughout Effectiveness (OTE) of the whole manufacturing system.

Most of the manufacturing systems are contain integrated systems like series, parallel and mixed type. And the peacock shoe manufacturing industry is a mixed type of system i.e. parallel, parallel, series and parallel type of manufacturing system.

Whatever the system types it is possible to find the system Overall Throughout Effectiveness (OTE) based on the Overall Throughout Effectiveness of the entire (OET In) manufacturing system and depend on the classified stage of the operation system.

The computation of the OTE system is follow after all OTE of the entire systems are computed and are be uniformed system. So, to facilitate it; the manufacturing systems are classified in to the basic four stages; which is based on the manufacturing relation between the entire systems. For each entire system the OTE and the metrics are computed and are become series. After that the OTE of the system is easily computed as follows equation (19).

$$OTE^{(System)} = \frac{\min \left\{ \min_{i=1,2,...,n-1} \{ OTE(1) Rth(i) \prod_{j=i+1}^n Q_j \}, OTE(n) Rth(n) \right\}}{\min_{i=1,2,...,n} \{ Rth(i) \}}$$

The OTE and metrics of the system

1st month OTE and A, P, and Q system

$OTE^{(System)}$

$$= \frac{\min \left\{ \min_{i=1,2,...,n-1} \left\{ \left((.3985(1) * \frac{200pcs(3)}{hr} * .996) \right) \left((.1758(2) * \frac{200pcs(3)}{hr} * .986) \right) \left((.1841(3) * \frac{200pcs(3)}{hr} * .9434) \right) \right\}, (.1997(4) Rth200pcs(3)/hr) \right\}}{\min_{i=1,2,...,n} \{ 200pcs(3)hr \}}$$

$$OTE^{(System)} = \min\{(39.7\%, 17.33\%, 17.32\% \text{ and } 19.97\%)\}$$

The system OTE is the minimum value from the above.

$$OTE^{(System)} = 17.32\%$$

This value shows that the moccasin operation stage is the bottleneck of the overall system for the first month. Table (25) shows that stage 3 is the bottleneck due to low performance. However due to the downstream effects has impact on the final output and stage three became the bottleneck for the system in terms of the OTE system.

The system OTE Metris are according to the equation (24-26).

$$A^S = A_{bottleneck \text{ in the entire}}$$

$$A^S = 96.73\% \text{ From four}$$

$$P^S = P_{bottleneck \text{ in the entire}}$$

$$P^S = 17.77\% \text{ From stage two}$$

From the quality control mechanism of the peacock Shoe manufacturing, the quality metrics of the all entire system affected by upstream entire quality characteristics and the quality rate of the system is the quality rate of the entire downstream values. Therefore the quality metric values of the system in all months are the quality rate value of the entire system quality rate of the fourth stage.

$$Q^S = \frac{Pa(total) - \sum_{1-2}^2 Pu}{Pa(total)}$$

$$Q^S = \frac{(6454+5400)-(387+284) pcs}{(6454+5400) pcs} = 94.339\%$$

By follow the above procedure calculating of system OTE and determining system metrics, the rest nine months value of system OTE and metrics are in the table below.

Table 26: system OTE and its metrics values versus bottleneck stage

DIRE INDUSTRIES PLC.										
PEACOCK SHOE FACTORY										
Month	Septem	Oct	Novem	Decem	Febr	January	March	April	May	June
Metrics	(3 rd stg)	(4 th stg)	(4 th stg)	(4 th stg)	(3 rd stg)	(3 rd stg)	(4 th stg)	(2 nd)	(1 st stg)	(2 nd stg)
OTE^{syste}	17.32%.	8.92%	14.9%	17.9%	16.7%	15.6%	17.3%	20%	23.1%	18.8%
A^{system}	89.7%	92.7%	88.10%	89.70%	87%	89.80%	92.5%	87.7%	92.0%	98.1%
P^{system}	17.77%	10.3%	14.9%	18.2%	17.6%	16.5%	18.59%	20.5%	24.9%	19.2%
Q^{system}	94.34%	93.2%	94.9%	95.4%	96%	94.9%	91.6%	94.8%	93.3%	96%

Source: the calculated from the entire system OTE and it metrics values.

From the above analysis of the system OTE, the system bottlenecks are identified among the entire system. And as stated from equation 24 up to 26; when bottlenecks are identified from the entire system for the identified; the system performance metrics of availability rate (A) and performance rate (P) values are the bottleneck metrics of entire system among the stages. And the quality amount is identified after final operations; the quality rate is calculated carefully according to the equation 26. The system availability rate according to the system OTE metrics performance determination, the bottleneck where formed from 1st month up to 10th is in the following stages (4, 4, 4, 4, 2, 4, 3, 4, 3 and 4) are respectively and which is bottleneck for system availability.

The performance rate of month 1 up to 10th is from stages (2, 2, 4, 4, 3, 3, 4, 2, 3 and 2) are respectively. From the above system performance metrics (P system) bottleneck, there is no stage one founded. And by current performance level stage one is non-bottleneck at any month. However it does not mean that it is a good level with respect to the world class value.

4.5 Analysis losses in manufacturing

Analyzing losses in the manufacturing is uses to identify types of losses, categories, as well as to know the relationship between each loss and the propagation ways of losses in the system and it facilitate to determine the necessary measurement action needed of improvement. In addition uses of analyzing losses of the manufacturing are uses to, clustering it in to specific metrics losses and its streams effect. According to (Gholizadeh, 2019; He et al., 2018; M.H.M. Ahmed, 2020; Nailwal et al., 2019 and ROODA, 2015) and the existed losses in the manufacturing the following are classified availability losses:- breakdown and power off, performance losses :-

both sequencing and scheduling and speed loss are the hidden losses, speed loss and minor stoppages; third metrics is Quality: it is affected by defect and yield loss.

The sequencing and scheduling losses are known by preparing different opportunity of sequencing and scheduling by heuristic models. And the speed losses are losses which can be happen by minimizing the speed of machine from its normal operation capacity. However the shoe manufacturing output performance measured by pair of shoes pair person and the capacity utilization is depend on the operator(s) speed.

4.5.1 Availability losses

Availability is the ratio of operating time to the planned production time and availability loss is the time where the organization is not undertaken the processing of manufacturing at the time of net operating period(Ng, Enrique et.al,2020 and P.A.Perumal et.al, 2019). According to the equation 24 up to 26 the system OTE metrics is determined and it is based on the analyzed values of entire OTE from table (26) and from the bottleneck values the system; the availability of 10th months is fixed to the following (4, 4, 4, 4, 2, 4, 3, 4, 3 and 4) stages respectively. Among the factors affect availability of the machine(s) are; machine breakdown, power off and materials shortage are identified. And the Couse of downtime and part which is breakdown is specified in the table 7 and appendix four with its frequency and happed factors respectively. The availability metric is the start up to determine the left two metrics. The availability directly concentrated on the loss of time by identifying the time at which the machine(s) are at down time during the net planed production time.

As possible to seen from the above table 7, there are five main time losses identified in industry. This above losses are which usually known and are unhidden. The time losses are different in amount from section to section. Comparison result of losses with each other, lasting section is cover 48.9%.The power problem loss is cover 45.57% to the rests. There are no time losses due to the lack of materials from the cutting section up to moccasin. However it is propagated of losses from the downstream and the buffer is formed during. Among the identified losses the speed and sequencing and scheduling losses are the hidden loss from the organization and can't to display; but known by the amount of performance metrics affected.

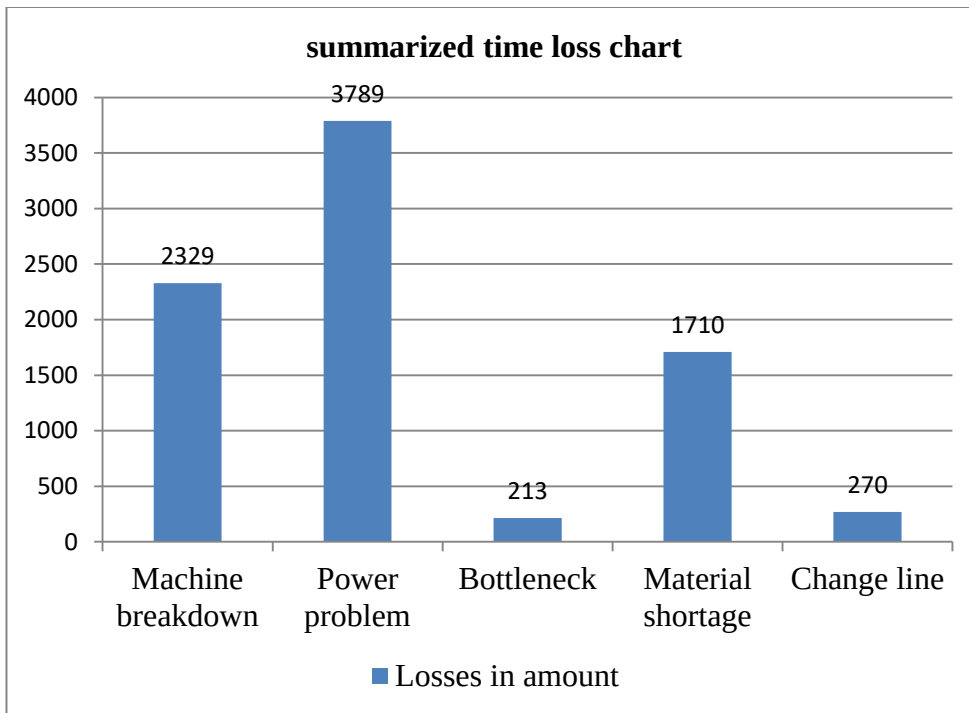


Figure 15: summary of the time loss chart

According to the summarized time losses in the (table 26) and also shown by (figure 17) by cause and effect diagram power problem time losses is cover the maximum in numbers. However time losses due to power off problems frequency is differ from section to section and within the sections also differ from conveyors to conveyors. As shown in the (table 7) among the sections, in the lasting section time loss due to power off is more frequented especially on the conveyor one (C1). And breakdown time loss is the next maximum figure. The breakdown occurrence is more frequented in lasting machines, but in terms of number of machine broken stitching machine are more and especially conveyor one (C1). The amount of time loss in each section with the conveyors is shown below by the pie chart (figure 16).

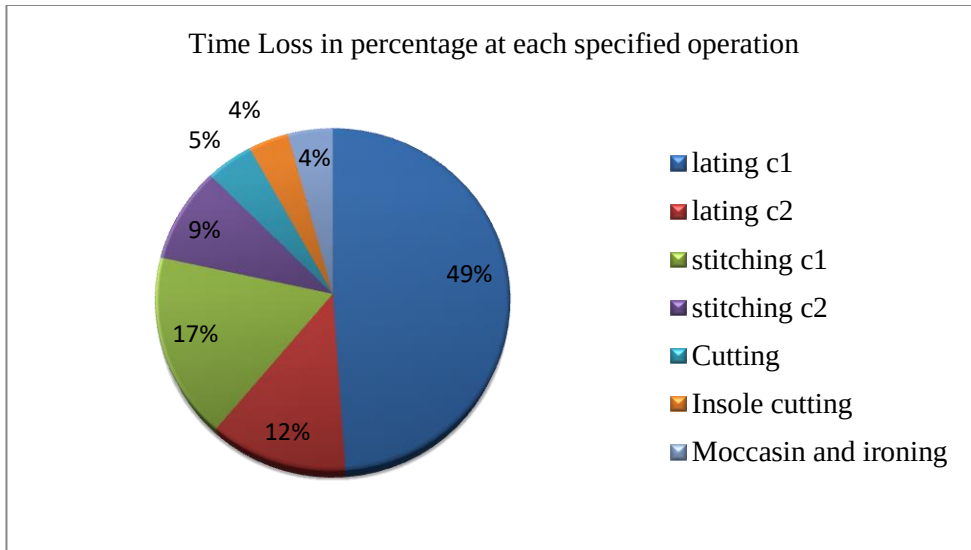


Figure 16:- the time loss percentage of each specified section and conveyors

4.5.1.1 Cause and effect diagram

The following C and E diagram figure 17 were drawn based on the table (7 and 28) as the following.

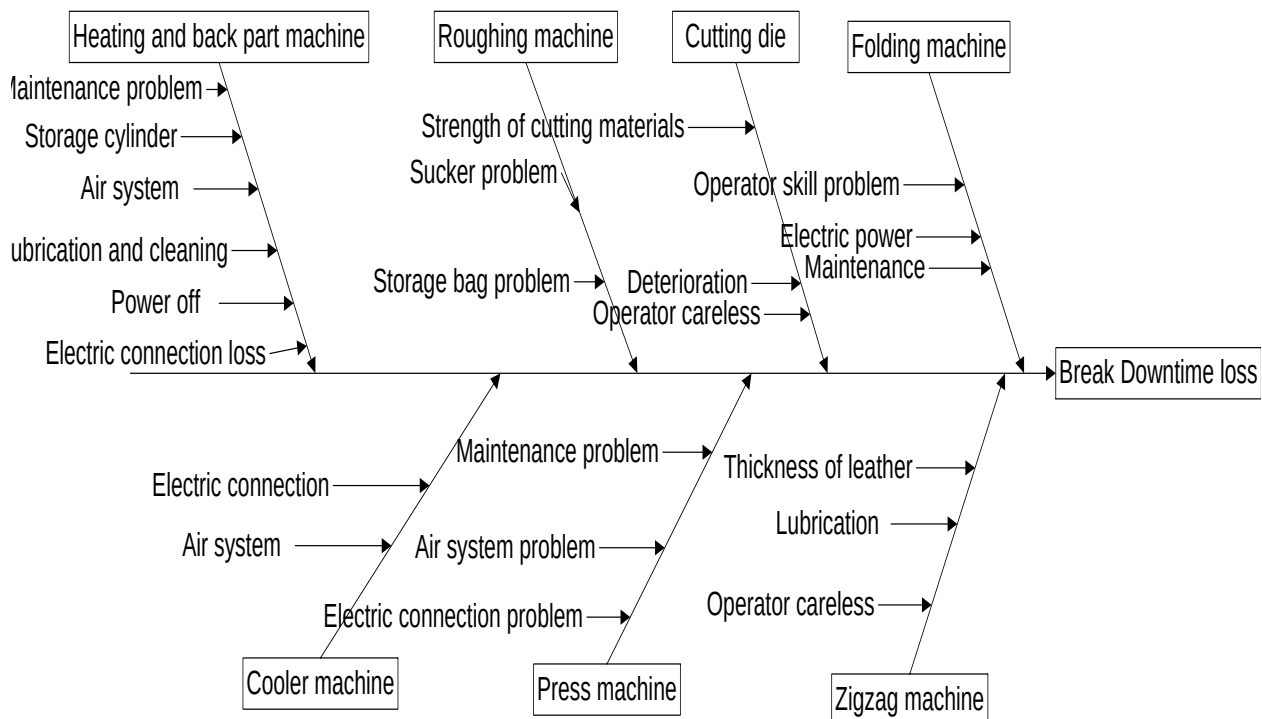


Figure 17: Break down time loss for availability analysis

On the Pareto diagram figure 19 there are lists of machine break down those cover 80% and by the fish bone diagram show that the reason of machine and parts break downs occurs are carefully specified.

As shown by the table 27 the most frequented breakdown machines are found in the lasting section. It shows the availability the availability of this section is the most affected from other sections and from the result of the system availability is mostly founded in the stage four which is lasting section. The availability results and factors affect are confirmed each other and this shows lasting section need the improvement for the improvement of system availability metrics. From the C and E results most of break down are reasons are similar which air pressure, electric connection loss and maintenance problems are the most and there is a propagation of losses due to the system is operating by pneumatic and each conveyors line are connected in series line. The power off downtime loss reasons are identified and most of the reasons are raised from the unconditioned are related with the breakdown time loss.

Table 27: loss categories and its frequency

		Sections					
		Lasting		Stitching			
		c1	c2	c1	c2		
Loss categories	Broken parts	Frequenc y		Frequency		Types of metrics	
BREACKDOWN	Freza machine breakdown	2				Availability loss	
	Zigzag machine breakdown			1			
	Back part machine breakdown	1		1			
	Press machine breakdown	5	2				
	SKL -18 machine breakdown			2			
	Folding 01 machine breakdown			4			
	Heating and lasting machine	9	1				
	For power off	3	1				
	Cutting die						
	Coller breakdown	1					
	Rive 12 kamsur machine			1			
	Heating and back part	2					
	Rev 02			1			
	GSP-06 M/C			1			
	Skiving machine break down						

	GDP machine breakdown				1	
Power off	power off	7	2	1	1	Availability loss
	Due to processing different type	4				
	No light	3		1		
	shoe loading	2				
	Electric connection loss on conveyer	1				
Bottleneck	Between M6&M7				1	Performance Loss
	Unspecified			2	1	
	on 5&6				1	
	on 25			1		
	On 15&On 16			1		
Material shortage	Material shortage(glue and insole)	1				Availability
	SILVER MAL- FUNCTION				1	
	Arranging	1	1	1	1	
	Glue material	1	1	1	1	
	Loading and unloading	1	1			
Production defect	In process damage Crack					Quality loss
	Scrap					
	Rework					
	In correct dimension due to wrong program					
	B- grade					

Source: From maintenance department.

The above table (27) shows the factors affect OEE metrics at different manufacturing section and the specific reasons of occurrences of losses, its frequency and the relationship between the happened losses and the OEE metrics. Table (7) indicates there is the time loss in figure at the cutting section which includes leather and insole cutting and moccasin operation; however there is no specified information in the (table 27) about it, because it merged from the downstream propagation to upstream but not all.

Among the losses which propagated are cutting die, back part machine and heating and back part breakdown and power due to no light, power off because of internal factors are the identified.

4.5.1.2 Downtimes analysis by Pareto chart

Among the identified losses down time loss is losses which affect the availability metrics and the specified under the availability losses are machine breakdown, power off and materials shortages are the downtime factors.

Among the three down time factors both machine breakdowns and power off time losses are required the critical solution through the analyzing prioritization, cause and effect for undertake possible remedy. For the Pareto analysis depend on the (table 29) of the identified breakdown parties and power off reasons as well as their frequency with respect to the loosed time which summarized from appendix four.

During the Pareto analysis vital few are identified. According to Pareto analysis, around 20% of the downtime factors causes 80% of total downtime. A Pareto chart was drawn to identify the predominant downtimes that caused around 80% of total downtime. From the (table 27) the heating and lasting machine, heating and back part and coolers are the most frequently broken down.

Table 28: Broken machines and time loss in minutes

Broken Machine name	Time in minute	Cumulative	Cumulative percent
Heating and lasting machine	867	867	21.6%
Heating and back part	772	1639	40.8%
Back part machine breakdown	754	2393	59.6%
Cooler breakdown	567	2960	73.7%
Folding 01 breakdown and stretch	171	3131	77.9%
Press machine breakdown	159	3290	81.9%
For power off	124	3414	85.0%
Cutting die	118	3532	87.9%
SKL -18 machine breakdown	87	3619	90.1%
Rev 02	67	3686	91.7%
Freza machine breakdown	64	3750	93.3%
Zigzag machine breakdown	63	3813	94.9%
Skiving machine break down	60	3873	96.4%
GDP machine breakdown	56	3929	97.8%
Rive 12 kamsur machine	52	3981	99.1%

GSP-06 M/C	37	4018	100.0%
sum	4018		
Categories of power off reason	Time in minute	Cumulative	Cumulative percent
No light	1433	1433	37.8%
power off	1247	2680	70.7%
Due to processing different type	513	3193	84.3%
Shoe loading	387	3580	94.5%
Electric connection loss on conveyers	209	3789	100.0%
Sum	3789		

From the above table the break down loss of lasting section due to break down of deferent machine is 4018 minute. And from the table 28 the time loss due to only machine breaks down in the lasting section is 783 minute. But the data in the table 28 is included machine stoppage due to the power off on the individual.

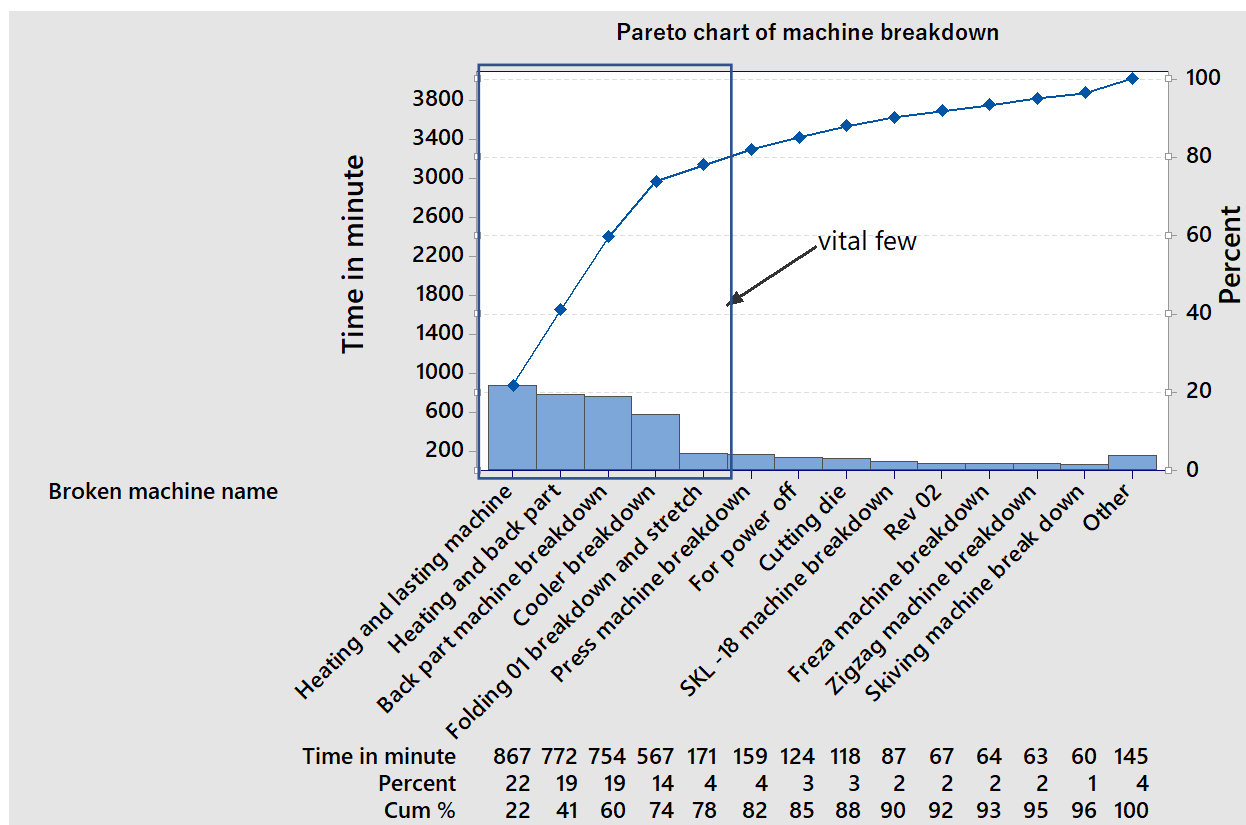


Figure 18: Breakdowns Pareto chart graph

Figure 19: Pareto chart of the power off on downtime

From breakdown downtimes losses; Heating and lasting machine, Heating breakdown, Back part machine breakdown, Cooler breakdown and Folding 01 machine breakdown, are the “vital few” and are the major broken machine parties, which cover 80%.

