SOLID WASTE IMPACT AND THEIR MANAGEMENT ON MANUFACTURING INDUSTRY DEVELOPMENT: A CASE STUDY OF AKAKI BASIC METALS INDUSTRY.

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DECLARATION

I hereby declare that the work presented in this thesis, "Solid Waste Impact and Their Management on Metal Manufacturing Industry for Industrial Sustainable Development: A Case Study of Akaki Basic Metals Industry," is a completely original work of mine and has never been used in any other project or to qualify for a master's degree at any other university. The required acknowledgement has also been made for all sources used in this thesis.

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I hereby attest that the candidate's aforementioned declaration is accurate to the best of my knowledge.

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ABSTRACT

Industrial solid waste and defective products are the leading and biggest problem for various industries and factories, affecting company productivity, efficiency, environmental pollution, competency, and loss of income. There are many causes of the impact of solid waste or defective products, so to minimize the waste, any countermeasure should be taken. The main objective of the study is to investigate the current state of solid waste and reject impact at Akaki Basic Metals Industry and to propose a model that leans towards zero waste management integration to reduce the level of waste and defective products in the company. Applying the primary and secondary data sources and collecting the primary data through questionnaires, observations, process flow, and cause of defect or waste products. And secondary data were collected from company records, internet sources, books, articles, etc., also applying both qualitative and quantitative methods to examine the data by using zero waste management and lean tools. According to the survey data on waste/reject rate, the three-year reports from 2012–2014 E.C. indicate that above 59.8 tons of metal waste, there are many causes related to machine, method, process, human, raw material, and laboratory factors for the waste or defective products. To resolve the problems associated with the above causes, we propose a model consisting of zero waste and lean management based on the results of the case study and create awareness of waste management for the metal manufacturing industry in the case of Akaki Basic Metals Industries.

Key words: lean and zero waste management, defective products, and solid waste.

Table of Contents

Contents

List of table

List of Figure

List of abbreviation

ABMI – Akaki Basic Metals Industry

PPC- Production Process Planning

MSW- Municipal Solid Waste

ICMR- International Conference Manufacturing Research

PSRC- Policy Study and Research Center

EPA- Environmental Protection Agency

IWMCE- Industrial Waste and Their Management Challenge in Ethiopia

UNIDO- United Nations Industrial Development Organization

MSF- Metehara sugar factory

FSF- Fincha sugar factory

KSF- Kessem sugar factory

EEPC- Ethiopian electric power corporation

CI- Cast iron

FWS- Foundry work shop

PMWS- part manufacturing work shops

CSA- central statistics agency

RDF- Refused derived fuel

METEC- Metal and Engineering Corp

Chapter One

1. Introduction and problem Justification

1.1. Introduction

In manufacturing, there are various problems that arise in the production process. One of these problems is the waste caused by the improper production of the product and the related problems caused by it, which lead the industry to various losses and costs.

There is a clear increase in global manufacturing activity, Industrialization, economic growth, and globalization have all contributed to rising product demand and manufacturing activity. Between 2001 and 2010, manufacturing activities around the world expanded by 35%, while the global GDP increased by 26% (Wiktorsson, 2012). Recently, the wastes of metal industries are also utilized in energy industries, in which ferrous metal and non-ferrous metal, compost materials, and others produced are used as sources of energy in the form of (Refuse derived fuel) (Norazli, 2015).

Industrial waste has grown in importance over the past 20 years and is now a serious problem that raises questions about the sustainability of the world and its consequences on the environment (Macarthur, 2012). The United States generated 259 million tons of municipal solid waste (MSW) in 2014, of which 23.3 million of those tons were metallic waste, or 9% of the total. Metallic waste accounts for around 7% of the overall yearly MSW creation. Procurement

Solid waste management is a minor and insufficient issue in the majority of African cities, which may be related to various issues. According to the UN Environment Programmed (UNEP, 2005), poor planning, poor governance, outdated technology, lax application of current laws, and a lack of financial incentives to support environmentally responsible development are among the factors that contribute to Africa's frequently poor solid waste management. The majority of open landfills in the area handle solid waste without enough control over environmentally sensitive areas. Since only 40–50% of rubbish is supposedly collected, (UNEP, 2004) reports that this has led to the dumping of refuse heaps in the urban environment of densely populated cities (UNIDO, 2009)

Rapid development in Ethiopia has resulted in the production of hazardous industrial wastes (teku, 2006). One of Ethiopia's most serious environmental issues, particularly in Addis Ababa, is improper management of the enormous amounts of industrial waste (Firdissa B. , 2016).