4.5.1.2.1 Development of autonomous maintenance (AM) frame work

The propose AM framework is designed by involving the office worker and managers according to their level of authority for creating the intentional motivation and to creating future hope in the heart of operators and production operators in the maintenance of their own equipment.

The framework focuses on three improvement areas: technical skills, attitude and working culture. Thus, this framework is developed as a part of skill-improvement program that provides step-by-step guidelines on how to train operators to maintain their own equipment. AM goal attain by illustrating the below proposed framework.

Table 29:-stage and procedure of AM frame work

Illustration stage	Procedures in the stage
Stage one :-initiation for preparation	AM team formation:- team division into sections Team rule and set activity Select line and equipment.
Stage two :- training and motivation	Creating interested, knowledgably, and technical skill full operator :-Recognizing Empower and change the employment, awarding, Training and lecturing on
Stage three:-execution	Implementing 5S principle through:-Initial cleaning, check quality of material, cleaning and lubrication t
Stage four :AM audits	Audit AM and follow the plan –do check -act (PDC) for the stage three

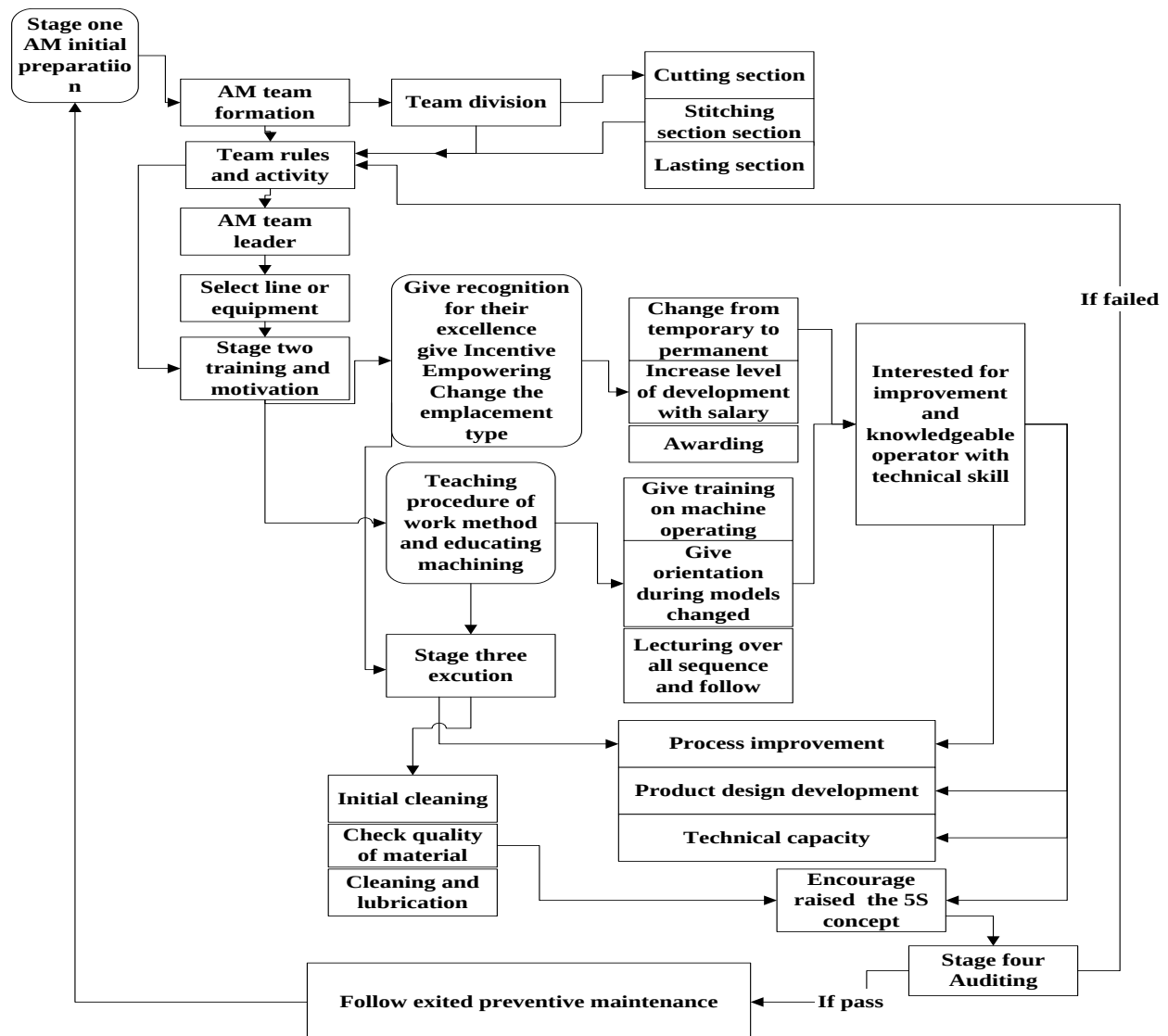


Figure 20:-AM frame work

4.5.1.2.2 Possible suggestion and Correction action for the down time loss

During the developing cause and effect diagram both figure (19 and 20) a lot of good information were be discovered and displayed using this tool through brain storming and observation. Observation and Brainstorming session has been carried out to find root causes and remedies have been identified. Based on these remedies identified, improvement action plan suggestion has been made to reduce the factors of the loss due to Equipment breakdown and powers off downtime loss are suggested and are shown in table.

Table 30: possible suggestion and correction action for both down time losses

S/ no	Power off time losses and Break down major problems.	Possible(reasons) root causes	Possible counter measurement.
1	Conveyers releases	✓ Operators' problems during loading shoes on the conveyors of lasting section, reworking of rejected different types of models of shoes. ✓ Lack of training for operators and assigned them to the operating machines ✓ Lack of attention during lading the shoe on the conveyors in the lasting section	Give training and follow the proper way of loading of each shoe models. As much as possible set quality characteristics at all section and eliminate the propagation of detect and control it first.
2	External factors	✓ Raining and line problems	It is external factors, but they can bought generators depend on it necessity to utilization of resource.
3	Power off	✓ Due to the carelessness of operators Broking of pipe of pneumatic air pump. ✓ Light problem's shortages	Cover the pipe line and away it from path of workers. For all machines of line separate the line for minimizing shortage of light and propagation downtime loss on the line.
4	Heating and back part machine	✓ Poor Maintenance and lack of timely checking machine depend on the change of	Having full information about the maintenance and follow up and well as apply autonomous

		machine sound and poor utilization of equipment i.e. without considering types of models and leather. ✓ Storage of cylinder fails which caused from malfunctioning. ✓ Discontinuity of Air system due to the power off and losses of electric connection ✓ Lack of Lubrication and cleaning ✓ Power off due to the operating problems and during processing different types of reworked shoes. ✓ Electric connection loss	maintenance. Give training. Incentive. Carefully loading and take adjustment as per as shoe model changed. Take the necessary quality control mechanism in all section and in all process by setting quality characteristics.
5	Press machine	✓ Maintenance problem and lubrication ✓ Air system problem ✓ Electric connection loss due to miss unlined	Timely cleaning and lubricating. Check, in particular after a model changed. . Check, in particular before starting type changed over, whether the correct preforms are used. Check and adjust the correct position and temperature.
6	Cooler machine	✓ Electric connection loss ✓ Air system discontinuity	Give training and cover the pneumatic line. Take possible improvement on the quality control mechanism and because the electric

			connection loss opportunity was occurred when reworking.
7		✓ Strength of Cutting material ✓ Deterioration ✓ Operator careless	Cleaning its tooth and lubricating. Follow the cutting procedure and correcting the cutting teeth when leather is changed. Check the quality of leather raw materials.
8	Folding machine	✓ Operator skill problem ✓ Electric power ✓ Cutting die Maintenance problem	Trained the operator. Give full skill on the operating before empower to operating for the new employees.
9	Zigzag machine	✓ Thickness leather ✓ Lack of Lubrication and cleaning problem ✓ Operator careless	Empowering operator. Follow the autonomous maintenance. Give incentive and other motivational award for the senior operators.

Source: From cause and effect analysis and brainstorming.

The above analysis's results show the Availability metric loss and the possible counter measurement, which is from cause and effect diagram and from table 28 most frequented down time problems are raised in the lasting section and each of them, are entire related to each other.

4.5.1.3 Performance metric loss analysis

Performance metrics is the second in magnitude for the OEE and OTE of the entire and system. Performance loss analysis use, the manufacturing or any sectors to show where they are; with respect to the predefined for indicate the area needed improvement.

In addition the performance loss analysis survive in today's rapidly changing environment, organizations must identify their existing positions, clarify their goals, and operate more effectively and efficiently(Tung et al., 2011).

And the measurement of the performance is one of the basic principles in the management and its measurement is very important because it identifies the gap between the actual, optimal and expected performance for facilitate needed improvement.

During the study the identified performance losses in the manufacturing are which clearly the organization also knew is bottleneck on the machine and materials shortage are performance losses. But by this research from the type of manufacturing the performance loss, which attract the researcher attention is sequencing and scheduling, speed losses and minor stoppages are consider as the major performance losses respectively. According to the system performance analysis result under the OTE entire, the system performance is laid in the following stage (2, 2, 4, 4, 3, 3, 4, 2, 3, and 2) for the previous ten (10) months. From the data of machine stoppage information on the appendix four, there a materials shortage in the 8th and 10th month in the stitching stage; due to that the second stage performance metrics become the performance of the system. And to solve this, the proper raw materials requirement planning is needed. As possible to see from the appendix four, almost there is no data and information which affects the performance metric of this stage.

The factors come from the speed loss and sequencing of operation and propagation of loss due to the break down indirectly.

4.5.1.4 Sequencing and scheduling loss analysis

The main essence of sequencing and scheduling is algorithms are to minimize the makespan in a flow shop ordered production(A. Gupta & Chauhan, 2015). To develop better make span for jobs, it is necessary to applying heuristics algorithms in the existing sequence of production flow and the best one selecting after the result of all heuristics are manipulated. These models are highly demanded by the market. The reason of computing sequencing and scheduling is to minimize the makes span (Cmax) and the total completion time (Tmax) to improving the performance metrics rate of the OTE.

Table 31: Shoes models and machine

S/no	Models	Machines
1	Simon	Cutting
2	Bead	Back part
3	Bade	Folding
4	Polo	Trimming
5	Lexingto	Hammering
6	Gimmy	Moccasin/ Ironing
7	Rigato	Lasing
8	Marry	
9	Peacock	
10	Greed	
11	Aspen	
12	Peach	
13	Mentero	
14	G-star	

Source: From company production department.

The processing time of each models pair on the each work center average of 14 times is recorded by stopwatch. The setup and adjusting of machine are included.

Table 32: Jobs and work center loading time

	M1	M2	M3	M4	M5	M6	M7
j1	4	2	3	2	4	3	6
j2	4	2	3	2	3	3	6
j3	4	3	2	2	3	2	6
j4	4	3	2	2	2	2	6
j5	3	2	2	2	2	3	6
j6	3	2	3	2	1	2	6
j7	4	2	2	1	2	3	5
j8	3	2	3	2	1	2	5
j9	3	2	1	2	1	2	6
j10	3	3	1	2	1	2	4
j11	3	2	1	1	1	3	4
j12	3	1	2	1	1	2	5
j13	2	2	1	2	1	2	4
j14	3	2	1	2	1	2	3

Source: Loading time for each job on the work center is recorded by stopwatch.

By using LENKIN the current Cmax and Tmax is as follows:

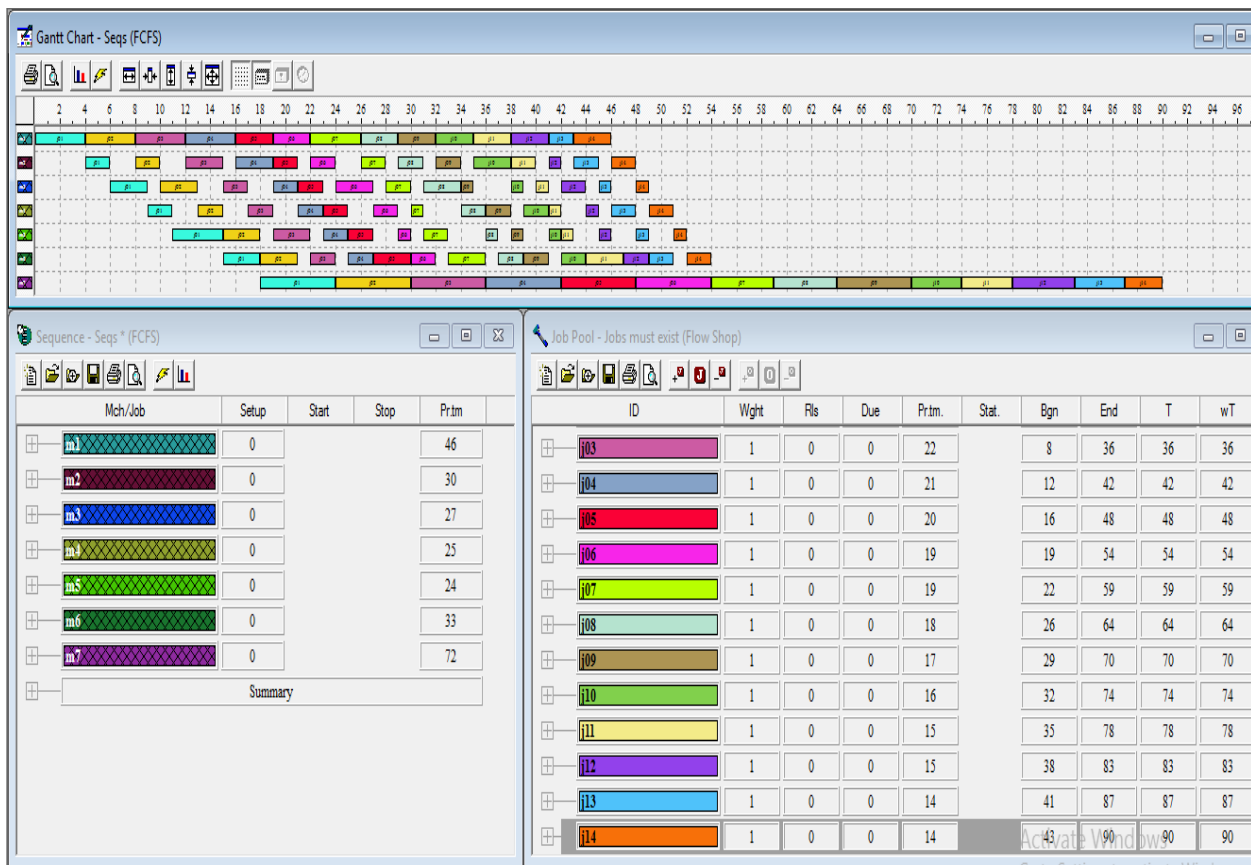


Figure 21: Gant chart of sequencing and scheduling.

Source: computed result from LENKIN.

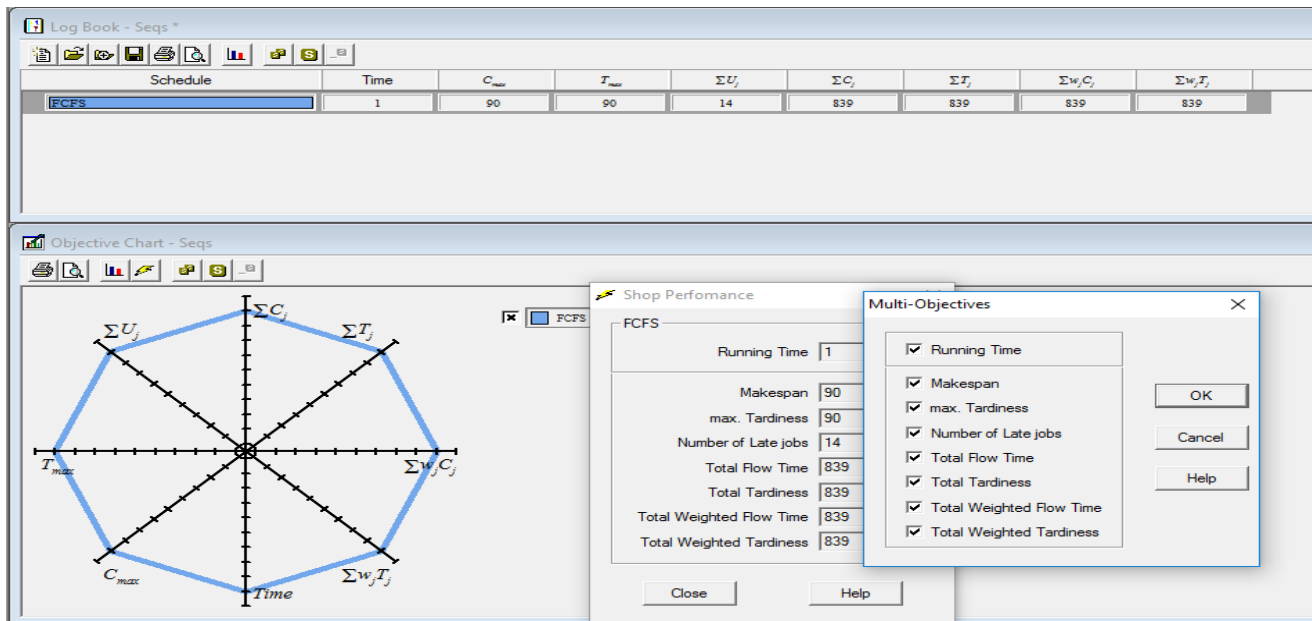


Figure 22: The analysis result of existing sequencing and scheduling.

Source: from LENKIN analysis result

According to (Chun-Lung Chena,*, Yeu-Ruey Tzengb, 2015)sequencing and scheduling are occur when the best sequence when n jobs that are to be processed on m machines in the same order in order to minimize the completion time of the last job on the last machine (makespan). In the sequencing and scheduling principle when the operation is the flow form and all jobs are must pass through all machines without affecting the sequence of order. And uses for minimize the losses of time due to improper sequence of job and maximize the output for maximize the performance metrics during the available time. It where manipulated by: - NEH and palmer which uses for developing better makespan for the sequencing and scheduling forms.

4.5.1.4.1 Heuristic algorithms

Heuristic algorithms are the most alternative for makespan minimization of the processing of n-jobs through m-machines with each job following the same technological order of machines for the preparing better C_{max} and T_{max} .

Each heuristics algorithms computed through different methods and for the single goal of minimizing of the total makespan.

A typical flow shop scheduling problem involves the determination of the order of processing of jobs with different processing times over different machines without affecting its rule of note prompt, jump recycle can e t c(Arun Gupta* and Sant Ram Chauhanb, 2014).

a) Palmer's algorithm

This method follows find out a weighted sum for each of all jobs. Then depend on the value, according to the weights sum values of each job on the all machines then descending job.

The step to be followed as follows:

1st step: - Consider a job scheduling problem for M machine and N jobs.

2nd step: - Assign some specific weights to each machine by the formula.

$$S(j) = -\sum_{t=1}^k (k - (2 * t - 1)) * 0(j, t)$$

3rd step: - Evaluate the weight of each job by a given procedure by multiplying the weights with the processing times of job on each machine.

4th step: - Sort the jobs in the decreasing order of their weights.

5th step: - Formulate a sequence based on the sorting done in Step 4.

6th step:- Calculate the Make Span for the above sequence.

Table 33: Job and machine relationship

j/M	M1	M2	M3	M4	M5	M6	M7	value
j1	4	2	3	2	4	3	6	9
j2	4	2	3	2	3	3	6	8
j3	4	3	2	2	3	2	6	5
j4	4	3	2	2	2	2	6	4
j5	3	2	2	2	2	3	6	11
j6	3	2	3	2	1	2	6	7
j7	4	2	2	1	2	3	5	5
j8	3	2	3	2	1	2	5	4
j9	3	2	1	2	1	2	6	9
j10	3	3	1	2	1	2	4	1
j11	3	2	1	1	1	3	4	5
j12	3	1	2	1	1	2	5	7

j13	2	2	1	2	1	2	4	6
j14	3	2	1	2	1	2	3	0
Weight	-3	-2	-1	0	1	2	3	

Source: collected by stopwatch from each machine during processing of each job.

Possible sequence of job by palmer

1	2	3	4	5	6	7	8	9	10	11	12	13	14
J5	J1	J9	J2	J6	J12	J13	J3	J7	J11	J4	J8	J10	J14

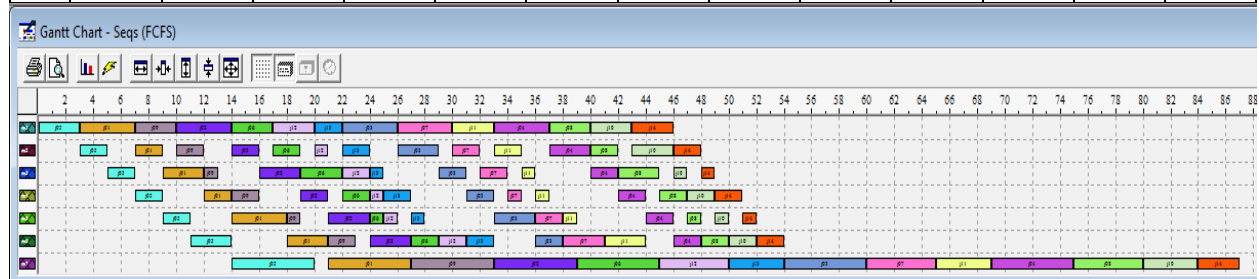


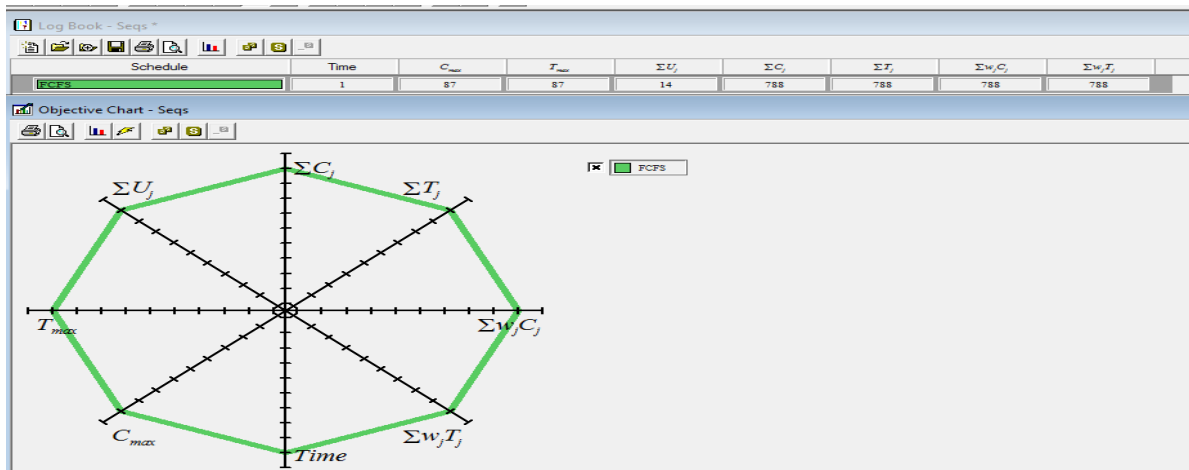
Figure 23:-Gantt chart of palmer ordering for processing of each job.

LEKIN - flexible job-shop scheduling system - [Job Pool - Jobs palmer (Flow Shop)]

Workspace File Schedule Job Operation Sort Tools Window Help

ID	Wght	Rls	Due	Prtm.	Stat.	Bgn	End	T	wT
j05	1	0	0	20		0	20	20	20
j01	1	0	0	24		3	27	27	27
j09	1	0	0	17		7	33	33	33
j02	1	0	0	23		10	39	39	39
j06	1	0	0	19		14	45	45	45
j12	1	0	0	15		17	50	50	50
j13	1	0	0	14		20	54	54	54
j03	1	0	0	22		22	60	60	60
j07	1	0	0	19		26	65	65	65
j11	1	0	0	15		30	69	69	69
j04	1	0	0	21		33	75	75	75
j08	1	0	0	18		37	80	80	80
j10	1	0	0	16		40	84	84	84
j14	1	0	0	14		43	87	87	87

Figure 24:-Job pool for palmer flow shop scheduling results



From the Gant chart and analysis

Maximum makespan (C_{max}) = 87 minute

Maximum tardiness (T_{max}) = 87 minute

b) Cambel duck-smith (CDS)

It is the merged and drive from John's rule; but not judged by the Jon's rule of $\text{MAX } p_{2j} \leq \min p_{3j}$ or $\leq \min p_{1j}$, Instead of john's rule for the Campbell Dudek and smith there is a possibility of sequence of M-1.

M1, M2 - - - - -Mm

S1:- M1, M2

S2:-M1+M2, Mm-1 +Mm

S3:-M1+M2+M3, Mm-2+Mm-1+Mm

SM-1:- M1+M2+- - - - Mm-1+M2+M3+- - - +Mm,

Table 34:-Possible ties

Slot	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1slot	J5	J9	J1	J2	J6	J12	J13	J3	J7	J11	J4	J8	J10	J14
2slot	J5	J1	J9	J2	J6	J12	J13	J7	J3	J11	J4	J8	J10	J14
3slot	J5	J1	J9	J2	J6	J12	J13	J7	J11	J3	J4	J8	J10	J14
4slot	J5	J1	J9	J2	J6	J12	J13	J11	J7	J3	J4	J8	J10	J14

Values	1 st slot	2 nd slot	3 th slot	4 th slot
Cmax	86	85	87	84
Tmax	86	85	87	84

The Cmax and Tmax value of each possible slot are greater than the dispatching rule result.

These values are less than the current Cmax and Tmax; however it is not less than the SPT

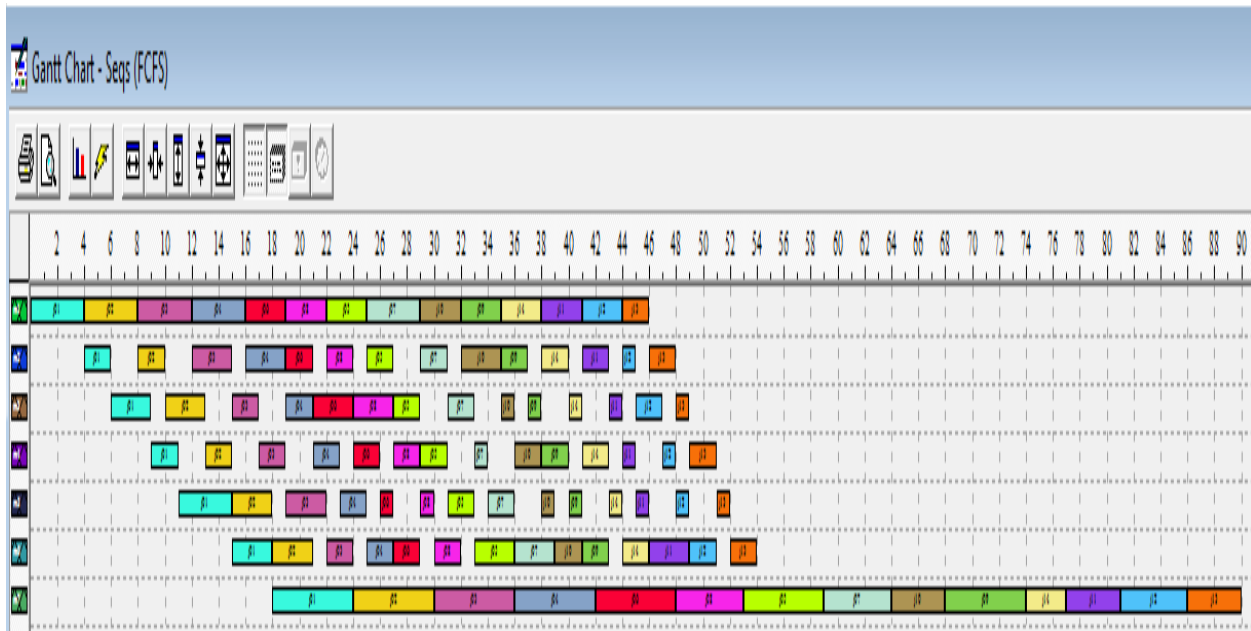
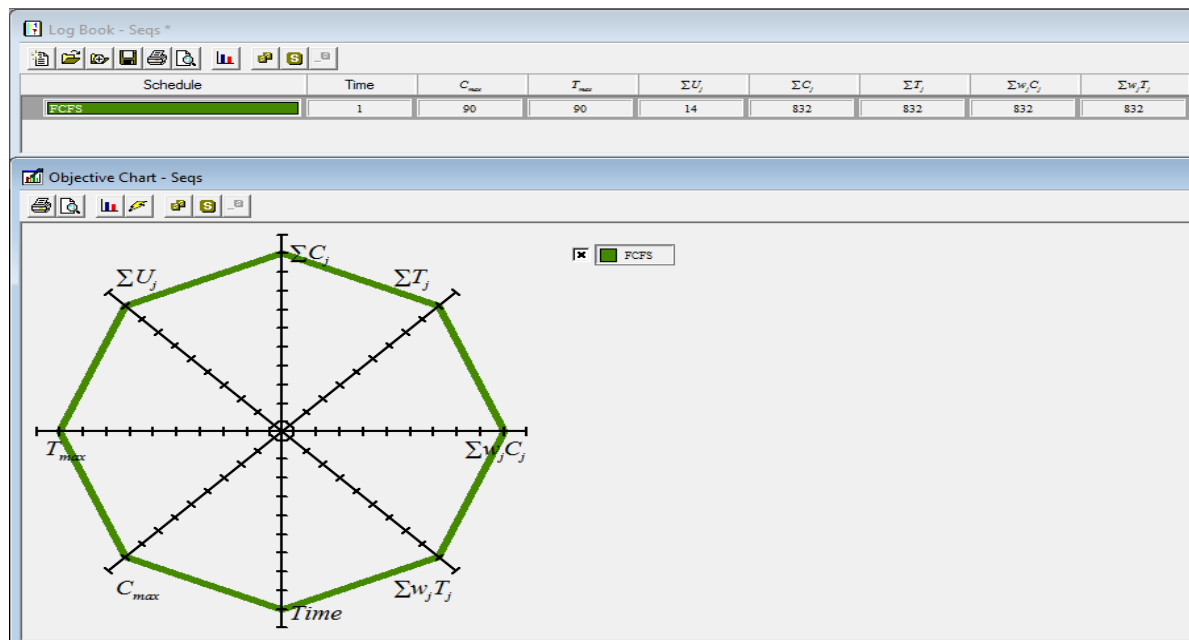


Figure 25:- Gant chart of processing sequence t

ID	Wght	Rls	Due	Prtm.	Stat.	Bgn	End	T	wT
i01	1	0	0	24		0	24	24	24
i02	1	0	0	23		4	30	30	30
i03	1	0	0	22		8	36	36	36
i04	1	0	0	21		12	42	42	42
i06	1	0	0	19		16	48	48	48
i08	1	0	0	18		19	53	53	53
i05	1	0	0	20		22	59	59	59
i07	1	0	0	19		25	64	64	64
i10	1	0	0	16		29	68	68	68
i09	1	0	0	17		32	74	74	74
i14	1	0	0	14		35	77	77	77
i11	1	0	0	15		38	81	81	81
i12	1	0	0	15		41	86	86	86
i13	1	0	0	14		44	90	90	90

through the CDS.

Figure 26:- Processing time result on the each machine and its C_{max} of the CDS.



From the above analysis result of Gant chart the CDS heuristic result is the same with the existing sequence of processing.

c) **Nawaz Ensore Ham(NEH) Algorithm**

Among the heuristics algorithms NEH computation attained after iterating the order; so it is very tried; These types of sequence order obtain through the critical path computation and from the result of computation the obtained sequence is as follow.

Table 35: The best critical path result for NEH computation

Best critical path from among
j2-j1=29
j3-j2-j1=34
j4-j3-j2-j1=39
j5-j4-j3-j2-j1=44
j7-j5-j4-j3-j2-j1=49
j7-j6-j5-j4-j3-j2-j1=55
j8-j7-j6-j5-j4-j3-j2-j1=60
j9-j8-j7-j6-j5-j4-j3-j2-j1=63
j9-j8-j7-j6-j5-j4-j3-j2-j1-j10=67
j12-j9-j10-j8-j7-j6-j5-j4-j3-j2-j1=71
j12-j11-j9-j10-j8-j7-j6-j5-j4-j3-j2-j1=75
j12-j14-j11-j9-j10-j8-j7-j6-j5-j4-j3-j2-j1= 78
j13-j14-j12-j11-j9-j10-j8-j7-j6-j5-j4-j3-j2-j1=82

Source:- from the critical path computation for the NEH heuristic algorithm

ID	Wght	Rls	Due	Pr.tm.	Stat.	Bgn	End	T	wT
j13	1	0	0	14		0	14	14	14
j14	1	0	0	14		2	17	17	17
j12	1	0	0	14		5	21	21	21
j11	1	0	0	15		8	26	26	26
j09	1	0	0	17		11	32	32	32
j10	1	0	0	16		14	36	36	36
j08	1	0	0	18		17	41	41	41
j07	1	0	0	19		20	46	46	46
j06	1	0	0	19		24	52	52	52
j05	1	0	0	20		27	58	58	58
j04	1	0	0	21		30	64	64	64
j03	1	0	0	22		34	70	70	70
j02	1	0	0	23		38	76	76	76
j01	1	0	0	24		42	82	82	82

Figure 27: The processing time of each job on the each machine throughout NEH algorithm.

Source: From LEKIN software.

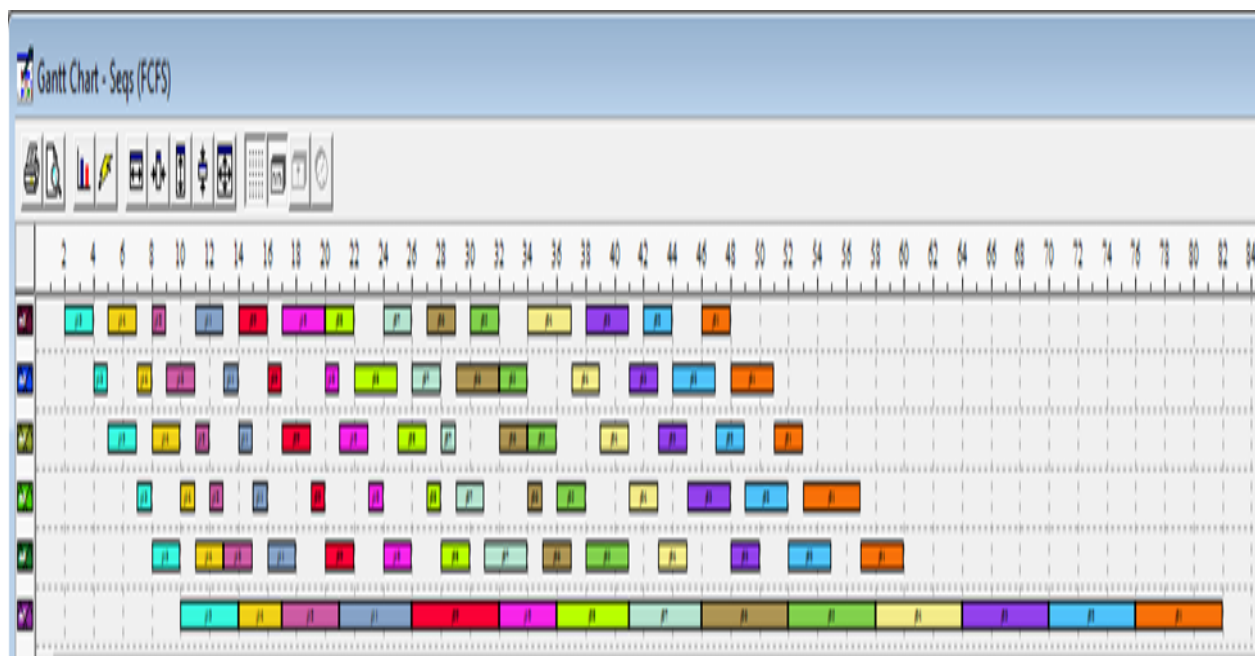


Figure 28: Gant chart by NEH algorithm

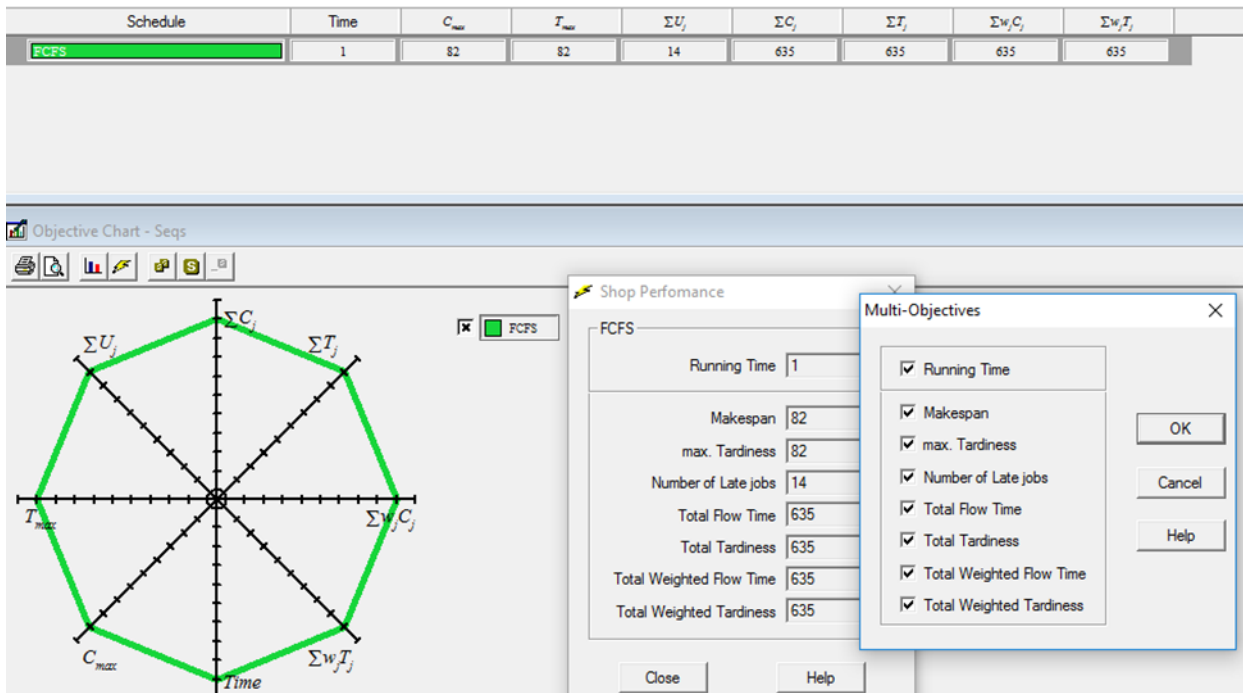


Figure 29: The NEH analysis result

And from the result of NEH, the value of C_{max} and T_{max} are equal. When the $C_{max} = T_{max} = 82$ minute.

NEH sequences follow **j13-j14-j12-j11-j9-j10-j08-j07-j06-j05-j04-j03-j02-j01**

The existing C_{max} is 90 minutes; however after the computation of the above heuristics algorithm the better make span obtained by NEH heuristics algorithms from others by 8(eight) minute optimized. Therefore NEH heuristics algorithms is the better bring better makespan.

4.5.1.4.1.1 Optimized amount in number of shoe by the NEH

To know the number of shoes can be manufactured with in the obtained C_{max} , and amount over the existing sequencing of operations, to identify the possible number of cycle(s) of all jobs on the individual machine is required. To know the number of cycle on each machine it is needed to identify the situations of whether it is waiting of job or idling of machine.

Waiting condition for the $M_k = P_j$ 01 on $(M_k - 1) - j_{14}$ on $M_k = \pm$ if it $-v$ the condition is waiting; and if $+V$ the condition is idling of machine M_k and job is no released. If the condition is idling the number of cycle of M_k for all jobs is depend on the $(M_k - 1)$. And if the condition is waiting to start, the number of cycle of all jobs on the M_k machine is depend on the M_k machine itself.

NB: - during identifying the condition, the last remember the condition of type of the machine (Mk-1) and it's finishing time of j01 on the (Mk-1) and possible starting of Mk j01. Condition is for the second cycle.

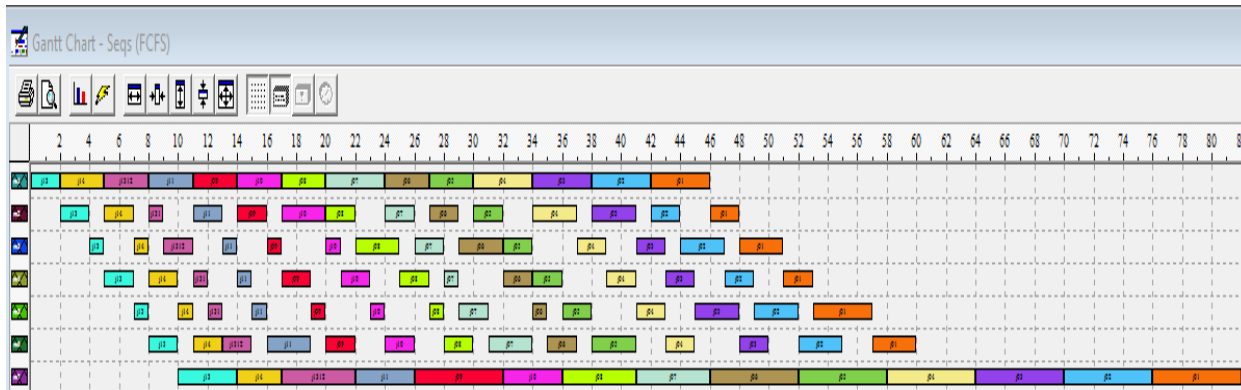


Figure 30:-NEH sequence GANT chart

Machine condition

M1= is no wait and no idle and it continues operation until the given net operation time; i.e. 420 minute per day.

M2 = p (j01 on m1- j14 on m2); (48-48) = 0; no idle no wait.

M3 = p (j01 on m2 –j14 on m3); (50 -51)= -1 waiting condition.

M4 = p (j01 on m3 - j14 on m4); (52-53) = -1 waiting condition.

M5 = p (j01 on m4 – j14 on m5); (55-57) = -2 waiting condition

M6 = p (j01on m5 – j14 on m6); (58-60) = -2 waiting condition

M7 = p (j01on m6 – j14 on m7); (62-82) = -20 waiting condition.

The condition for all machines is waiting and the number of possible cycle for all job on the ideal machine is depend on the Mk machine.

Where $k = 1, 2, 3 \dots 7$ in this case and

Mk-1 is one unit back for the number of machine.

Since the all condition is waiting the possible number of cycle of job on the each machine is calculated as follow.