Production wastes are recognized as an input of production systems with proper waste management techniques and philosophies. For instance, wastes generated from metal industries may affect its major consumer construction industry production quality; consequently, it may also cause environmental, economic, and social hazards. Due to that, construction industries are looking for cost-effective structural materials and the utilization of renewable materials (Baird, 2016).

There are numerous approaches offered for streamlining the procedure. Additionally, they overlap one another by promoting comparable waste management strategies and sharing similar objectives (Lilja, 2009.). Lean production, waste minimization, zero-emission, and avoiding waste are a few examples of such ideas. This study contributes to the subject of sustainable manufacturing by giving a comparison of tools, policies, visions, and concepts for industrial waste management in order to aid in overcoming the aforementioned difficulties.

Therefore, industrial waste management eliminates the problems that arise in different work processes, i.e., the losses associated with mixed products and the unnecessary products that fill the environment, and increases productivity for the company and reduces waste problems.

1.2. Background and Justification

In today's competitive and industrial age, metal industries need to deliver fast and with quality products according to their clients' promises. It can produce each production process without any problems, create customer satisfaction, reduce wasted products, reduce high costs, and increase productivity, which is also responsible for environmental and socio-economic problems.

Various types of waste have been generated in the metal manufacturing industries during the processes of casting, machining, and welding; galvanizing; bending; bar cutting; forging; maintenance; finishing; part assembly; and heat treatment. Due to this environmental waste, incidents have occurred with rejected products, scrap material, the disposal of machine lubricants, resin, and catalyst suffocation during the molding process, and the disposal of acids and chemicals after the galvanizing process.

Manufacturing waste, chemical waste, mining waste, oil & gas waste, nuclear waste, power plant waste, and other wastes from different industries are considered as industrial wastes. Appropriate industrial waste management system is implemented to achieve considerable economic as well as environmental benefits (J. Nimita Jebaranjitham, 2022); Moo-Young, 2019).

Given its effects on sustainability and the environment, the production of industrial waste is likewise a major concern (Macarthur, 2012). European homes and businesses produced 2.5 billion tonnes of garbage in 2014, of which 10% (255 million tonnes) came from the manufacturing industry (Commission, 2012); European Commission, 2017; Naturvårdsverket, 2017).

When it comes to recycling, the metal smelting industry is one of the most demanding production sectors. But it still generates solid, liquid, and volatile wastes. Many of the recently implemented environmental rules have a significant effect on the foundry business as a result. Costs have increased for the sector as a result of trying to comply with these requirements, especially when compared to rivals in nations with laxer environmental regulations. In fact, several companies have decided it's more practical to shift their operations abroad than to abide by the growing environmental legislation. The manufacturing process of metal casting involves the use of several harmful chemical components and generates significant emissions of particles and dangerous gases (Acharya et al., 2014).

In the EU-27, households generated 221 million tons of waste in 2010, whereas manufacturing generated 280 million tons of waste (roughly 10.9% of the total). In 2010, the UK, Poland, Italy, Germany, and France together produced about 60% of the total manufacturing waste, while the UK produced roughly 23 million tones (8% of the total manufacturing waste) and Sweden produced 7.8 million tons of manufacturing waste (2.7% of the total manufacturing waste). However, trash quantity is only one issue; the other is waste quality, whether it be harmful or not, useful or not. The present problem in industrial waste management is maintaining high-quality materials in the industrial system (Sasha Shahbazi1 M. K., 2013).

In Africa some studies show that rapid population growth, increasing in income level, expansion of urbanization, expansion of industrialization and agricultural development in production give high rise of waste generation that highly impacts the nation's health and green environment pollution (Mbuligwe S. E., 2006 ; (Dr.kassu jilcha, 2020).

The existing Akaki basic metals industry generally contains different workshops like foundry workshops, part manufacturing workshops, forging workshops; Fabrication workshops, heat treatment workshops, and chrome plating workshops, but my focus in this study is on foundry and part manufacturing workshops because both workshops have a different working process has taken and reject/waste rate is high.