No cycle of $M_k = (\text{flow time of } j_1-j_k \text{ on } M_k + \text{idle time of } M_k \text{ for the first before start job}) + (\text{flow time of } j_1-j_k \text{ on } M_k) \cdot h = 420 \text{ minutes.}$

Where $M_k \geq 2$

M_1 possible cycle = 46 minute = 1 cycle

$(420 \text{ minutes} \cdot 1 \text{ cycle}) = (46 \text{ minute} \cdot h); h = (420 \div 46) = 9.130 \text{ cycle} \approx 9 \text{ possible cycle.}$

Table 36:- possible number of cycle of all job on the each machine

M_k , where $k > 2$	Formula	Possible number of cycle for each machine
M2	$48 + (46)h = 420$	$9.086 \approx 9$
M3	$51 + (47)h = 420$	$8.89 \approx 9$
M4	$53 + (48)h = 420$	$8.6645 \approx 9$
M5	$57 + (50)h = 420$	$8.26 \approx 8$
M6	$60 + (52)h = 420$	$7.9923 \approx 8$
M7	$82 + (72)h = 420$	$5.89444 \approx 6$

Source:- from analysis and NEH GANT chart

From the above, the bottle neck number of cycle is on the m_7 and with at most 6 possible number of cycle when there is no any down time. By the new proposed sequencing except the J_{01} , J_{02} and J_{03} the rest job 11 has 6 possible number of full cycle on machine seven.

Totally there is three models of shoe is additionally can fully processed according to the (figure 35) below. Therefore the shoe can produce up to the final operation due to the prepared by NEH algorithm is 12 pieces of shoe pair day. Which is $3 \cdot 2 \text{ line} \cdot 2(\text{pair})$. When compare the above with the current processing, the possible number of cycle(s) founded the same with the above. From the current Gant chart of sequence it is easy to determine the maximum and bottle neck possible number of all job on the cycle on the all machine with in the one day which is called as system cycle. And by existing sequence only 8 jobs has full 6 possible number of cycle on the M_7 .

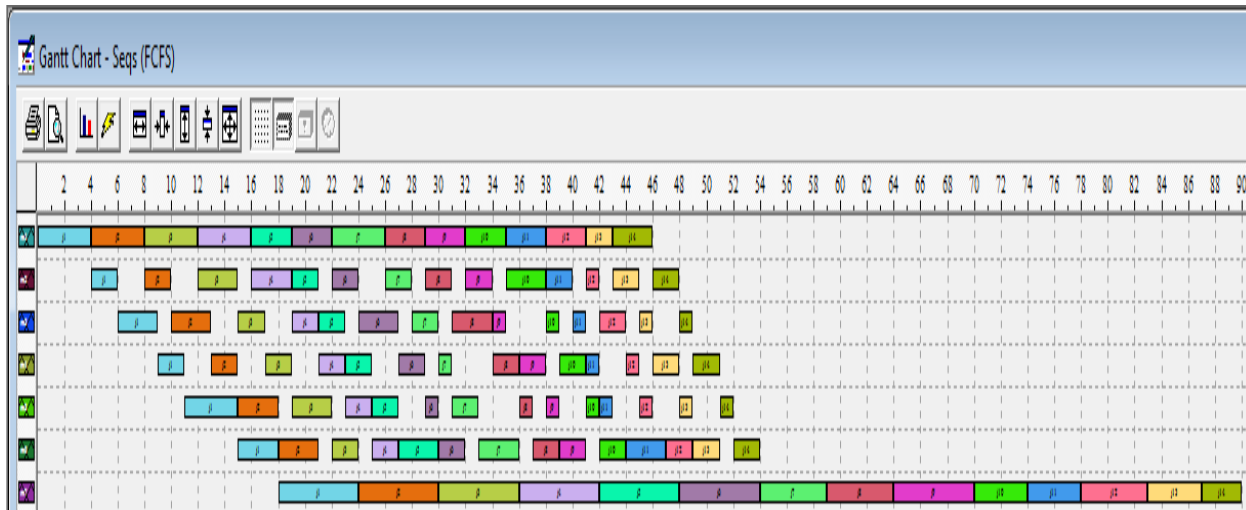


Figure 31:-present Gant chart of pull models taken for the purpose of determine system possible cycle pair day.

As possible to understand from the Gant chart, the M 7 seven conditions is waiting condition

Condition= $P(j01 \text{ on } m6 - J14 \text{ on } m7)$; (57 -90) minute = -33 minute

And the possible system cycles pair day were the possible cycle of all jobs on the machine seven (M7).

M7 possible cycle = $90 + (72) \cdot h = 420$ minute.

M7 possible cycle = 5.5833 cycles/ day.

4.5.1.5 Speed loss and minor stoppage of the manufacturing

From types of manufacturing the speed losses are differ from each other. If the manufacturing type is computerized continues and product type, the speed loss is caused from the minimizing the speed of run machine(s). And if manufacturing type is process type, the loss may be caused from the die change, material (s) and minimizing the speed of run machine.

Idling and minor stop losses and reduced speed losses are affect the performance metrics at OEE level and up to OTE(A. Pandey, 2019). The performance metrics also affected by the employee work-life, attention and management and flow up(Bustamam et.al, 2020). This implies, the employers are major key role for the achievement of organizational goal. The peacock shoe manufacturing industry (PSMI) is man-machine incorporated system. Then the output is depending on the speed of both man and machine. The employee performance is 4 pair of shoes / day. And current employee performance is realized the UNEDO report again. And performance average is 348.12 pairs/ day. The total number of employees in floor shop is 157. Those causes are lack of training, lack of attention and flow up, no any encouragement

and incentive, lack of cleaning and lubrication of machine and leather problem and processing different types of models.

4.5.2 Quality metrics loss analysis

Among the OEE and OTE metrics, quality metrics is a more significant than the rest. And it is because of this metrics is attained at the final after consuming all necessary resource. And the quality level is 99% at the world class values. The quality metric is affected by defect and reduce yield(M.H.M. Ahmed, 2020; A. Pandey, 2019; ROODA, 2015 and Tung et al., 2011). But in the manufacturing there is only defect quality loss; which is occurred in the form of B-grade and rejected. In the table 4 and 3 both B-grade defect and rejected defect amount are presented respectively. The quality data were collected only from the lasting section under the attribute quality characteristics.

Table 37:- A total number of defected shoes

	moths	1	2	3	4	5	6	7	8	9	10
conveyers	C1	387	138	238	323	317	391	547	504	827	529
	C2	284	283	320	276	291	280	328	315	519	221
	Total defected	671	421	558	599	608	771	875	819	1346	750

Source:- the summarized from table 3 and 4 the total of defective amounts.

The above table shows summation of both rejected and B-grade quality characteristics. The core center of quality is its specifications and characteristics required from the products. The summing up reason of the two types defected, is show there is no partial quality level; however there is intervals in quality acceptance way when it is based variable; but in attribute, it follow pass and fail.

4.5.2.1 Control chart analysis

The above defected data is collected through the 10 (then) months of production duration; which is from September to June E.C.

During control chart analysis the two main things are have to be clear.

- I. If the data is so large i.e. data greater than 30 sample number the problem may be hide in the data.
- II. If the data so small i.e. less than 15 assignable number the cause of the problems may be exclude. And to minimize these two problems the sable size from 25 up to 30 is appropriate. For

this quality control analysis the data sample size is took form the 30(thirty) weeks production output.

During developing control limit for the data; it may be attribute or variable the point which are called upper control limit, lower control limit and the middle line are the required.

$$\text{middle line (CL) or } (P_{\text{bar}}) = \frac{\sum NP}{\sum N}$$

$$\text{Upper control limit (UCL)} = P_{\text{bar}} + 3(\sqrt{P_{\text{bar}}(1 - P_{\text{bar}})/N})$$

$$\text{Lower control limit (LCL)} = P_{\text{bar}} - 3(\sqrt{P_{\text{bar}}(1 - P_{\text{bar}})/N})$$

Criteria of restriction in the control chart considered

One-point plots outside the 3-sigma control limits.

Two out of three consecutive points plot beyond the 2-sigma warning limits.

Four out of five consecutive points plot at a distance of 1-sigma or beyond from the center line

Eight consecutive points plot on one side of the center line

To develop controlled process there are different types of control charts. The most frequently used charts are the X-bar chart and p-charts. Depend on the factor affect the product quality characteristics and controlling; all of the other types of control charts are derivatives of these charts. Following study focus on the on **p** chart which is attribute and varied sample size data. The **p** chart is used to evaluate process stability when counting the number of defectives form of quality checking. The **p** chart is useful to track the number of defective units in a sample of units (rather than the proportion of defective units). Once the control limits (i.e. UCL, CL and LCL) are established for the **p** chart, these limits may be used to monitor the number nonconforming going forward and inclination.

When a point is outside these control limits, it indicates that the number of nonconforming units of the process is out-of-control. An assignable cause is suspected whenever the control chart indicates an out-of-control process.

Table 38: the data for attribute control chart

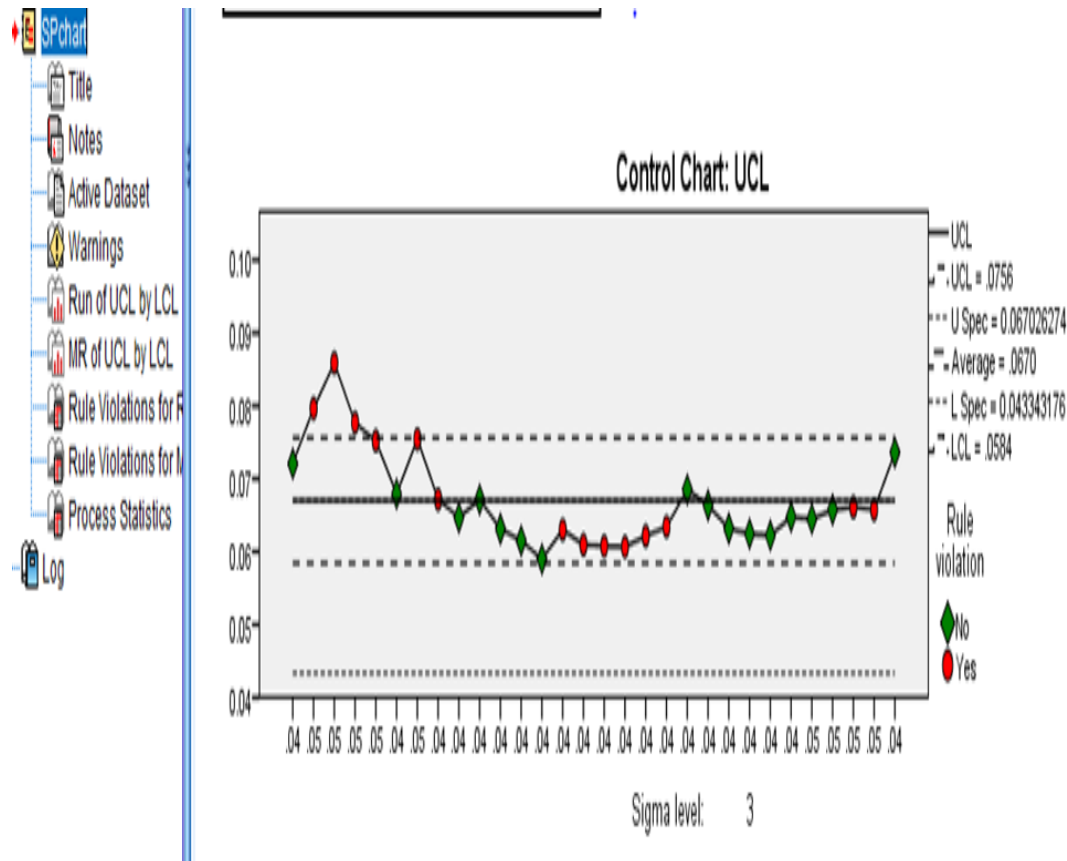
No of weeks	No of produced	No of defected	Proportion	P_bar	UCL	LCL
1	1972	141	.07	.06	.07	.04
2	2473	147	.06	.06	.08	.05
3	1914	148	.08	.07	.09	.05
4	3006	166	.06	.06	.08	.05
5	2948	160	.05	.06	.08	.05
6	3372	117	.03	.06	.07	.04
7	3657	156	.04	.06	.08	.05
8	3078	195	.06	.05	.07	.04
9	3965	193	.05	.05	.06	.04
10	2449	120	.05	.05	.07	.04
11	3160	100	.03	.05	.06	.04
12	3449	141	.04	.05	.06	.04
13	4476	183	.04	.05	.06	.04
14	3765	146	.04	.05	.06	.04
15	3166	201	.06	.05	.06	.04
16	3470	187	.05	.05	.06	.04
17	3835	212	.06	.05	.06	.04
18	3581	238	.07	.05	.06	.04
19	3466	238	.07	.05	.06	.04
20	2196	238	.11	.05	.07	.04
21	4051	130	.03	.06	.07	.04
22	4154	222	.05	.05	.06	.04
23	4607	229	.05	.05	.06	.04
24	4992	203	.04	.05	.06	.04
25	3635	334	.09	.05	.06	.04
26	5145	400	.08	.05	.06	.05
27	5259	409	.08	.06	.07	.05
28	5605	377	.07	.06	.07	.05
29	5604	287	.05	.06	.07	.05
30	1632	86	.05	.06	.07	.04

Figure 32: first Scenario control chart result

```

SPCHART
  /IR=UCL BY LCL
  /STATISTICS=CP CPU CPL CPK
  /RULES=All
  /ID=pbar
  /SPAN=2
  /SIGMAS=3
  /USL=0.067026274
  /LSL=0.043343176
  /TARGET=0.055184725.

```



Source: from the IBM SPSS statistics 20 analysis result of the inserted attribute data.

From the above control chart results five (5) points 2nd, 3rd, 4th and 5th are continuously out of the upper control limit and 7th is also above UCL and are violate the control chart rule. The other points are violating the control chart rules. From control chart results and appendix -2 A, show, two out of three consecutive points plot beyond the 2-sigma warning limits. Four points are out from the five consecutive points plot at a distance of 1-sigma or beyond from the center line. And eight consecutive points plot on one side of the center line. On the above control chart result from point 2 up to 5 the point is out of the control chart and due to the release painting glue defect is happen.

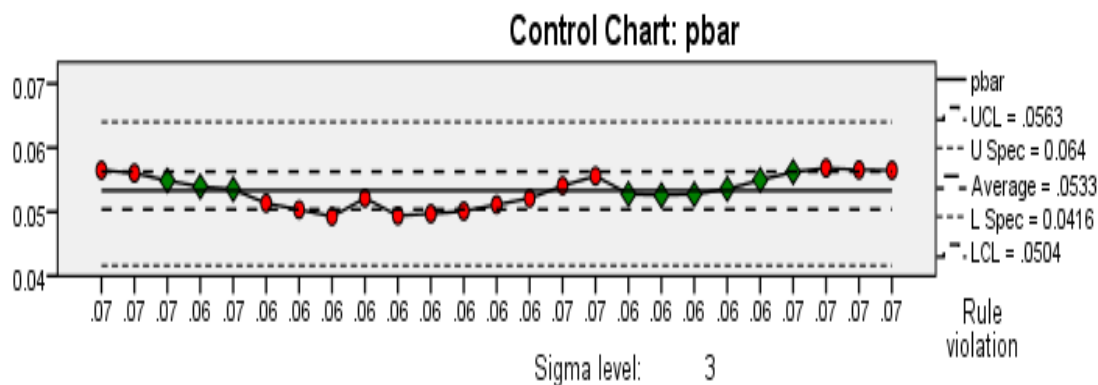


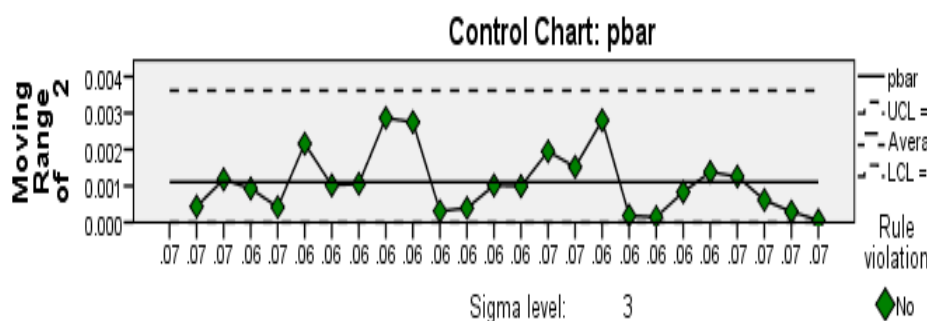
Figure 33: the second iteration of control chart result

Source: - From SPSS analysis result of control chart.

The second iteration none violate control limit boundary. However it violate the western electrical hand book rulers by rundown and it hold inclination and cyclic. The above figure shows that it is sided and the process is not fully controlled therefore by using SPSS moving two ranges, it become in control in all.

By the two moving average the control chart become controlled.

Figure 34: the two moving range of control chart.



Source: From SPSS analysis result of the two moving average after second iteration.

The above control chart is now become fully control by both control limit boundary and by western electrical hand book rule.

4.5.2.1.1 Cause and effect analysis

Among the statistical quality control Pareto chart uses for show the most vitals among, cause and effect diagram(C&E) depict an array of potential causes of quality problems(Abdul et.al, 2014). Cause and Effect analysis is merged from the brain wave ways of finding the reason of why the problems are happen. This brain wave uses for figure out the collected reason of causes which is raise from the group. The C&E diagram shown in Figure constructed after the quality characteristics of shoes are identified

and the quality improvement team was take analysis on it through brain wave sessions involving all quality controller teams are taking part in the related production and test activities. The C&E diagram shows major factors that can cause loosing binding, broken due to more stretched and broken of stitching leather components in the production process of factory.

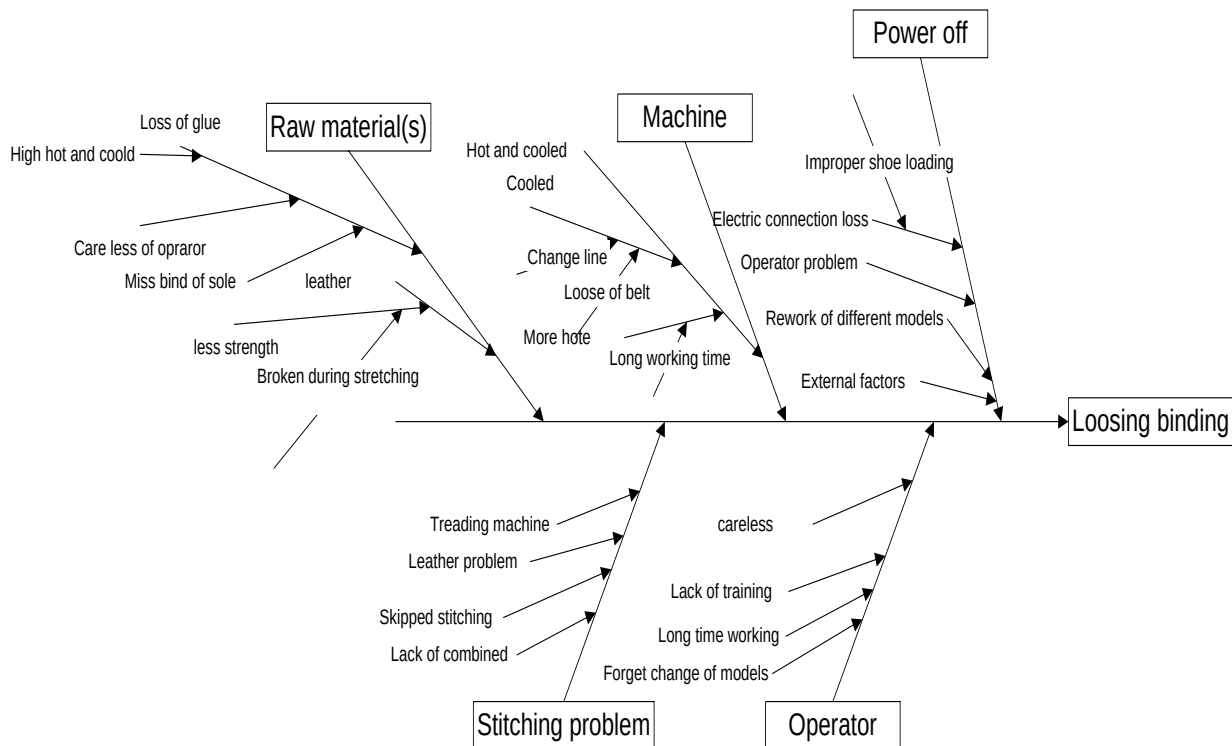


Figure 38: Cause and effect diagram for the first vital view

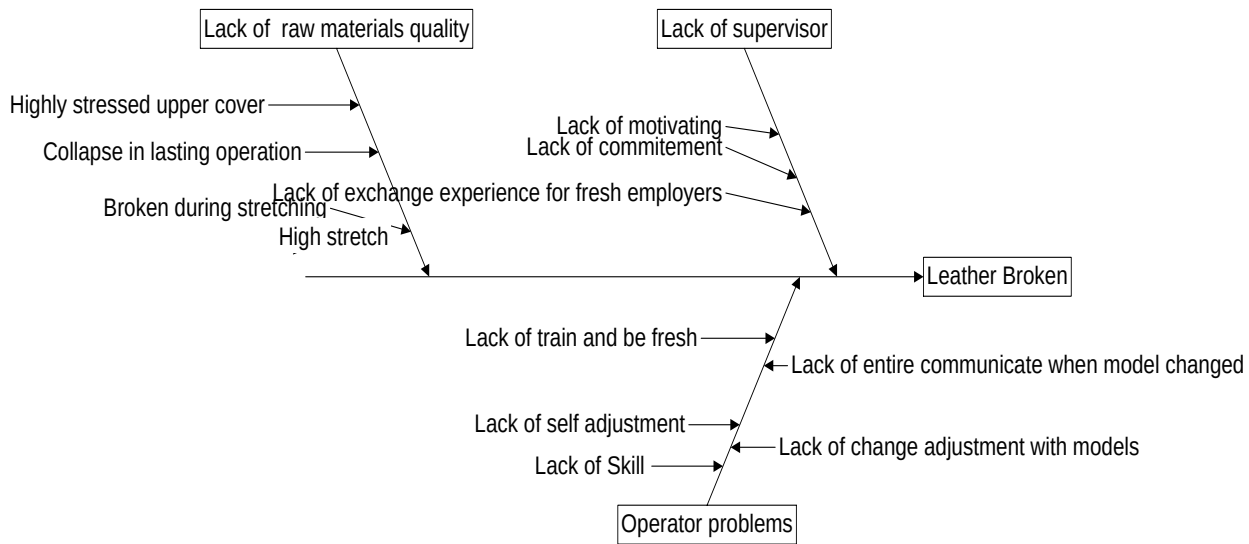


Figure 39: Cause and effect diagram for the second most vital view

4.5.2.1.2 Pareto analysis

Pareto principle is the quality control mechanism, which says that about 80% of outcomes are typically created by about 20% of causes (Parmar & Deshpande, 2014). This study conducted Pareto analysis for the lasting department. Pareto Analysis states that 80% of quality problems in the end product or service are caused by 20% of the problems in the production or service processes.

The first attempt is to find the most mount of occurring defects and then rank them according to their economic impact. As stated earlier the quality control mechanism is visual and correcting at the time in the both cutting and stitching section. But in the lasting department it is carefully concerned and rejected and accepted are identified here. Based on the attribute quality characteristics there are 8(eight) types of defects were identified that are responsible for the instability of the process in the lasting department. Date for this Pareto analysis is the 10 (ten) month data related to the defects are collected with their amount of defected (see Table 7). The Pareto diagram is shown in (Figure 35) it is revealed that the four defect types (*loosing binding, more stretched, broken stitching and poor painting*) are the vital few that results 80% of the total problems in the lasting department. In the other words this implies, if these three types of defects are alleviated, the company can resolve easily more than 80% of its problems.

Table 39:-Types of defect in the lasting section and its cumulative percentage

S/NO	Types of defect	defect in number	cumulative	Cumulative defect percent
1	Loosing binding	1958	1958	32%
2	More stretched	981	2939	48%
3	Broken stitching	846	3785	62%
4	Poor painting color	820	4605	75%
5	Broken leather	549	5154	84%
6	Miss attaching sole	437	5591	92%
7	Collapsed	367	5958	98%
8	Crack	146	6104	100%
	SUM	6104		

Source: From quality control department of company.

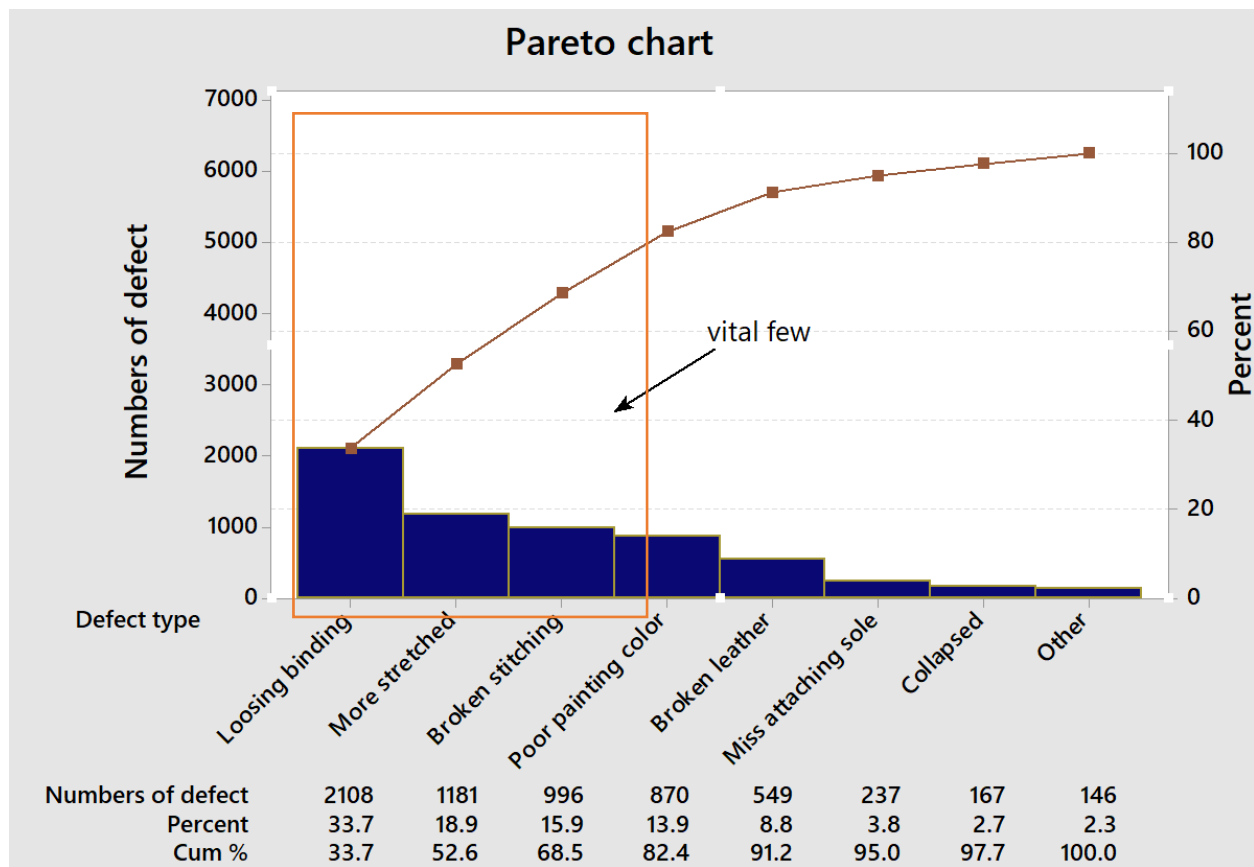


Figure 35: Pareto chart of the lasting section defects

Source: from quality control department.

From the above applied quality control tools; by control chart assignable causes are identified, pareto charts show the most vital view of defect and by using C&E diagram the cause of most vital view are identified. Control chart helps to identified assignable causes which are eliminated depend on the sources. This assignable cause eliminate from the process by initiating the out of control action plan (OCAP).

Table 40 action plant for the reason of defect

Defect	Reason	Out control action plan(OCAP)
Loosing of binding	✓ Loosing of glue: miss painting glue, it occurs due to lack of experience of fresh employers. ✓ Careless of operator: lack of flexibility with as model changed. ✓ Broken of stretching: it is happen from less quality of leather, skipped stitching and uncombined stitching. ✓ Miss combined of external and internal sole and sometimes exchange of left to the right. ✓ More hot of machine during long working time and cause the burning of stitch and the glue become dry	✓ Give training for fresh employers, supervising. ✓ Giving attention and follow the instruction. ✓ Check quality of leather before and change the leather types as models are changed. ✓ Change adjustment of tread machine as models are changed. ✓ Adjusting the lasting machine power as per as machine temperature increases during long time operation and give attention during the loading the shoe on the conveyors.
Leather broken	✓ Less quality of leather: the quality requirements for each shoe models are differ from each other. ✓ Stretching machine problem: the machine is no easily adjusted able.	✓ The operators are carefully adjusting the stretching machine with the model types. ✓ Select leather types for models types.
Crack	✓ Feeding problems on the folding and hammering machine.	✓ The supervisors have to carefully follow and

	✓ Improper operation on the roughing machine.	identify the models required hammering and rough operation and brushing it carefully. So give attention for all operations.
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All the above cause of loss(s) is interrelated to each other by the form of propagation and up and down stream effect due to the production system and the power connection; especially in the lasting operation.

4.6 Possible result from the combine action plan and proposed solution

As explained above most of the cause of losses has the behavior of propagation in the system directly and indirectly. Factors of loss happen in the cutting section propagated indirectly. Due to there is no quality controlling at this and lack of missing the leather type as per as its model it generate defect and machine break down in the left operations section. Example, Leather broken is happening from the less quality of leather: the quality requirements for each shoe models are differ from each other and improper cutting is generating quality problem during the stitching. Among the losses which directly affect all metrics is break down, shortage of raw materials power off and lack of training, careless ness of employees are the figures.

4.7 Summarized improvement Strategy from the three metrics

To bring the unique change in the manufacturing regard on the OEE at all sections it need entire organization change witch based on the overall interest. As stated above, at all section among the OEE metrics, performance metrics is below 50%. This indicates, the PSMI required detailed for improvement. To improve the performance metric, the require stand point are stated by the form of action plans and the easiest way is following of the prepared sequencing and scheduling. From the AM and action plan implementation, the break down due to the internal cause are improved and the cyclic improvement diagram is like as the following.

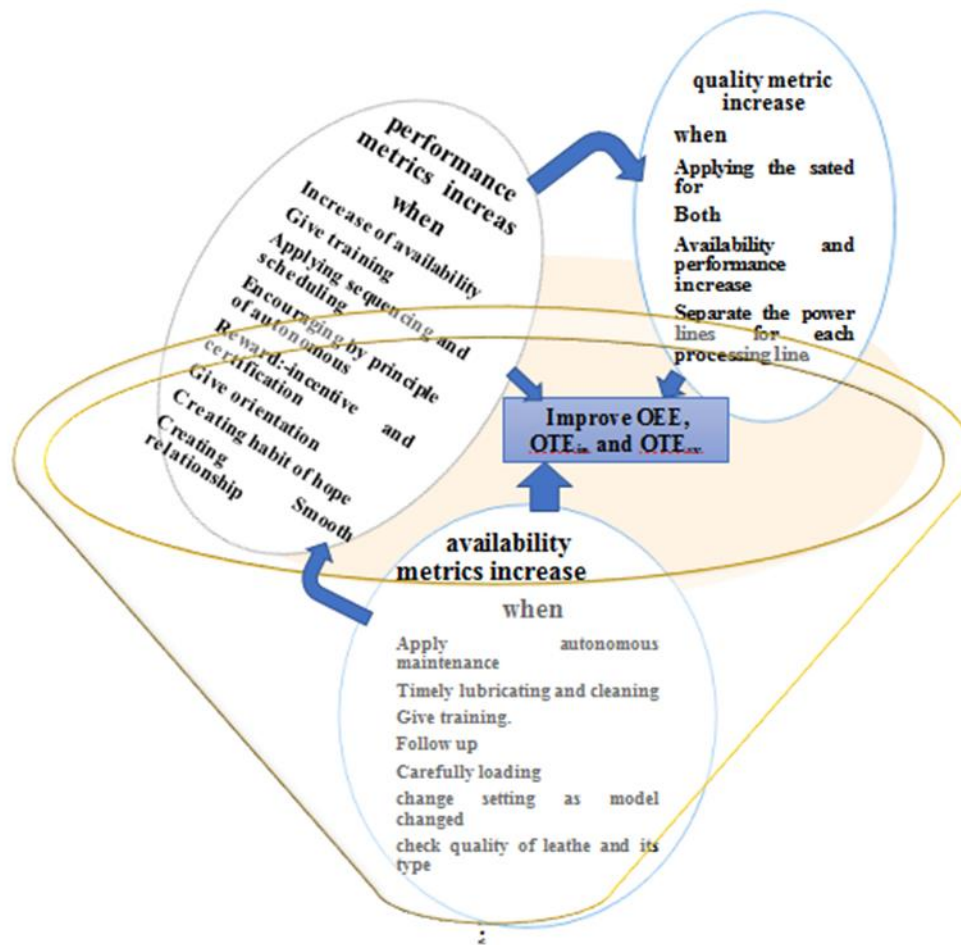


Figure 36:- The summarized improvement strategy of OEE metrics

Below table 41 show the monthly break down at all section and the break down are contain break down due to power off and break down due to the power off can't improve by internal action.

Table 41:- Monthly break down in each section

Reason of losses	Lasting C1	C2	Stitching C1	C2	Cutting	Insole	Moccasin
1st month	45	0	95	25	71	76	0
2nd month	43	20	70	45	96	18	45
3rd month	10	35	0	0	21	42	70
4 th month	174	0	0	0	0	33	0
5 th month	8	10	50	0	16	5	15
6 th month	48	67	40	0	0	20	0
7 th month	10	0	0	0	12	0	37
8th month	80	0	0	0	28	19	0
9 th month	15	0	30	0	46	9	57
10 th month	10	225	120	30	47	20	65
Sum	443	357	405	100	337	242	289

Source:-complained from appendix four A

Table 42:- possible Improvement of break down

Broken Machine name	Time in minute	Improved	Unchanged
Heating and lasting machine	509	368	due to power off
Heating and back part	367	367	
Back part machine breakdown	217	217	
Cooler breakdown	178	178	
Folding 01 breakdown and stretch	171	0	Power off
Press machine breakdown	159	159	
For power off	124	0	
Cutting die	118	118	
SKL -18 machine breakdown	87	87	

Rev 02	67	67	
Freza machine breakdown	64	64	
Zigzag machine breakdown	63	63	
Skiving machine break down	60	60	
GDP machine breakdown	56	56	
Rive 12 kamsur machine	52	52	
GSP-06 M/C	37	37	
sum	2329	1893	

Source: - appendix four A and B.

Improved output by Sequencing and scheduling at all section as below table

Table 43:-improved output by heuristic –NEH algorithms

Sen	Cutting		Stitching				Lasting				Moccasin		Insole	
Mo nth	Lin e		C1		C2		C1		C2					
	Act ual	Impr oved	Act ual	Impr oved	Act ual	Impr oved	Act ual	Impr oved	Act ual	Impr oved	Act ual	Impr oved	Act ual	Impr oved
Sep tem	119 74	1221 4	540 5	5525	444 4	4564	645 4	6574	540 0	5520	347 0	3710	104 86	1072 6
Oct	677 6	7064	317 8	3322	369 0	3834	397 0	4114	244 8	2592	370 2	3990	218 3	2471
No ve m	117 11	1201 1	724 8	7398	643 3	6583	513 9	5289	586 5	6015	400 3	4303	417 6	4476
Dec em	130 29	1334 1	642 6	6582	771 4	7870	771 8	7874	533 2	5488	538 4	5696	120 35	1234 7
Fab r	141 03	1439 1	556 4	5708	107 88	1093 2	889 9	9043	566 7	5811	392 8	4216	123 99	1268 7
Jan ury	148 87	1518 7	798 4	8134	707 7	7227	815 6	8306	714 8	7298	405 6	4356	173 40	1764 0

Mar	144	1467	424	4363	704	7163	466	4783	572	5844	578	6029	108	1108
ch	37	7	3		3		3		4		9		49	9
Apr	177	1808	489	5040	950	9657	653	6686	934	9492	538	5684	145	1487
il	86	6	0		7		6		2		4		74	4
Ma	174	1779	940	9556	976	9924	110	1122	915	9312	600	6312	282	2856
y	84	6	0		8		66	2	6		0		50	2
Jun	958	9873	636	6506	631	6454	118	1197	626	6412	597	6261	165	1680
e	5		2		0		32	6	8		3		17	5

From the improved result of table 41 of break down, the Availability of each section was increased as the following. With respect to previous computed, Availability before, the improved availability from the break down was increased in each section. The performance output will smoothly increase as soon as all the proposed action plan on all metrics and sequencing and scheduling is implemented section and line was increases. From the previous the daily output/person is 4 pairs and after the implementation the daily output pair employee is increased to 9 pairs. During the above computation, the availability metrics value is enough for the world class value at all section in all equipment and line and as well as at stage and system level also and from the proposed values the improvement amount by Availability is the below table 44. The performance metric improvement is known by the amount of output of the system and the system output is determined by the stage which is bottleneck for the system.

Table 44:-improve amount of OEE metrics at all line and equipment

Section		Increased amount in interval availability metrics	Previous P metrics	Improved P metrics of each month.
Leather Cutting		0 -.0.96%	17.77%	35.54%
Insole cutting c		0 – 0.9047%	10.28%	20.56%
Stitching	C1	0 - 1.131%	16.85%	33.7%
	C2	0 - 0.455%	18.23%	36.46%
Moccasin/ ironing		0 – 0.67%	17.55%	35.1%
Lasting	C1	0 – 1.593%	17.48%	34.96%
	C2	0 – 0.64%.	18.59%	37.18%
			20.57%	41.14%
			24.90%	49.8%

			19.20%	38.4%
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Source: - based on the proposed action plan, AM strategy and heuristics solution.

The quality metric improvement is based on the improvement of both metrics; because the cause of defect almost all by the cause of availability and performance metric loss. However as the quality control of the manufacturing is only in the lasting section, most of the break is formed in the lasting section cannot control by proposed action plan and AM strategy. Example heating and lasting machine break down. The quality metrics of the lasting section can be increased 97.5% -99%. The system availability and performance metrics are founded in the 4, 4, 4, 4, 2, 4, 3, 4, 3 and 4 and 2, 2, 4, 4, 3, 3, 4, 2, 3 and 2 stages respectively. The increment in performance metrics uniformly increase in all stage. The improved OTE entire, OTE system and its metrics is below.

Table 45:-Improved Value of OTE entire and OTE system and its metrics

month	sept	Oct	Nove	Dec	Fabr	Jan	March	April	May	June
metrics										
A_{System}	97.53%	93.56 %	94.24 %	99.19 %	99.98 %	99.48 %	99.87 %	99.97 %	99.87 %	98.46 %
p_{System}	40.00%	23.10 %	37.90 %	41.38 %	39.48 %	39.33 %	42.07 %	46.27 %	36.12 %	43.70 %
Q_{System}	96.74%	90.43 %	96.54 %	96.82 %	96.86 %	98.00 %	96.26 %	98.62 %	96.33 %	98.44 %
OTE^{intire}	37.63%	20.83 %	34.61 %	39.77 %	38.56 %	39.12 %	39.20 %	46.27 %	33.00 %	42.80 %
OTE^{System}	37.61%	20.83 %	34.61 %	39.77 %	38.23 %	38.34 %	39.20 %	26.26 %	31.46 %	42.80 %

Source;-from the improvement and used the stated equation 18, 19, 20, 21, 24 and etc.

The improvement amount mat be more than and it depend on the implementation of the proposed solution.

CHAPTER FIVE

5.1 CONCLUSION AND RECOMMENDATION

5.1.1 Conclusion

This study under taken on the improvement of system metrics; and the analysis were done started from cutting section, stitching and lasting section. During the study of OTE improvement the equipment, line, stage and system metrics effectiveness analyses and improvement methods has been done in all section through an OEE, OTE entire and OTE system. During the analysis for facilitating the analysis the production arrangement was presented. Most of the manufacturing systems are contain integrated systems like series, parallel and mixed type. And the peacock shoe manufacturing industry is a mixed type of system i.e. parallel, parallel, series and parallel type of manufacturing system Based on the arrangement the measurement are done at equipment, line, stage and system level interim of OEE, OTE entire and OTE system and the metrics. The results from the analysis regard on the OEE and OTE metrics I were below the world class values and therefore to implementing the proposed method are required.

For the analyzing and improvement of OEE and OTE as well as the metrics the appropriate analyzing methods are statistical quality control methods like cause and effect diagram, Pareto chart, attribute quality control and the action plans, AM frame work strategy, heuristics algorithms. The study has been started with activity of gathering the appropriate data, beside, production output, defect product, broken machine with their frequency, stoppage time factor generate breakdown and presenting these data in a comprehensible manner and calculating the relevant performance indicators in all section. And interpreting these figures, to understand or explain equipment, line, stage and propagation and up and down stream losses on the system and the necessary solution is provided. From the analysis result most all in all the quality metrics for all the system was laid in the fourth stage. The system performance and availability metrics were depend on the bottleneck performance in the entire and bottleneck availability.

The OEE, OTE, at stages and system level used as tools of performance indicator and measures, analysis and identifies line effectiveness losses to indicate area of improvement, through priorities improvement efforts and provides recommended strategy to be implemented to minimize the metrics losses at all stages.

The production system representation were built for the production system to provide a deep understanding of the system, bottleneck of the system to understand real theoretical output of the system and propagation of losses as well as up and down stream effect. Based on the results of the study, the following conclusions are drawn.

- In this study different metrics of loss are identified from external and internal factors. Among the metrics, mostly availability was affected by external and internal factors; the internal factors are mostly by break down and the external losses are power off and no light. Time in minute due to breakdown loss 2329 minute and due to no light and power off 3789 minute; most of the break down are found in the lasting section. The most frequented of break down was Heating and lasting machine by nine times. The recorded time of the breakdown of each parts and equipment differ from equipment to equipment. The time repair for the machine are less because of the machine are easy to repair within the short period of time; therefor the availability of the machine are not more affected as per as the frequency of breakdown occurrence. From the analysis result, performance metrics was the mostly affected; the factors affect the performance was scheduling, speed loss, operators and propagated break down loss. And quality losses are caused from the machine break down, operators, raw materials and power off and no light. During the 10th months the both availability and performance metrics were in the followed stage 10th is in the following stages (4, 4, 4, 4, 2, 4, 3, 4, 3 and 4) and (2, 2, 4, 4, 3, 3, 4, 2, 3 and 2) are respectively and the total defect amount were 6104 pcs.
- Due to the above losses OEE, OTE entire and OTE system below the world class value; the real value of OTE system is between 10% - 25%. This loss was included propagation and steam in addition to the metrics losses. Among the metrics performance was the most affected at equipment, line and stages and at section.
- Depend on the losses of Metrics the necessary ways of improvement like:- action plan, heuristics and AM strategy was developed. To develop almost the optimum makespan different heuristic algorism and dispatching rules are computed and each of them bring different result by different sequence of job on the same machine.
- The better make span for the jobs were attained by the NEH algorithms by optimized eight minutes from the existing; if new job are incorporated, to develop the batter makespan for the jobs the production planner and operators can develop the better make span by following the above procedures.

- From design capacity and the analysis result; the mashing and ironing equipment output is represent the actual theoretical output of the system; therefore, all equipment and lines actual theoretical output is determined by the mashing. During the analysis result, the entire and system OTE are laid at different stage and OTE of the system and the metrics of the system found at different at the same time.
- From the study generally the performance metrics at all section below the world class value through the 10th month result and this metrics need good attention to implement the proposed action, NEH heuristic result and implementing of AM in addition to action plan.
- Finally the improvement diagram was developed in comprehensive way and according to the proposed the OTE system slightly increased to 20.8% up to 40.80%.

5.1.2 Recommendation

From the result of the study the following recommendation suggested.

- ✓ To utilize the employee resource need carefully fellowship and implemented all proposed solution and separate electric connection in the lasting machine and
- ✓ Cover the air pipe line of the lasting machine and change the electric connection from series to parallel for the line.
- ✓ Incorporate the quality control for intermediate of the stages and in both cutting and stitching section.
- ✓ Set the quality characteristics of each operation and follow up it in start from raw material receive.
- ✓ Follow the prepared sequencing of scheduling for the operation and follow the sequencing and scheduling when other models are founded. And prepare the sequence of operation for the local product.
- ✓ Since the kaizen implementation was achieve from daily execution work, motivate the worker and initiate them and put the kaizen uses from office to each section floor.