The list of metal production waste that occurred in Akaki's basic metals industry includes the process of the foundry and part manufacturing workshops. Like sand waste, pattern-making waste, scrap waste, mold-making waste, scrap transportation waste, molten metal waste, defective products, waste of raw material, and electric consumption waste. Due to this, the case company from the three-year performance report for the foundry workshops in 2012 E.C., 16% worked only outside of what was planned, 2013 E.C 11.3% and 2014 E.C. 10.4% lower than the production planned gain in birr. From the causes of waste and different problem results, this leads to high revenue loss. So, working in this area helps the company avoid waste and return problems.

Therefore, the purpose of the study is to investigate the current situation of the metal manufacturing industry's waste impact and its management for sustainable development and propose a method that minimizes waste for the metals industry through the integration of lean production and a zero-waste management strategy.

1.3. Problem Statement

The industrial wasted products and the related problems in the industry do not benefit the employees and the customers, it harms the organization and country economy, and it also create problems in the working environment.

According to Hoornweg (2012), industrial solid wastes are mostly visible, unusable products produced and derived from industrial activity in a specific industrial region. These undesired industrial wastes are divided into different kinds based on their source and end use. They are among the worst contaminants, and they cause environmental pollution if they are not collected (Hoornweg, 2012) ; Bhada-Tata, 2012). Similar to today, intermittent increases in industrial effluent are linked to urban industrial growth. A common cause of water pollution as a result is now industry (Firdissa B. , 2016).

The waste from the various metal producing businesses that is the subject of this study is a solid industrial waste that is discarded from various industrial-based activities. During the other production steps, they are released. These wastes can be toxic or lethal when ingested or absorbed, corrosive (capable of corroding metal containers like tanks), ignitable (which can cause fires), reactive (which are unstable by nature, they cause explosions, and they release toxic fumes when heated), ignitable, and ignitable (Yalew, 2012). Solid industrial waste management has grown to be a significant concern in many developing nations (Abebe, 2018).

Ethiopia's industrialization and growth have hastened the development of toxic, hazardous, and industrial dynamics (Assnakew, 2017). To prevent heavy metal contamination of water, soils, and crops, industrial pollution management techniques are required (Teklu, 2012). Unfortunately, Ethiopia lacks the resources necessary to address these and other significant environmental problems, just like other poor nations (Teku, 2006).

The industries in Ethiopia were established to create a profitable business and beyond that to be competitive in the domestic and international market, but due to many problems, they are out of competition and record losses. Similarly, ABMI (Akaki Basic Metals Industry) is one of those companies that suffer from many challenges/problems. High concentration of waste of product and raw material, high production cost, low profit, and high rate of downtime due to frequent lack of order, machine failures, and maintenance are some of the company’s problems.

The cast steel products of ABMI foundry workshops like roller, trash plate, roller flange, scraper plate, swing roller, pinion gear, ash door, ash door frame, ferrous, nonferrous material, and different machine part accessories, etc. are some of the casting products. These are inspected for defects since these were the important castings for the foundry industry as they had more demand and the profit margin for these values of products is high. In the process of steel and cast-making production, the company has encountered different problems. Especially the problems are related to waste and defective products in the different areas of the production lines.

The case company quality and PPC (production process control) department three years report show that 2012 E.C (7220.26 Kg), 2013 E.C (43,364.03 Kg), 2014 (5806.18 Kg) of metal wastes were produced in ABMI, (not only because due to this waste of high electric power waste, raw material waste (sand, chemicals, others), time waste, etc. also marketing report also shows that there are defective products, customer complaints, delivery time problem has reported to the company.

As the company does many jobs, the problems are also different, but the waste products and related problems are repeated, but they do not try to eliminate the problems. So, this research focused on the type, and factors influential of metal waste and control in case manufacturing industry and assessed to minimize the metal waste system in order to enhance the company's effectiveness.

1.4. Research question

The following questions will be addressed by this research, taking into account the problem statement from section 1.3.

1. What are the root causes for solid waste generation in the global and Akaki Basic Metal industry?
2. What are the impacts of solid waste on metal manufacturing industry competitiveness, the socio-economy and the environment?
3. How to minimize solid wastes / defective product in metal industry by using lean and zero waste management integration in Akaki Basic Metals Industry?

1.5. Research objective

1.5.1. General objectives

The study's overall goals are to examine the existing condition of solid waste impact and management in the manufacturing industry, with a focus on Akaki basic metals, and to suggest a solid waste-free steel casting manufacturing system.

1.5.2. Specific objectives

- ✓ To identify the root causes of metal manufacturing industry solid wastes
- ✓ To analyze and discuss the impacts of solid wastes on metal manufacturing industry competitiveness, the socio-economy and the environments.
- ✓ To develop a model for improve the concept of waste management & reduce the waste in metal manufacturing industry.

1.6. Scope and Limitation of the study

1.6.1. Scope

The scope this research was limited and focused on solid Waste Management in the metal products manufacturing industry in Ethiopia at the case company, Akaki basic metals industry foundry and part manufacturing workshop because some workshops are not fully operating (heat treatment, forging, fabrication, chrome plating). Waste/defective products were considered from the receipt of the purchased raw material, sand washing, pattern making processes, mold making process, scrap preparation time, melting unit, lab unit, finished product, machining unit, etc. in addition, the company manufacture ferrous and nonferrous materials. The problems that were encountered collect data from the case company the last three years waste of product, rework, and customer complain, cause of problem and rate of the defect and reworks, also waiting time and lastly, propose waste management technique in Akaki Basic Metals Industry.

1.6.2. Limitation

This study was also challenged to get data related with machines maintenance histories, quality record for planned and executed work at every factory or quality department, low factories manufacturing operation, reliable data collection and recording, and more. In addition to above stated limitation, the study observed the following limitation

- Some workshops are not fully operating (heat treatment, forging) or newly established (training office)
- Unavailability of similar local industries for bench markings

1.7. Significance of the Research

Depending on the objectives investigate the solutions to the manufacturing of waste/reject-related problems in ABMI and propose the appropriate model strategies for waste management. They will get important concepts on waste management improvement and will motivate to work for it. Since there are few studies on waste management in the metal product area, it will give a comprehensive point for researchers on reducing waste through the implementation of waste management.

In addition, anybody who is interested in reducing or eliminating manufacturing wastes/defects and also developing policy and regulation of waste management can also get good ideas from this. Finally, the study will contribute a lot to providing a step-by-step, unambiguous road map of improvement that leads to predictable results. This model provides the product confidence, assured, guaranteed, and necessary for the principal subject. In addition, the study was used as a reference for those who work in this area.

1.8. Organization of the Paper

This thesis is organized into six chapters. The first chapter summarizes the background, problem statement, objectives, scope, and significance of the study.

The literature review which shows metal manufacturing industries, the definition, and characteristics of waste management, how to integrate lean and zero waste management, definition of solid waste, lean tools, zero waste hierarchy, and review of literature conducted the subject is presented in the second chapter.

The third chapter covers the research methodology. The data type, collection method, sampling method, data analysing, tools and method, ethical consideration and research design are described in this chapter.

Chapter four discusses the results of the study. It presents the data obtained from the case. The proposed solution and its outcome after implementation relying on the results obtained are also presented.

Chapter five, to develop a model waste management due to reference of discussion part.

Finally Chapter Six: Conclusions and Recommendations: In this section, the main problems of this thesis will be summarized, and an overview of the key findings will be given. In addition, it states whether the research succeeded in achieving the suggested goals.

Chapter Two

2. Literature Review

2.1. Introduction

This literature review chapter covers mostly reviewing pieces of literature about waste in the metal manufacturing industry including an overview of lean manufacturing (lean management), zero waste management, and the concept of waste. Simultaneously, the literature gaps and summary were identified in order to fill the body of knowledge.

2.2. Basic Concepts

The basic concept of the literature has been shown below metal manufacturing industry for sustainable development has a great involvement on economical and income for one country according to this involvement cause of unsustainable factors has been occurred in the manufacturing industry, the main cause is different types of waste happen in any process, metal solid waste/ reject material and due to this delay time, raw material high consumption, low productivity, customer complain, etc. and different minimization and removal of solid waste management tools and techniques has shown like lean and zero waste management implementation in different attitude.

2.3. Metal manufacturing industry for development

The International Standard for Industrial Classification classifies metal industry into basic metal and engineering industry. According to this classification, the engineering industries can be further grouped into four areas: manufacture of basic iron and steel, manufacturer of fabricated metal products except machinery and equipment, manufacturer of machinery and equipment, and manufacturer of motor vehicles, trailers & semi-trailers (FDRE, 2017).