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Appendixes

Appendix one: - collected data of weekly production report of all section

Table of week 1:- collected data of weekly production report of all section

									
		DIRE INDUSTRIES PLC.							
		PEACOCK SHOE FACTORY							
		WEEKLY PRODUCTION REPORT OF ALL DIPARTMENTS							
		WEEKLY PRODUCTION							
DEPT	LIN E		5/1/2012	6/1/2012	7/1/2012	8/1/2012	9/1/2012	10/1/2012	Total prod/n
CUTTING		Target	960	960	846	991	867	466	5090
		Actual	640	380	578	471	363	200	2632
		D/ce	320	580	268		504	266	1938
STITCHING	C1	Target	400	450	450	450	400	250	2400
		Actual	310	320	300	300	320	160	1710
		D/ce	90	130	150		80	90	540
	C2	Target	450	450	520	220	460	220	2320
		Actual	250	160	240	220	250	130	1250
		D/ce	200	290	280		210	90	1070
LASTING	C1	Target	410	410	410	440	440	220	2330
		Actual	311	301	300	273	300	146	1631
		D/ce	99	109	110		140	74	532
	C2	Target	400	410	430	409	410	190	2249
		Actual	152	235	235	230	270	140	1262
		D/ce	248	175	195		140	50	808
MOCASSIN		Target	250	250	250	250	250	150	1400
		Actual	140	162	150	166	164	93	875
		D/ce	110	88	100		86	57	441
INSOLE		Target	1616	1264	1156	1102	615	324	6077
		Actual	0	530	670	500	622	300	2622
		D/ce	1616	734	486		-7	24	2853

Table of week 2:- collected data of weekly production report of all section

									
		Dire industries plc.							
		Peacock shoe factory							
		Weekly production report of all departments							
		Weekly production						Total procn	
DEPT	LINE	12/1/2012		13/1/2012	14/1/2012	15/1/2012	16/1/2012		
				2	2	2	2		
CUTTING		Target	1007	879	705	874	891	4356	
		Actual	1054	394	517	519	178	2662	
		D/ce	-47	485	188		713	1339	
STITCHING	C1	Target	450	450	450	450	450	2250	
		Actual	310	300	260	230	100	1200	
		D/ce	140	150	190		350	830	
	C2	Target	440	410	430	432	408	2120	
		Actual	230	190	130	220	80	850	
		D/ce	210	220	300	212	328	1270	
LASTING	C1	Target	420	450	410	440	440	2160	
		Actual	277	407	316	301	200	1501	
		D/ce	143	43	94		240	520	
	C2	Target	410	410	450	450	410	2130	
		Actual	310	317	256	290	188	1361	
		D/ce	100	93	194		222	609	
MOCASSIN		Target	250	250	250	250	250	1250	
		Actual	147	166	178	175	74	740	
		D/ce	103	84	72	75	176	510	
INSOLE		Target	1200	1200	1200	1200	1200	6000	
		Actual	435	456	421	400	120	1832	
		D/ce	765	744	779		1080	3368	

Table of week3:- collected data of weekly production report of all section

		DIRE INDUSTRIES PLC.						
		PEACOCK SHOE FACTORY						
		WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS						
		WEEKLY PRODUCTION						TOTAL PR/N
DEPT	LINE	19/1/2012		20/1/2012	21/1/2012	22/1/2012	23/1/2012	
CUTTING		Target	815	891	804	814	836	4160
		Actual	468	613	546	590	660	2877
		D/ce	347	278	258	224	176	1283
STITCHING	C1	Target	450	500	600	600	700	2850
		Actual	240	170	220	214	193	1037
		D/ce	210	330	380	386	507	1813
	C2	Target	430	476	401	463	401	2171
		Actual	190	162	177	170	203	902
		D/ce	240	314	224	293	198	1269
LASTING	C1	Target	420	450	410	440	440	2160
		Actual	150	300	260	267	291	1268
		D/ce	270	150	150	173	149	892
	C2	Target	410	410	450	450	450	2170
		Actual	316	173	220	210	280	1199
		D/ce	94	237	230	240	170	971
MOCASSIN		Target	250	250	250	250	250	1250
		Actual	172	180	191	225	156	924
		D/ce	78	70	59	25	94	326
INSOLE		Target	1200	1200	1200	1200	1200	6000
		Actual	3330	480	523	610	780	2726
		D/ce	867	720	677	590	420	3274

Table of week 4 :- collected data of weekly production report of all section

		DIRE INDUSTRIES PLC.						
		PEACOCK SHOE FACTORY						
		WEAKLY FACTORY PRODUCTION REPORT OF ALL DEPARTMENTS						
		WEEKLY PRODUCTION						
DEPT	LINE	26/1/2012	27/1/2012	28/1/2012	29/1/2012	30/1/2012	1/2/2012	TOTAL PRODUCTION
CUTTING		Target	993	836	905	850	950	4534
		Actual	709	630	524	530	610	3203
		D/ce	284	206	381	320	340	1881
STITCHING	C1	Target	400	450	410	480	450	2410
		Actual	240	153	190	190	170	993
		D/ce	160	297	220	290	280	1417
	C2	Target	401	463	443	483	422	2487
		Actual	135	185	211	186	220	1047
		D/ce	266	278	232	297	202	1440
LASTING	C1	Target	450	460	470	350	350	2431
		Actual	280	315	373	350	294	1696
		D/ce	170	145	97	0	56	735
	C2	Target	450	450	450	450	440	2465
		Actual	410	280	212	156	25	1173
		D/ce	40	170	238	294	415	1292
MOCASSIN		Target	250	250	250	250	250	1500
		Actual	155	134	142	135	157	849
		D/ce	95	116	108	115	93	651
INSOLE		Target	1200	1200	1200	1200	600	6600
		Actual	615	711	704	737	539	3683
		D/ce	585	489	496	463	661	2917

Table of week 5: - collected data of weekly production report of all section

		DIRE INDUSTRIES PLC.						
		PEACOCK SHOE FACTORY						
		WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS						
		WEEKLY PRODUCTION						TOTAL PRODU CTION
DEPT	LI NE	3/2/2012	4/2/2012	5/2/2012	6/2/2012	7/2/2012	8/2/2012	
Cutting		Target	927	950	900	850	950	5127
		Actual	500	770	894	809	507	3810
		D/ce	427	180	6	41	443	1317
Stitching	C1	Target	400	400	400	400	400	2220
		Actual	150	150	150	120	140	790
		D/ce	250	250	250	280	260	1430
	C2	Target	450	424	400	400	400	2274
		Actual	208	244	240	174	197	1193
		D/ce	242	180	160	226	203	1081
Lasting	C1	Target	450	450	450	450	440	2465
		Actual	228	348	310	266	306	1608
		D/ce	222	102	140	184	134	857
	C2	Target	350	350	350	350	350	2100
		Actual	171	225	157	183	170	991
		D/ce	179	125	193	167	180	1109
Moccasin		Target	250	250	250	250	250	1500
		Actual	123	134	148	162	158	881
		D/ce	127	116	102	88	92	619
Insole		Target	1200	1200	1200	1200	1200	6600
		Actual	762	750	260	0	0	1772
		D/ce	438	450	940	1200	1200	4828

Table of week 6 :- collected data of weekly production report of all section

DIRE INDUSTRIES PLC.									
PEACOCK SHOE FACTORY									
PEACOCK FOOTWEAR									
WEEKLY PERFORMANCE REPORT OF ALL DIPARTMENTS									
		WEEKLY PRODUCTION							Total prod
DEPT	LIN E	10/2/2012	11/2/2012	12/2/2012	13/2/2012	14/2/2012	15/2/2012		
CUTTING		Targe t	993	836	905	850	950	550	5084
		Actua l	570	421	489	642	474	170	2766
		D/ce	423	415	416	208	476	380	2318
STITCHING	C1	Targe t	400	400	400	400	400	220	2220
		Actua l	180	200	200	190	200	320	1290
		D/ce	220	200	200	210	200	-100	930
	C2	Targe t	400	425	400	400	400	220	2245
		Actua l	220	230	350	250	211	235	1496
		D/ce	180	195	50	150	189	-15	749
LASTING	C1	Targe t	450	450	450	450	450	225	2475
		Actua l	257	13	246	263	285	75	1139
		D/ce	193	437	204	187	165	150	1336
	C2	Targe t	350	350	350	350	350	350	2100
		Actua l	261	216	278	339	206	67	1367
		D/ce	89	134	72	11	144	283	733
MOCASSIN		Targe t	250	250	250	250	250	250	1500
		Actua l	178	144	125	162	161	74	844
		D/ce	72	106	125	88	89	176	656
INSOLE		Targe t	1200	1200	1200	1200	1200	600	6600
		Actu				0		17	17
		D/ce	1200	1200	1200	1200	1200	583	6583

Table of week 7: - collected data of weekly production report of all section

		DIRE INDUSTRIES PLC.						
		PEACOCK SHOE FACTORY						
		WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS						
		WEEKLY PRODUCTION						
DEPT	LINE		24/2/2012	25/2/2012	26/2/2012	27/2/2012	28/2/2012	tota pro
CUTTING		Target	993	836	905	850	950	4534
		Actua	20			542	70	632
		D/ce	973	836	905	308	880	3902
STITCHING	C1	Target	400	400	400	400	400	2000
		Actual	280	233	265	250	20	1048
		D/ce	120	167	135	150	380	952
	C2	Target	400	425	400	400	400	2025
		Actual	226	202	220	199	44	891
		D/ce	174	223	180	201	356	1134
LASTING	C1	Target	450	450	450	450	450	2250
		Actual	231	196	260	93	162	942
		D/ce	219	254	190	357	288	1308
	C2	Target	350	350	350	350	350	1750
		Actual	200	240	160	245	185	1030
		D/ce	150	110	190	105	165	720
MOCASSIN		Target	250	250	250	250	250	1250
		Actual	179	169	158	138	143	787
		D/ce	71	81	92	112	107	463
INSOLE		Target	1200	1200	1200	1200	1200	6000
		Actual	32	138	294	100	250	814
		D/ce	1168	1062	906	1100	950	5186

Table of week 8 :- collected data of weekly production report of all section

		DIRE INDUSTRIES PLC.							
		PEACOCK SHOE FACTORY							
		WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS							
		WEEKLY PRODUCTION							Total pr
DEPT	LINE	1/3/2012	2/3/2012	3/3/2012	4/3/2012	5/3/2012	6/3/2012		
CUTTING		Target	993	836	905	850	950	950	3798
		Actual		165	40	127	136	104	280
		D/ce	993	671	865	723	814	846	3518
STITCHING	C1	Target	400	400	400	400	400	400	1600
		Actual	418	400	370	340	360	160	1308
		D/ce	-18	0	30	60	40	240	292
	C2	Target	400	425	400	400	400	400	1600
		Actual	252	220	240	240	230	120	842
		D/ce	148	205	160	160	170	280	758
LASTING	C1	Target	450	450	450	450	450	450	1800
		Actual	270	255	355			130	755
		D/ce	180	195	95	450	450	320	1045
	C2	Target	350	350	350	350	350	350	1400
		Actual	205	221	350	376	219	92	866
		D/ce	145	129	0	-26	131	258	534
MOCASSIN		Target	250	250	250	250	250	250	1000
		Actual	176	138	106	116	112	52	446
		D/ce	74	112	144	134	138	198	554
INSOLE		Target	1200	1200	1200	1200	1200	1200	4800
		Actual		5	34				34
		D/ce	1200	1195	1166	1200	1200	1200	4766

Table of week 9 :- collected data of weekly production report of all section

		DIRE INDUSTRIES PLC.						
		PEACOCK SHOE FACTORY						
		WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS						
		WEEKLY PRODUCTION						Total pro
DEPT	LINE	8/3/2012	9/3/2012	10/3/2012	11/3/2012	12/3/2012	13/3/2012	
CUTTING		Target	993	836	905	850	950	5484
		Actual	265	428	342	310	311	1822
		D/ce	728	408	563	540	639	3662
STITCHING	C1	Target	400	400	400	400	400	2400
		Actual	320	300	320	320	180	1760
		D/ce	80	100	80	80	220	640
	C2	Target	400	425	400	400	400	2425
		Actual	215	217	159	162	114	1029
		D/ce	185	208	241	238	286	1396
LASTING	C1	Target	450	450	450	450	450	2700
		Actual	163	144	281		67	655
		D/ce	287	306	169	450	383	2045
	C2	Target	350	350	350	350	350	2100
		Actual	155	237	238	220	114	1259
		D/ce	195	113	112	130	236	841
MOCASSIN		Target	250	250	250	250	250	1500
		Actual	100	124	123	155	155	811
		D/ce	150	126	127	95	95	689
INSOLE		Target	1200	1200	1200	1200	1200	7200
		Actual	137	285	94		14	530
		D/ce	1063	915	1106	1200	1186	6670

Table of week 10 :- collected data of weekly production report of all section

		DIRE INDUSTRIES PLC.						
		PEACOCK SHOE FACTORY						
		WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS						
		WEEKLY PRODUCTION						Tota pro
DEPT	LINE	15/3/2012	16/3/2012	17/3/2012	18/3/2012	19/3/2012	20/3/2012	
CUTTING		Target	993	836	905	850	950	5484
		Actual	501	1090	1330	866	935	5162
		D/ce	492	-254	-425	-16	15	322
STITCHING	C1	Target	400	400	400	400	400	2400
		Actual	340	320	310	270	250	1600
		D/ce	60	80	90	130	150	800
	C2	Target	400	425	400	400	400	2425
		Actual	154	163	150	230	359	1256
		D/ce	246	262	250	170	41	1169
LASTING	C1	Target	450	450	450	450	450	2700
		Actual	330	304	293	272	243	1562
		D/ce	120	146	157	178	207	1138
	C2	Target	350	350	350	350	350	2100
		Actual	309	206	265	227	254	1444
		D/ce	41	144	85	123	96	656
MOCASSIN		Target	250	250	250	250	250	1500
		Actual	179	194	189	190	195	1107
		D/ce	71	56	61	60	55	393
INSOLE		Target	1200	1200	1200	1200	1200	7200
		Actual		22			200	402
		D/ce	1200	1178	1200	1200	1000	6798

Table of week 11 :- collected data of weekly production report of all section

		DIRE INDUSTRIES PLC.						
		PEACOCK SHOE FACTORY						
		WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS						
		WEEKLY PRODUCTION						
DEPT	LINE	22/3/2012		23/3/2012	24/3/2012	25/3/2012	26/3/2012	27/3/2012
CUTTING		Target	993	836	905	850	950	950
		Actual	920	775	650	650	530	170
		D/ce	73	61	255	200	420	780
STITCHING	C1	Target	400	400	400	400	400	400
		Actual	300	260	280	290	280	130
		D/ce	100	140	120	110	120	270
	C2	Target	400	425	400	400	400	400
		Actual	420	406	450	450	480	240
		D/ce	-20	19	-50	-50	-80	160
LASTING	C1	Target	450	450	450	450	450	450
		Actual	202	265	312	338	285	140
		D/ce	248	185	138	112	165	310
	C2	Target	350	350	350	350	350	350
		Actual	241	263	204	256	292	150
		D/ce	109	87	146	94	58	200
MOCASSIN		Target	250	250	250	250	250	250
		Actual	184	192	196	202	222	193
		D/ce	66	58	54	48	28	57
INSOLE		Target	1200	1200	1200	1200	1200	1200
		Actual	491	584	520	400	480	290
		D/ce	709	616	680	800	720	910

Table of week 12:- collected data of weekly production report of all section

		DIRE INDUSTRIES PLC.							
		PEACOCK SHOE FACTORY							
		WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS							
		WEEKLY PRODUCTION							Total pro
DEPT	LINE	29/3/2012	30/3/2012	1/4/2012	2/4/2012	3/4/2012	4/4/2012		
CUTTING		Target	993	836	905	850	950	950	5484
		Actual	460	60	203	493	861	140	2217
		D/ce	533	776	702	357	89	810	3267
STITCHING	C1	Target	400	400	400	400	400	400	2400
		Actual	300	270	305	243	301	180	1599
		D/ce	100	130	95	157	99	220	801
	C2	Target	400	425	400	400	400	400	2425
		Actual	400	400	500	360	480	230	2370
		D/ce	0	25	-100	40	-80	170	55
LASTING	C1	Target	300	300	300	300	300	150	1650
		Actual	370	346	380	369	361	189	2015
		D/ce	-70	-46	-80	-69	-61	-39	-365
	C2	Target	300	300	300	300	300	150	1650
		Actual	293	248	266	137	257	156	1357
		D/ce	7	52	34	163	43	-6	293
MOCASSIN		Target	250	250	250	250	250	250	1500
		Actual	196	220	211	218	209	87	1141
		D/ce	54	30	39	32	41	163	359
INSOLE		Target	1200	1200	1200	1200	1200	1200	7200
		Actual	440	568	400	410	491	264	2573
		D/ce	760	632	800	790	709	936	4627

Table of week 13 :- collected data of weekly production report of all section

		DIRE INDUSTRIES PLC.							
		PEACOCK SHOE FACTORY							
		WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS							
		WEEKLY PRODUCTION							Total pro
DEPT	LINE	6/4/2012	7/4/2012	8/4/2012	9/4/2012	10/4/2012	11/4/2012		
CUTTING		Target	993	836	905	850	950	950	5484
		Actual	301	160	224	340	390	190	1605
		D/ce	692	676	681	510	560	760	3879
STITCHING	C1	Target	400	400	400	400	400	400	2400
		Actual	282	240	260	277	310	160	1529
		D/ce	118	160	140	123	90	240	871
	C2	Target	400	425	400	400	400	400	2425
		Actual	415	440	350	181	188	101	1675
		D/ce	-15	-15	50	219	212	299	750
LASTING	C1	Target	300	300	300	300	300	150	1650
		Actual	337	406	423	421	380	202	2169
		D/ce	-37	-106	-123	-121	-80	-52	-519
	C2	Target	300	300	300	300	300	150	1650
		Actual	299	323	252	280	252	82	1488
		D/ce	1	-23	48	20	48	68	162
MOCASSIN		Target	250	250	250	250	250	250	1500
		Actual	163	157	165	204	201	89	979
		D/ce	87	93	85	46	49	161	521
INSOLE		Target	1200	1200	1200	1200	1200	1200	7200
		Actual	621	631	692	695	777	344	3760
		D/ce	579	569	508	505	423	856	3440

Table of week 14 :- collected data of weekly production report of all section

		DIRE INDUSTRIES PLC.						
		PEACOCK SHOE FACTORY						
		WEAKLY PRODUCTION REPORT OF ALL DIPARTMENTS						
		WEEKLY PRODUCTION						Total pro
DEPT	LINE	13/4/2012	14/4/2012	15/4/2012	16/4/2012	17/4/2012	18/4/2012	
CUTTING		Target	993	836	905	850	950	5484
		Actual	398	711	550	670	520	2869
		D/ce	595	125	355	180	430	2615
STITCHING	C1	Target	400	400	400	400	400	2400
		Actual	161	259	264	269	260	1343
		D/ce	239	141	136	131	140	1057
	C2	Target	400	425	400	400	400	2425
		Actual	230	250	148	168	200	1106
		D/ce	170	175	252	232	200	1319
LASTING	C1	Target	300	300	300	300	300	1650
		Actual	471	483	224	321	227	1852
		D/ce	-171	-183	76	-21	73	-202
	C2	Target	300	300	300	300	300	1650
		Actual	160	268	251	218	244	1226
		D/ce	140	32	49	82	56	424
MOCASSIN		Target	250	250	250	250	250	1500
		Actual	219	198	240	280	285	1354
		D/ce	31	52	10	-30	-35	146
INSOLE		Target	1200	1200	1200	1200	1200	7200
		Actual	601	360		113	573	1977
		D/ce	599	840	1200	1087	627	5223

Table of week 15 :- collected data of weekly production report of all section

DIRE INDUSTRIES PLC.									
PEACOCK SHOE FACTORY									
PEACOCK FOOTWEAR WEEKLY PERFORMANCE REPORT OF ALL DIPARTMENTS									
WEEKLY PRODUCTION									Total pro
DEPT	LINE	20/4/2012		21/4/2012	22/4/2012	23/4/2012	24/4/2012	25/4/2012	
CUTTING		Target	993	836	905	850	950	950	5484
		Actual	80	483	1060	940	1510	490	4563
		D/ce	913	353	-155	-90	-560	460	921
STITCHING	C1	Target	400	400	400	400	400	400	2400
		Actual	300	340	320	240	325	160	1685
		D/ce	100	60	80	160	75	240	715
	C2	Target	400	425	400	400	400	400	2425
		Actual	300	403	440	430	440	220	2233
		D/ce	100	22	-40	-30	-40	180	192
LASTING	C1	Target	300	300	300	300	300	150	1650
		Actual	255	238	237	288	264	190	1472
		D/ce	45	62	63	12	36	-40	178
	C2	Target	300	300	300	300	300	150	1650
		Actual	130	235	235	238	220	119	1177
		D/ce	170	65	65	62	80	31	473
MOCASSIN		Target	250	250	250	250	250	250	1500
		Actual	260	304	299	274	298	139	1574
		D/ce	-10	-54	-49	-24	-48	111	-74
INSOLE		Target	1200	1200	1200	1200	1200	1200	7200
		Actual	660	565	590	470	680	300	3265
		D/ce	540	635	610	730	520	900	3935

Table of week 16 :- collected data of weekly production report of all section

		DIRE INDUSTRIES PLC.							
		PEACOCK SHOE FACTORY							
		WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS							
		WEEKLY PRODUCTION							Total pro
DEPT	LINE	27/4/2012	28/4/2012	29/4/2012	30/4/2012	1/4/2012	2/4/2012		
CUTTING		Target	993	836	905	850	950	950	5484
		Actual	1175		1060	1125	983	377	4720
		D/ce	-182	836	-155	-275	-33	573	764
STITCHING	C1	Target	400	400	400	400	400	400	2400
		Actual	280		290	195	220	110	1095
		D/ce	120	400	110	205	180	290	1305
	C2	Target	400	425	400	400	400	400	2425
		Actual	370		360	396	360	200	1686
		D/ce	30	425	40	4	40	200	739
LASTING	C1	Target	300	300	300	300	300	150	1650
		Actual	308		272	400	418	217	1615
		D/ce	-8	300	28	-100	-118	-67	35
	C2	Target	300	300	300	300	300	150	1650
		Actual	200		177	300	330	175	1182
		D/ce	100	300	123	0	-30	-25	468
MOCASSIN		Target	250	250	250	250	250	250	1500
		Actual	232		300	234	207	70	1043
		D/ce	18	250	-50	16	43	180	457
INSOLE		Target	1200	1200	1200	1200	1200	1200	7200
		Actual	460		440	490	479	270	2139
		D/ce	740	1200	760	710	721	930	5061

Table of week 17 :- collected data of weekly production report of all sections

		DIRE INDUSTRIES PLC.						
		PEACOCK SHOE FACTORY						
		WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS						
		WEEKLY PRODUCTION						Total pro
DEPT	LINE	4/5/2012	5/5/2012	6/5/2012	7/5/2012	8/5/2012	9/5/2012	
CUTTING		Target	993	836	905	850	950	5484
		Actual	1002	755	620	180	509	3466
		D/ce	-9	81	285	670	441	2018
STITCHING	C1	Target	400	400	400	400	400	2400
		Actual	230	240	300	300	250	1470
		D/ce	170	160	100	100	150	930
	C2	Target	400	425	400	400	400	2425
		Actual	450	500	530	500	520	2800
		D/ce	-50	-75	-130	-100	-120	-375
LASTING	C1	Target	300	300	300	300	300	1650
		Actual	500	329	366	502	415	2362
		D/ce	-200	-29	-66	-202	-115	-712
	C2	Target	300	300	300	300	300	1650
		Actual	163	253	222	415	365	1603
		D/ce	137	47	78	-115	-65	47
MOCASSIN		Target	250	250	250	250	250	1500
		Actual	71	100	112	92	117	576
		D/ce	179	150	138	158	133	924
INSOLE		Target	1200	1200	1200	1200	1200	7200
		Actual	630	553	590	562	560	3205
		D/ce	570	647	610	638	640	3995

Table of week 18 :- collected data of weekly production report of all sections

		DIRE INDUSTRIES PLC.					
		PEACOCK SHOE FACTORY					
		WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS					
		WEEKLY PRODUCTION					Total pro
DEPT	LINE		13/5/2012	14/5/2012	15/5/2012	16/5/2012	
CUTTING		Target	905	850	950	950	3655
		Actual	674	1017	1102	683	3476
		D/ce	231	-167	-152	267	179
STITCHING	C1	Target	400	400	400	400	1600
		Actual	260	250	240	120	870
		D/ce	140	150	160	280	730
	C2	Target	400	400	400	400	1600
		Actual	480	540	500	260	1780
		D/ce	-80	-140	-100	140	-180
LASTING	C1	Target	300	300	300	150	1050
		Actual	456	441	423	177	1497
		D/ce	-156	-141	-123	-27	-447
	C2	Target	300	300	300	150	1050
		Actual	330	312	200	110	952
		D/ce	-30	-12	100	40	98
MOCASSIN		Target	250	250	250	250	1000
		Actual	148	187	189	78	602
		D/ce	102	63	61	172	398
INSOLE		Target	1200	1200	1200	1200	4800
		Actual	520	580	650	310	2060
		D/ce	680	620	550	890	2740

Table of week 19 :- collected data of weekly production report of all sections

DIRE INDUSTRIES PLC.								
PEACOCK SHOE FACTORY								
WEEKLY PERFORMANCE REPORT OF ALL DIPARTMENTS								
WEEKLY PRODUCTION								
DEPT	LINE		18/5/2012	19/5/2012	20/5/2012	21/5/2012	22/5/2012	23/5/2012
CUTTING		Target	993	836	905	850	950	950
		Actual	534	280	470	420	60	680
		D/ce	459	556	435	430	890	270
STITCHING	C1	Target	400	400	400	400	400	400
		Actual	240	270	240	300	300	80
		D/ce	160	130	160	100	100	320
	C2	Target	400	425	400	400	400	400
		Actual	517	520	592	500	520	270
		D/ce	-117	-95	-192	-100	-120	130
LASTING	C1	Target	300	300	300	300	300	150
		Actual	461	335	305	253	350	178
		D/ce	-161	-35	-5	47	-50	-28
	C2	Target	300	300	300	300	300	150
		Actual	257	258	251	232	175	105
		D/ce	43	42	49	68	125	45
MOCASSIN		Target	250	250	250	250	250	250
		Actual	212	214	214	221	252	135
		D/ce	38	36	36	29	-2	115
INSOLE		Target	1200	1200	1200	1200	1200	1200
		Actual	770	520	720	708	660	290
		D/ce	430	680	480	492	540	910

Table of week 20 :- collected data of weekly production report of all sections

DIRE INDUSTRIES PLC.									
PEACOCK SHOE FACTORY									
WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS									
PEACOCK F O O T W E A R		WEEKLY PRODUCTION							Total pro
DEPT	LINE		25/5/2012	26/5/2012	27/5/2012	28/5/2012	29/5/2012	30/5/2012	
CUTTING		Target	993	836	905	850	950	950	5484
		Actual	590	350	572	550	170		2232
		D/ce	403	486	333	300	780	950	3252
STITCHING	C1	Target	400	400	400	400	400	400	2400
		Actual	200	200	155	334	380	403	1672
		D/ce	200	200	245	66	20	-3	728
	C2	Target	400	425	400	400	400	400	2425
		Actual	540	527	427	430	409	240	2573
		D/ce	-140	-102	-27	-30	-9	160	-148
LASTING	C1	Target	300	300	300	300	300	150	1650
		Actual	332	382	444	490	475	207	2330
		D/ce	-32	-82	-144	-190	1	-57	-504
	C2	Target	300	300	300	300	300	150	1650
		Actual	212	256	180	168	213	90	1119
		D/ce	88	44	120	132	87	60	531
MOCASSIN		Target	250	250	250	250	250	250	1500
		Actual	139	176	187	213	276	141	1132
		D/ce	111	74	63	37	-26	109	368
INSOLE		Target	1200	1200	1200	1200	1200	1200	7200
		Actual	550	517	500	350	310	330	2557
		D/ce	650	683	700	850	890	870	4643

Table of week 21 :- collected data of weekly production report of all sections

		DIRE INDUSTRIES PLC.							
		PEACOCK SHOE FACTORY							
		WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS							
		WEEKLY PRODUCTION							Total pro
DEPT	LINE	2/6/2012	3/6/2012	4/6/2012	5/6/2012	6/6/2012	7/6/2012		
CUTTING		Target	993	836	905	850	950	950	5484
		Actual	920	430	960	470	1010	60	3850
		D/ce	73	406	-55	380	-60	890	1634
STITCHING	C1	Target	400	400	400	400	400	400	2400
		Actual	370	314	400	400	400	200	2084
		D/ce	30	86	0	0	0	200	316
	C2	Target	400	425	400	400	400	400	2425
		Actual	343	153	184	260	240	200	1380
		D/ce	57	272	216	140	160	200	1045
LASTING	C1	Target	300	300	300	300	300	150	1650
		Actual	389	382	458	328	440	179	2176
		D/ce	-89	-82	-158	-28	1	-29	-385
	C2	Target	300	300	300	300	300	150	1650
		Actual	230	350	385	400	413	522	2300
		D/ce	70	-50	-85	-100	-113	-372	-650
MOCASSIN		Target	250	250	250	250	250	250	1500
		Actual	183	168	173	166	195	68	953
		D/ce	67	82	77	84	55	182	547
INSOLE		Target	1200	1200	1200	1200	1200	1200	7200
		Actual	420	530	600	787	930	585	3852
		D/ce	780	670	600	413	270	615	3348

Table of week 22 :- collected data of weekly production report of all sections

		DIRE INDUSTRIES PLC.							
		PEACOCK SHOE FACTORY							
		WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS							
		WEEKLY PRODUCTION							Total pro
DEPT	LINE	9/6/2012		10/6/2012	11/6/2012	12/6/2012	13/6/2012	14/6/2012	
CUTTING		Target	993	836	905	850	950	950	5484
		Actual	883	560	80	278	460	170	2431
		D/ce	110	276	825	572	490	780	3053
STITCHING	C1	Target	400	29	400	400	400	400	2029
		Actual	400	400	460	400	480	240	2380
		D/ce	0	-371	-60	0	-80	160	-351
	C2	Target	400	425	400	400	400	400	2425
		Actual	410	250	180	260	240	120	1460
		D/ce	-10	175	220	140	160	280	965
LASTING	C1	Target	300	300	300	300	300	150	1650
		Actual	416	359	400	350	429	162	2116
		D/ce	-116	-59	-100	-50	1	-12	-336
	C2	Target	300	300	300	300	300	150	1650
		Actual	415	230	382	375	320	57	1779
		D/ce	-115	70	-82	-75	-20	93	-129
MOCASSIN		Target	250	250	250	250	250	250	1500
		Actual	181	168	243	251	74	4	921
		D/ce	69	82	7	-1	176	246	579
INSOLE		Target	1200	1200	1200	1200	1200	1200	7200
		Actual	812	795	955	813	760	440	4575
		D/ce	388	405	245	387	440	760	2625

Table of week 23 :- collected data of weekly production report of all sections

		DIRE INDUSTRIES PLC.							
		PEACOCK SHOE FACTORY							
		PEACOCK FOOTWEAR							
		WEEKLY PERFORMANCE REPORT OF ALL DIPARTMENTS							
		WEEKLY PRODUCTION							Total pro
DEPT	LIN E	16/6/2012	17/6/2012	18/6/2012	19/6/2012	20/6/2012	21/6/2012		
CUTTING		Target	993	836	905	850	950	950	5484
		Actual	330	310	736	1160	1149	390	4075
		D/ce	663	526	169	-310	-199	560	1409
STITCHING	C1	Target	400	29	400	400	400	400	2029
		Actual	350	240	260	260	260	130	1500
		D/ce	50	-211	140	140	140	270	529
	C2	Target	400	425	400	400	400	400	2425
		Actual	250	270	208	310	456	222	1716
		D/ce	150	155	192	90	-56	178	709
LASTING	C1	Target	300	300	300	300	300	150	1650
		Actual	162	221	180	280	378	533	1754
		D/ce	138	79	120	20	1	-383	-25
	C2	Target	300	300	300	300	300	150	1650
		Actual	218	300	323	218	243	110	1412
		D/ce	82	0	-23	82	57	40	238
MOCASSIN		Target	250	250	250	250	250	250	1500
		Actual	6	5					11
		D/ce	244	245	250	250	250	250	1489
INSOLE		Target	1200	1200	1200	1200	1200	1200	7200
		Actual	640	691	742	920	887	600	4480
		D/ce	560	509	458	280	313	600	2720

Table of week 24 :- collected data of weekly production report of all sections

		DIRE INDUSTRIES PLC.						
		PEACOCK SHOE FACTORY						
		PEACOCK FOOTWEAR						
		WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS						
		WEEKLY PRODUCTION						Total pro
DEPT	LINE		24/6/2012	25/6/2012	26/6/2012	27/6/2012	28/6/2012	
CUTTING		Target	836	905	850	950	950	4491
		Actual	831	717	1117	1336	530	4531
		D/ce	5	188	-267	-386	420	-40
STITCHING	C1	Target	29	400	400	400	400	1629
		Actual	320	400	380	337	180	1617
		D/ce	-291	0	20	63	220	12
	C2	Target	425	400	400	400	400	2025
		Actual	502	503	506	510	260	2281
		D/ce	-77	-103	-106	-110	140	-256
LASTING	C1	Target	300	300	300	300	150	1350
		Actual	405	400	430	420	248	1903
		D/ce	-105	-100	-130	1	-98	-432
	C2	Target	300	300	300	300	150	1350
		Actual	303	301	350	420	193	1567
		D/ce	-3	-1	-50	-120	-43	-217
MOCASSIN		Target	250	250	250	250	250	1250
		Actual	2	6	2			10
		D/ce	248	244	248	250	250	1240
INSOLE		Target	1200	1200	1200	1200	1200	6000
		Actual	877	960	896	870	500	4103
		D/ce	323	240	304	330	700	1897

Table of week 25 :- collected data of weekly production report of all sections

		DIRE INDUSTRIES PLC.						
		PEACOCK SHOE FACTORY						
		WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS						
		WEEKLY PRODUCTION						Total pro
DEPT	LINE	30/6/2012	1/7/2012	2/7/2012	3/7/2012	4/7/2012	5/7/2012	
CUTTING		Target	993	836	905	850	950	5484
		Actual	1056	870	720	1201	800	5047
		D/ce	-63	-34	185	-351	150	437
STITCHING	C1	Target	400	29	400	400	400	2029
		Actual	320	325	360	320	288	1763
		D/ce	80	-296	40	80	112	266
	C2	Target	400	425	400	400	400	2425
		Actual	500	508	479	240	390	2377
		D/ce	-100	-83	-79	160	10	48
LASTING	C1	Target	300	300	300	300	300	1650
		Actual	460	350	386	370	360	2107
		D/ce	-160	-50	-86	-70	1	-396
	C2	Target	300	300	300	300	300	1650
		Actual	330	322	300	329	287	1728
		D/ce	-30	-22	0	-29	13	-78
MOCASSIN		Target	250	250	250	250	250	1500
		Actual						0
		D/ce	250	250	250	250	250	1500
INSOLE		Target	1200	1200	1200	1200	1200	7200
		Actual	973	706	818	230	490	3597
		D/ce	227	494	382	970	710	3603

Table of week 26 :- collected data of weekly production report of all sections

		DIRE INDUSTRIES PLC.						
		PEACOCK SHOE FACTORY						
		WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS						
		WEEKLY PRODUCTION						Total pro
DEPT	LINE		7/6/2012	8/7/2012	9/7/2012	10/7/2012	11/7/2012	12/7/2012
CUTTING		Target	993	836	905	850	950	950
		Actual	700	940	760	780	1230	640
		D/ce	293	-104	145	70	-280	310
STITCHING	C1	Target	400	29	400	400	400	400
		Actual	300	300	320	380	380	180
		D/ce	100	-271	80	20	20	220
	C2	Target	400	425	400	400	400	400
		Actual	571	560	480	400	195	40
		D/ce	-171	-135	-80	0	205	360
LASTING	C1	Target	300	300	300	300	300	150
		Actual	310	374	444	473	453	206
		D/ce	-10	-74	-144	-173	1	-56
	C2	Target	300	300	300	300	300	150
		Actual	235	285	280	228	165	128
		D/ce	65	15	20	72	135	22
MOCASSIN		Target	250	250	250	250	250	250
		Actual						
		D/ce	250	250	250	250	250	250
INSOLE		Target	1200	1200	1200	1200	1200	1200
		Actual	786	530	622	840	560	310
		D/ce	414	670	578	360	640	890

Table of week 27:- collected data of weekly production report of all sections

		DIRE INDUSTRIES PLC.						
		PEACOCK SHOE FACTORY						
		WEEKLY PERFORMANCE REPORT OF ALL DIPARTMENTS						
		WEEKLY PRODUCTION						Total pro
DEPT	LINE	21/6/2012	22/7/2012	23/7/2012	24/7/2012	25/7/2012	26/7/2012	
CUTTING		Target	993	836	905	850	950	5484
		Actual	670	60	740	210	800	2780
		D/ce	323	776	165	640	150	2704
STITCHING	C1	Target	400	29	400	400	400	2029
		Actual	280	0		110	90	480
		D/ce	120	29	400	290	310	1549
	C2	Target	400	425	400	400	400	2425
		Actual	280	280	320	320	340	1720
		D/ce	120	145	80	80	60	705
LASTING	C1	Target	300	300	300	300	300	1650
		Actual	296					296
		D/ce	4	300	300	300	1	1055
	C2	Target	300	300	300	300	300	1650
		Actual	279	300	280	380	450	1900
		D/ce	21	0	20	-80	-150	-250
MOCASSIN		Target	250	250	250	250	250	1500
		Actual						0
		D/ce	250	250	250	250	250	1500
INSOLE		Target	1200	1200	1200	1200	1200	7200
		Actual	600	595	460	530	389	2834
		D/ce	600	605	740	670	811	4366

Table of week 28 :- collected data of weekly production report of all sections

		DIRE INDUSTRIES PLC.						
		PEACOCK SHOE FACTORY						
		WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS						
		WEEKLY PRODUCTION						Total pro
DEPT	LINE	28/7/2012	29/7/2012	30/7/2012	1/8/2012	2/8/2012	3/8/2012	
CUTTING		Target	993	836	905	850	950	5484
		Actual	660	900	750	830	1018	4718
		D/ce	333	-64	155	20	-68	766
STITCHING	C1	Target	400	29	400	400	400	2029
		Actual	140					140
		D/ce	260	29	400	400	400	1889
	C2	Target	400	425	400	400	400	2425
		Actual	340	360	450	500	560	2762
		D/ce	60	65	-50	-100	-160	-337
LASTING	C1	Target	300	300	300	300	300	1650
		Actual						0
		D/ce	300	300	300	300	1	1351
	C2	Target	300	300	300	300	300	1650
		Actual	381	394	376	426	481	2274
		D/ce	-81	-94	-76	-126	-181	-624
MOCASSIN		Target	250	250	250	250	250	1500
		Actual		0	0	0	0	0
		D/ce	250	250	250	250	250	1500
INSOLE		Target	1200	1200	1200	1200	1200	7200
		Actual	330	440	430	610	728	2778
		D/ce	870	760	770	590	472	4422

Table of week 29 :- collected data of weekly production report of all sections

DIRE INDUSTRIES PLC.								
PEACOCK SHOE FACTORY								
PEACOCK FOOTWEAR WEEKLY PERFORMANCE REPORT OF ALL DIPARTMENTS								
WEEKLY PRODUCTION								Total pro
DEPT	LINE		5/8/2012	6/8/2012	7/8/2012	8/8/2012	9/8/2012	10/8/2012
CUTTING		Target	993	836	905	850	950	950
		Actual	950	1249	1420	1478		780
		D/ce	43	-413	-515	-628	950	170
STITCHING	C1	Target	400	29	400	400	400	400
		Actual	150	180	201	201		
		D/ce	250	-151	199	199	400	400
	C2	Target	400	425	400	400	400	400
		Actual	560	560	560	600		315
		D/ce	-160	-135	-160	-200	400	85
LASTING	C1	Target	300	300	300	300	300	150
		Actual	275	480	530	550		172
		D/ce	25	-180	-230	-250	1	-22
	C2	Target	300	300	300	300	300	150
		Actual	388	462	550	520		124
		D/ce	-88	-162	-250	-220	300	26
MOCASSIN		Target	250	250	250	250	250	250
		Actual						
		D/ce	250	250	250	250	250	250
INSOLE		Target	1200	1200	1200	1200	1200	1200
		Actual	500	560	630	650		310
		D/ce	700	640	570	550	1200	890

Table of week 30 :- collected data of weekly production report of all sections

DIRE INDUSTRIES PLC.									
PEACOCK SHOE FACTORY									
PEACOCK FOOTWEAR WEEKLY PERFORMANCE REPORT OF ALL DIPARTMENTS									
WEEKLY PRODUCTION									Total pro
DEPT	LINE	12/8/2012		13/8/2012	14/8/2012	15/8/2012	16/8/2012	17/8/2012	
CUTTING		Target	993	836	905	850	950	950	4491
		Actual		1434	1465	955	258		4112
		D/ce	993	-598	-560	-105	692	950	379
STITCHING	C1	Target	400	29	400	400	400	400	1629
		Actual		220	230	350	408	200	1408
		D/ce	400	-191	170	50	-8	200	221
	C2	Target	400	425	400	400	400	400	2025
		Actual		550	570	400	404	220	2144
		D/ce	400	-125	-170	0	-4	180	-119
LASTING	C1	Target	300	300	300	300	300	150	1350
		Actual		506	501	480	478	211	2176
		D/ce	300	-206	-201	-180	1	-61	-647
	C2	Target	300	300	300	300	300	150	1350
		Actual		501	460	480	487	497	2425
		D/ce	300	-201	-160	-180	-187	-347	-1075
MOCASSIN		Targe	250	250	250	250	250	250	1250
		Actua							0
		D/ce	250	250	250	250	250	250	1250
INSOLE		Targe	1200	1200	1200	1200	1200	1200	6000
		Actua		590	870	570	636	430	3096
		D/ce	1200	610	330	630	564	770	2904

Table of week 31 :- collected data of weekly production report of all sections

		DIRE INDUSTRIES PLC.						
		PEACOCK SHOE FACTORY						
		WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS						
		WEEKLY PRODUCTION						Total pro
DEPT	LINE		19/8/2012	20/8/2012	21/8/2012	22/8/2012	23/8/2012	24/8/2012
CUTTING		Target	993	836	905	850	950	950
		Actual	643	916	447	565		200
		D/ce	350	-80	458	285	950	750
STITCHING	C1	Target	400	29	400	400	400	400
		Actual	400	400	440	500		260
		D/ce	0	-371	-40	-100	400	140
	C2	Target	400	425	400	400	400	400
		Actual	300	540	338	530		283
		D/ce	100	-115	62	-130	400	117
LASTING	C1	Target	300	300	300	300	300	150
		Actual	312	360	424	467		193
		D/ce	-12	-60	-124	-167	1	-43
	C2	Target	300	300	300	300	300	150
		Actual	459	490	432	497		520
		D/ce	-159	-190	-132	-197	300	-370
MOCASSIN		Target	250	250	250	250	250	250
		Actual						
		D/ce	250	250	250	250	250	250
INSOLE		Target	1200	1200	1200	1200	1200	1200
		Actual	650	860	1414	1496		650
		D/ce	550	340	-214	-296	1200	550

Table of week 32 :- collected data of weekly production report of all sections

		DIRE INDUSTRIES PLC.						
		PEACOCK SHOE FACTORY						
		WEEKLY PERFORMANCE REPORT OF ALL DIPARTMENTS						
		WEEKLY PRODUCTION						Total pro
DEPT	LINE	26/8/2012	27/8/2012	28/2012	29/8/2012	30/8/2012	1/8/2012	
CUTTING		Target	993	836	905	850	950	4491
		Actual	480		953	915	872	2870
		D/ce	513	836	-48	-65	78	1621
STITCHING	C1	Target	400	29	400	400	400	1629
		Actual	430		500	250	566	1602
		D/ce	-30	29	-100	150	-166	27
	C2	Target	400	425	400	400	400	2025
		Actual	440		485	230	537	1402
		D/ce	-40	425	-85	170	-137	623
LASTING	C1	Target	500	500	500	500	250	2250
		Actual	520		472	125	615	1426
		D/ce	-20	500	28	375	1	940
	C2	Target	300	300	300	300	150	1350
		Actual	491		495	481	522	1990
		D/ce	-191	300	-195	-181	-222	-640
MOCASSIN		Target	250	250	250	250	250	1250
		Actual						0
		D/ce	250	250	250	250	250	1250
INSOLE		Target	1200	1200	1200	1200	1200	6000
		Actual	1060		1160	590	360	2290
		D/ce	140	1200	40	610	840	3710

Table of week 33 :- collected data of weekly production report of all sections

		DIRE INDUSTRIES PLC.							
		PEACOCK SHOE FACTORY							
		WEEKLY PERFORMANCE REPORT OF ALL DIPARTMENTS							
		WEEKLY PRODUCTION							Total pro
DEPT	LINE	3/9/2012		4/9/2012	5/9/2012	6/9/2012	7/9/2012	8/9/2012	
CUTTING		Target	1050	1066	1050	1050	1050	450	5716
		Actual	321	229	744	1200	1233	30	3757
		D/ce	729	837	306	-150	-183	420	1959
STITCHING	C1	Target	550	550	550	550	550	350	3100
		Actual	360	430	473	458	440	200	2361
		D/ce	190	120	77	92	110	150	739
	C2	Target	450	450	450	450	400	200	2400
		Actual	290	430	350	274	310	120	1774
		D/ce	160	20	100	176	90	80	626
LASTING	C1	Target	500	500	500	500	500	250	2750
		Actual	403	347	400	400	426	220	2196
		D/ce	97	153	100	100	1	30	481
	C2	Target	500	520	490	415	410	225	2560
		Actual	485	455	428	400	420	223	2411
		D/ce	15	65	62	15	-10	2	149
MOCASSIN		Target	250	250	250	250	250	250	1500
		Actual	8	8	9	84	161	90	360
		D/ce	242	242	241	166	89	160	1140
INSOLE		Target	1200	1200	1200	1200	1200	1200	7200
		Actual	550	660	570	640	709	280	3409
		D/ce	650	540	630	560	491	920	3791

Table of week 34 :- collected data of weekly production report of all sections

		DIRE INDUSTRIES PLC.						
		PEACOCK SHOE FACTORY						
		WEEKLY PERFORMANCE REPORT OF ALL DIPARTMENTS						
		WEEKLY PRODUCTION						
DEPT	LINE		10/9/2012	11/9/2012	12/9/2012	13/09/2012	14/09/2011	15/09/2011
CUTTING		Target	1250	1000	1250	100	1050	450
		Actual	1300	1230	1233	760	1282	638
		D/ce	-50	-230	17	-660	-232	-188
STITCHING	C1	Target	500	450	450	450	450	200
		Actual	450	452	405	350	440	200
		D/ce	50	-2	45	100	10	0
	C2	Target	450	520	500	500	500	250
		Actual	201	270	300	550	530	270
		D/ce	249	250	200	-50	-30	-20
LASTING	C1	Target	480	480	480	480	480	480
		Actual	515	464	504	585	360	154
		D/ce	-35	16	-24	-105	120	326
	C2	Target	420	450	445	450	420	205
		Actual	430	379	509	445	455	192
		D/ce	-10	71	-64	5	-35	13
MOCASSIN		Target	180	180	180	180	100	
		Actual	166	174	183	189	96	6
		D/ce	14	6	-3	-9	4	-6
INSOLE		Target	1200	1200	1200	1200	1200	650
		Actual	560	700	616	732	770	440
		D/ce	640	500	584	468	430	210

Table of week 35 :- collected data of weekly production report of all sections

DIRE INDUSTRIES PLC.									
PEACOCK SHOE FACTORY									
WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS									
WEEKLY PRODUCTION									
DEPT	LINE	10/9/2011		11/9/2011	12/9/2011	13/09/2011	14/09/2011	15/09/2011	Total pro
CUTTING		Target	1250	1000	1250	100	1050	450	5100
		Actual	1300	1230	1233	760	1282	638	6443
		D/ce	-50	-230	17	-660	-232	-188	-1343
STITCHING	C1	Target	500	450	450	450	450	200	2500
		Actual	450	452	405	350	440	200	2297
		D/ce	50	-2	45	100	10	0	203
	C2	Target	450	520	500	500	500	250	2720
		Actual	201	270	300	550	530	270	2121
		D/ce	249	250	200	-50	-30	-20	599
LASTING	C1	Target	480	480	480	480	480	480	2880
		Actual	515	464	504	585	360	154	2582
		D/ce	-35	16	-24	-105	120	326	298
	C2	Target	420	450	445	450	420	205	2390
		Actual	430	379	509	445	455	192	2410
		D/ce	-10	71	-64	5	-35	13	-20
MOCASSIN		Target	180	180	180	180	100		820
		Actual	166	174	183	189	96	6	814
		D/ce	14	6	-3	-9	4	-6	6
INSOLE		Target	1200	1200	1200	1200	1200	650	6650
		Actual	560	700	616	732	770	440	3818
		D/ce	640	500	584	468	430	210	2832

Table of week 36 :- collected data of weekly production report of all sections

		DIRE INDUSTRIES PLC.						
		PEACOCK SHOE FACTORY						
		WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS						
		WEEKLY PRODUCTION						Ttotal pro
DEPT	LINE	17/9/2012	18/9/2012	19/9/2012	21/9/2012	22/9/2012		
CUTTING		Target	1200	1200	1350	1350	675	5775
		Actual	665	1004	933	680	200	3482
		D/ce	535	196	417	670	475	2293
STITCHING	C1	Target	450	450	450	450	225	2025
		Actual	450	400	480	480	180	1990
		D/ce	0	50	-30	-30	45	35
	C2	Target	600	600	600	600	300	2700
		Actual	550	560	500	303	230	2143
		D/ce	50	40	100	297	70	557
LASTING	C1	Target	500	500	500	500	500	2500
		Actual	271	346	400	595	461	2073
		D/ce	229	154	100	1	39	523
	C2	Target	445	420	410	400	208	1883
		Actual	328	340	416	366	112	1562
		D/ce	117	80	-6	34	96	321
MOCASSIN		Target						0
		Actual	10		10	10	4	34
		D/ce	-10	0	-10	-10	-4	-34
INSOLE		Target	1200	1200	1200	1200	600	5400
		Actual	800	872	920	846	260	3698
		D/ce	400	328	280	354	340	1702

Table of week 37 :- collected data of weekly production report of all sections

 DIRE INDUSTRIES PLC. PEACOCK SHOE FACTORY PEACOCK FOOTWEAR WEEKLY PERFORMANCE REPORT OF ALL DIPARTMENTS									
		WEEKLY PRODUCTION							Total pro
DEPT	LINE	24/9/2012	25/9/2012	26/9/2012	27/9/2012	28/9/2012	29/9/2012		
CUTTING		Target	1210	1163	1090	1014	1090	600	6167
		Actual	490	330	730	720	360	170	2800
		D/ce	720	833	360	294	730	430	3367
STITCHING	C1	Target	480	480	480	480	480	240	2640
		Actual	480	500	200	240	320	160	1900
		D/ce	0	-20	280	240	160	80	740
	C2	Target	600	600	600	600	400	300	3100
		Actual	600	510	380	610	640	303	3043
		D/ce	0	90	220	-10	-240	-3	57
LASTING	C1	Target	660	660	660	660	660	330	3630
		Actual	488	694	639	598	685	282	3386
		D/ce	172	-34	21	62	1	48	270
	C2	Target	405	420	420	420	420	210	2295
		Actual	335	350	290	280	370	134	1759
		D/ce	70	70	130	140	50	76	536
MOCASSIN		Target							0
		Actual	8	7	7	8	8		38
		D/ce	-8	-7	-7	-8	-8	0	-38
INSOLE		Target	1200	1200	1200	1200	1200	600	6600
		Actual	852	636	642	718	384	326	3558
		D/ce	348	564	558	482	816	274	3042

Table of week 38 :- collected data of weekly production report of all sections

DIRE INDUSTRIES PLC.								
PEACOCK SHOE FACTORY								
PEACOCK F O O T W E A R								
WEEKLY PERFORMANCE REPORT OF ALL DIPARTMENTS								
WEEKLY PRODUCTION								Total pro
DEPT	LINE		1/10/2012	2/10/2012	3/10/2012	4/10/2012	5/10/2012	6/10/2012
CUTTING		Target	998	990	1090	1214	900	1250
		Actual	275	329	160	170	970	1027
		D/ce	723	661	930	1044	-70	223
STITCHING	C1	Target	419	490	490	100	1000	500
		Actual	300	265	400	400	120	400
		D/ce	119	225	90	-300	880	100
	C2	Target	700	700	700	700	7044	350
		Actual	600	470	500	500	500	560
		D/ce	100	230	200	200	6544	-210
LASTING	C1	Target	675	675	675	675	675	675
		Actual	620	556	670	534	600	721
		D/ce	55	119	5	141	75	-46
	C2	Target	410	410	410	410	410	205
		Actual	310	310	268	265	250	155
		D/ce	100	100	142	145	160	50
MOCASSIN		Target						0
		Actual	12	25	8	9	7	4
		D/ce	-12	-25	-8	-9	-7	-4
INSOLE		Target	1200	1200	1200	1200	1200	600
		Actual	656	655	612	840	1022	750
		D/ce	544	545	588	360	178	-150

Table of week 39:- collected data of weekly production report of all sections

		DIRE INDUSTRIES PLC.						
		PEACOCK SHOE FACTORY						
		WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS						
		WEEKLY PRODUCTION						
DEPT	LINE	8/10/2012	9/10/2012	10/10/2012	11/10/2012	12/10/2012	13/10/2012	Total pro
CUTTING		Target	600	600	600	600	300	3300
		Actual	496	562	440	443	308	2794
		D/ce	104	38	160	157	-8	506
STITCHING	C1	Target	443	383	600	600	300	2926
		Actual	250	340	527	504	200	2375
		D/ce	193	43	73	96	100	551
	C2	Target	700	700	450	250	150	2500
		Actual	500	600	620	170		2334
		D/ce	200	100	-170	-194	80	166
LASTING	C1	Target	675	675	675	675	675	4050
		Actual	625	759	758	644	686	4174
		D/ce	50	-84	-83	-27	-11	-154
	C2	Target	300	300	310	310	155	1685
		Actual	160	255	180	396	220	1431
		D/ce	140	45	130	-86	-65	254
MOCASSIN		Target						0
		Actual	9	8		8	5	38
		D/ce	-9	-8	0	-8	-5	-38
INSOLE		Target	1200	1200	1200	1200	600	6600
		Actual	1246	1010	916	904	600	5618
		D/ce	-46	190	284	296	0	982

Table of week 40 :- collected data of weekly production report of all sections

		DIRE INDUSTRIES PLC.						
		PEACOCK SHOE FACTORY						
		WEAKLY PERFORMANCE REPORT OF ALL DIPARTMENTS						
		WEEKLY PRODUCTION						
DEPT	LINE							Tota l pro
CUTTING		15/10/2012	16/10/2012	117/10/2012	18/10/2012	19/10/2012	129/10/2012	
		Target	600	600	600	600	300	3300
		Actual	496	562	440	545	443	2794
STITCHING	C1	D/ce	104	38	160	55	157	506
		Target	443	383	600	600	300	2926
		Actual	250	340	527	554	200	2375
	C2	D/ce	193	43	73	46	96	551
		Target	700	700	450	250	250	2500
		Actual	500	600	620	444	170	2334
LASTING	C1	D/ce	200	100	-170	-194	80	166
		Target	675	675	675	675	675	4050
		Actual	625	759	758	702	644	4174
	C2	D/ce	50	-84	-83	-27	1	-154
		Target	300	300	310	310	310	1685
		Actual	160	255	180	220	396	1431
MOCASSIN		D/ce	140	45	130	90	-86	254
		Target						0
		Actual	9	8		8	8	38
INSOLE		D/ce	-9	-8	0	-8	-8	-38
		Target	1200	1200	1200	1200	1200	6600
		Actual	1246	1010	916	904	942	5618
		D/ce	-46	190	284	296	258	982

Appendix two :-Control chart violation points; from SPSS v.20
A-Frist iteration

Rule Violations for Run	
pbar	Violations for Points
.06	Greater than +3 sigma
.07	Greater than +3 sigma
.07	2 points out of the last 3 above +2 sigma
.06	Greater than +3 sigma
.06	2 points out of the last 3 above +2 sigma
.06	4 points out of the last 5 above +1 sigma
.06	2 points out of the last 3 above +2 sigma
.06	4 points out of the last 5 above +1 sigma
.06	2 points out of the last 3 above +2 sigma
.06	4 points out of the last 5 above +1 sigma
.05	8 consecutive points above the center line
.05	4 points out of the last 5 below -1 sigma
.05	2 points out of the last 3 below -2 sigma
.05	4 points out of the last 5 below -1 sigma
.05	2 points out of the last 3 below -2 sigma
.05	4 points out of the last 5 below -1 sigma
.05	2 points out of the last 3 below -2 sigma

.05	4 points out of the last 5 below -1 sigma
.05	4 points out of the last 5 below -1 sigma
.05	8 consecutive points below the center line
.05	4 points out of the last 5 below -1 sigma
.05	8 consecutive points below the center line
.06	8 consecutive points below the center line
.06	8 consecutive points below the center line

14 points violate control rules.

B:-second iteration of control chart rule violation points

Rule Violations for Run	
LCL	Violations for Points
.04	Greater than +3 sigma
.04	2 points out of the last 3 above +2 sigma
.04	6 points in a row trending down
.04	Less than -3 sigma
.04	6 points in a row trending down
.04	Less than -3 sigma
.04	2 points out of the last 3 below -2 sigma
.04	6 points in a row trending down
.04	4 points out of the last 5 below -1 sigma
.04	Less than -3 sigma
.04	2 points out of the last 3 below -2 sigma
.04	4 points out of the last 5 below -1 sigma
.04	Less than -3 sigma

.04	2 points out of the last 3 below -2 sigma
.04	4 points out of the last 5 below -1 sigma
.04	Less than -3 sigma
.04	2 points out of the last 3 below -2 sigma
.04	4 points out of the last 5 below -1 sigma
.04	2 points out of the last 3 below -2 sigma
.04	4 points out of the last 5 below -1 sigma
.04	8 consecutive points below the center line
.04	4 points out of the last 5 below -1 sigma
.04	8 consecutive points below the center line
.04	6 points in a row trending up
.04	6 points in a row trending up
.05	Greater than +3 sigma
.05	2 points out of the last 3 above +2 sigma
.05	6 points in a row trending up
.05	Greater than +3 sigma
.05	2 points out of the last 3 above +2 sigma
.05	4 points out of the last 5 above +1 sigma
.04	Greater than +3 sigma
.04	2 points out of the last 3 above +2 sigma
.04	4 points out of the last 5 above +1 sigma

16 points violate control rules.

Appendix three: - weekly Defected amount

A:-Both B-grade and rejected

weeks	Conveyer one	Conveyer two	Total reject	Conveyer one	Conveyer two	Total B-grade	Total N ^o of defected
1	27	50	77	24	5	29	106
2	44	46	90	14	10	24	114
3	23	13	36	0	14	14	50
4	39	32	71	0	0	0	71
5	35	103	138	0	0	0	138
6	40	114	154	1	7	8	162
7	40	74	114	1	7	8	122
8	65	0	65	13	63	76	141
9	62	65	127	0	20	20	147
10	50	71	121	7	20	27	148
11	65	62	127	24	15	39	166
12	70	60	130	7	23	30	160
13	60	57	117	0	0	0	117
14	75	59	134	22	0	22	156
15	60	69	129	16	50	66	195
16	82	65	147	13	33	46	193
17	60	37	97	23	0	23	120
18	63	29	92	0	8	8	100
19	68	25	93	0	48	48	141
20	63	53	116	67	0	67	183
21	95	51	146	0	0	0	146
22	48	44	92	50	59	109	201
23	115	72	187	0	0	0	187
24	65	72	137	23	52	75	212
25	117	63	180	55	3	58	238
26	117	63	180	55	3	58	238
27	117	63	180	55	3	58	238
28	70	60	130	0	0	0	130
29	109	60	169	53	0	53	222
30	80	43	123	20	86	106	229
31	100	79	179	10	14	24	203
32	170	76	246	52	36	88	334
33	181	120	301	38	61	99	400
34	252	94	346	24	39	63	409
35	255	69	324	53	0	53	377
36	175	112	287	0	0	0	287

37	46	40	86	0	0	0	86
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B:- amount of defect pair its reason.

		Defect data							
No of week	No of piece defect	Loosening binding	More stretched	Broken stitching	Poor painting color	Broken leather	Miss attaching sole	Collapsed	Crack
1	141	42	12	3	7	31	27	12	7
2	147	23	28	15	25	34	14	8	0
3	148	35	12	45	10	23	0	23	0
4	166	59	12	43	8	6	21	9	8
5	160	32	2	23	36	17	37	12	1
6	117	47	25	17	0	9	15	0	4
7	156	10	44	17	30	17	9	29	0
8	195	101	11	10	39	13	10	11	0
9	193	62	42	3	58	21	0	7	0
10	120	56	0	10	29	11	0	13	1
11	100	37	3	11	11	8	4	19	7
12	141	34	12	32	21	9	13	20	0
13	183	17	14	75	43	8	3	20	3
14	146	32	25	20	10	5	3	32	19
15	201	67	21	46	12	9	23	17	7
16	187	87	40	1	45	12	3	0	0
17	212	85	94	15	8	3	0	0	7
18	238	132	42	17	26	12	0	7	2
19	238	112	54	62	1	0	4	0	4
20	238	108	73	44	12	0	0	1	0
21	130	32	43	5	32	3	4	9	2
22	222	67	54	32	42	0	12	7	8
23	229	99	9	23	12	54	22	2	8
24	203	44	46	32	42	2	4	12	21
25	334	98	36	74	54	21	36	2	13

26	400	125	58	45	52	63	50	0	7
27	409	102	79	46	61	58	38	20	5
28	377	111	57	28	39	67	28	40	7
29	287	70	26	52	40	24	45	25	5
30	86	32	7	0	15	9	12	10	0
Sum		1958	981	846	820	549	437	367	146

Appendix four: time losses categories and loss amount in minutes

A:-Loss types and its amounts in minute in a week pair section

loss categories and loss amount in minutes								total
Reason of losses	lasting		stitching		cutting	Insole	Moccasin	
week 1	c1	c2	c1	c2				
machine breakdown	30	0	20			30		80
power problem	150	25	60		18			253
bottleneck				40				40
week 2								
machine breakdown	10			25	48	26		109
power problem		60			12	12		84
bottleneck			10	10				20
change line			40	90				130
week 3								
Machine breakdown	5		35					40
power problem	225							225
bottleneck			30					30
change line				25				25
week 4								
Machine breakdown			40		23	20		83
power problem		45				21		66
bottleneck			40					40
change line			60					60
1st month								

week5								
machine breakdown		20	70		40		45	175
power problem	25					20		45
bottleneck				30				30
week6								
machine breakdown				45	36			81
power problem	70							70
bottleneck			20			5		25
change line			10					10
week7								
machine breakdown	28					18		46
power problem	230							230
material shortage	180							180
change line			10					10
week 8								
machine breakdown	15				20			35
power problem	990					2		992
2 nd month								
Week 9								
machine breakdown		35				42	28	105
power problem	1095					11		1106
week 10								
machine breakdown	60							60
week11								
machine breakdown	10				21		17	48
power problem	50					7		57
week12								
machine breakdown							25	25
power problem		170						170
3rd month								

power problem	40	20		20		14		94
change line			20					20
week 15								
machine breakdown	118					33		151
power problem				11				11
week 16								
machine breakdown	56							56
4 th month								
week 17								
machine breakdown		10				5		15
bottleneck					3			3
material shortage				30				30
week18								
machine breakdown	3						15	18
bottleneck			20					20
week19								
machine breakdown	5		50					55
week 20								
machine breakdown					16			16
5 th month						19		19
week21								
machine breakdown	23	27						50
power problem	25							25
week 22								
machine breakdown			20					20
power problem	60						16	76
week 23								
machine breakdown	20	40						60
power problem						16		16
week 24								

machine breakdown	5		20			20		45
6 th month								
week 25								
machine breakdown	10						37	47
26 week								
material shortage	30							30
week 27								
machine breakdown					12			12
week 28								
power problem	35							35
7 th month								
30 week								
machine breakdown						19		19
31 week								
machine breakdown	35							35
bottleneck			13					13
32 week								
machine breakdown	45				28			73
power problem	15							15
33 week								
machine breakdown						9		9
power problem	80							80
material shortage	240	240	240	260				980
34 week								
machine breakdown					26			26
power problem							15	15
35 week								
machine breakdown			30		20			50
power problem					5			5
material shortage	20	20						40

change line			15					15
36 week								
machine breakdown	15						57	72
power problem							9	9
9 th month								0
38 week								
machine breakdown	5			30	47		32	114
power problem					3			3
bottleneck								0
material shortage			260	150				410
39 week								
machine breakdown	5		60			20	7	92
power problem		150					13	163
40 week								
machine breakdown		225	20				26	271
power problem							10	10
material shortage			40					40
10 th month								
machine breakdown			240			26		266

B:-Frequency of each loss and cause of loss.

The most breakdown rampant sections						
Lasting			Stitching			
		C1	C2	C1	C2	
Loss categories	Reason of losses	Frequency		Frequency		Reason of parts are break down and power off(why those are occurred
Breakdown	Freza machine breakdown	2				Known as roughing machine, sucker problem, Sucker storage bag problems
	Zigzag machine breakdown			1		Lubrication

Back part machine breakdown	1		1		Un appropriate maintenance type, Lubrication Air problem(air sucker or storage cylinder)
Press machine breakdown	5	2			Air problem, Maintenance problem, Electrical system problem
SKL -18 machine breakdown			2		Lubrication and lack of skill and carelessness
Folding 01 machine breakdown			4		This machine needs high electric power to heat, So if power will off the waiting Is minimum 30M To start the production again, Up to the machine heats
Heating and lasting machine	9	1			Power, lubrication, Maintenance problems, air
For power off	3	1			Government
Cutting die			1 cutting section		Period of usage, cutting die material type
Cooler breakdown	1				Air system problem, electric problem
Rive 12 kamsur machine			1		Air system problem, electric problem
Heating and back part	2				Air system problem, electric problem, Lubrication, maintenance problems
Rev 02			1		Miss operating
GSP-06 M/C			1		Lubrication and lack of skill and carelessness
Skiving machine break down				1	Emery paper problem, skiving blade problem
GDP machine breakdown				1	

Uff!!!