The profile of the metal industry defined by ISIC Rev 3.1, (code 27: manufacture of basic metals) covers the following activities: The manufacturing and casting of non-ferrous metals like iron and steel as well as the manufacturing of basic precious metals this division is based on the productive activities characterized by the processing of metal products from metal ore and/or scrap metal. Manufacturing activities vary from refining metals, casting molten metal into desired shapes, or producing inputs for the refining or casting processes. The metals industries utilize both ferrous and non-ferrous metals and produce pure metal products or alloys in the form of end products, stock, and intermediates for use by other industries (Steve Evans, 2014).

For the sustainable development of one country metals and metal products have a high involvement in the development, there for different metal product factories that produce reinforcement bars, LTZ shape products, casting metals to produce different machine accessories, and other metal products manufacture in this sector. So, these products uses for construction and accessories for machineries, solve problems of shortage happen on the metal sector in the country, minimize foreign currency at a higher rate, and high positive impact on development.

Table 2.1. Indirect imports and exports of steel (2004-2013)

Imports/ exports	**Years (2004 – 2013) thousands of tons**									
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Indirect imports	110	185	254	280	291	351	412	339	302	263
Indirect exports	2	0	0	3	3	4	7	3	1	0
Indirect net exports steel.	-108	-184	-254	-277	-287	-346	-405	-336	-301	-263

Source: (SSY, 2015)

Table 2.1 shows that the indirect imports higher than exports a very high rate which means metal products manufacture in our country is very small to expect the demand needed.

The global steel and consumption have continued to grow at a rapid pace, with emerging economies coming to the fore, in recent years. For instance, steel production in 1970, 2000, 2013 and 2014 production was 595 Mt, 850 Mt, 1649 Mt and 1665 MT respectively. Similarly, the average growth of the steel production was 1.6%, from 1970-1975 and 6.2% from 2000-2005 although it dropped to 3.8% from 2010-2014. With regard to geographical distribution, in 2014, 49.4% of the world’s crude steel production was covered by China, whereas the share of Africa was only 0.9 % (FDRE, 2017).

Figure. 2.1. Crude steel production trend from 2007-2014

Source: World Steel Association 2015, Global Iron and Steel Market (Deloitte, 2015).

Africa's total crude steel production was 15.695 Mt in 2011 and slightly decreased to 15.337 Mt in 2012, but it increased by 0.626 Mt in 2013. Africa, the second populous continent in the world, produced15.022 Mt of steel, and this was 0.9 % of the world's total crude steel in the year 2014 (WSA, 2015 ; FDRE, 2017).

It is clear that the Ethiopian government is determined to transform the economy from agricultural-led to industry-led during the ongoing Growth and Transformation Plan of the country. In the course of the entire process of economic growth and transformation of the country, there is a huge demand for the steel sector products. The core demand drivers for the steel industry are: expansion of infrastructures, establishment of industry parks (7.4 Mt for the next ten years), continuous investment in mega projects, housing programs (4.9 million houses for the next ten years) and so on. These drivers will escalate the demand for steel products in the future (FDRE, 2017).

In 2006E.C, there were 2758 medium and large-scale manufacturing industries in Ethiopia out of which 241 were steel industries. This means that the steel industries account only for 8.7% of the manufacturing sector (SSY, 2015).

Table .2.2 Local Production and Import in the Metal Sector

Year	Local production (in billion birr)	Import (in billion birr)	Total (in billion birr)	Local production Share (%)
2005/06	2.35	13.3	15.65	15
2006/07	3.454	17.0	20.454	16.9
2007/08	3.833	23.0	26.833	14.2
2008/09	4.255	29.4	33.655	13.1
2009/10	6.124	40.2	46.324	13.2
2010/11	6.648	50	56.648	11.7

Source: MIDI (2012)

In countries like Ethiopia, the steel companies are not producing as much as needed, most of the companies are working below their capacity, and the country cannot get the steel products it needs properly in addition, it is exposed to high foreign exchange rate.

Most of the steel companies are working below what they should be doing, even though there are various problems, companies cannot produce quality products and they are not using perishable products and raw materials properly and they are working traditionally, and this may lead to accumulation and creation of damaged/ wasted products. (Demissie, 2020). In steel production firms wastes generated from the material can be sourced due to various reasons. In this particular case company experts, the evaluation showed that most of frequently workers' limited awareness and lack of training towards waste minimization is considered as the main source of waste material. As the expert's evaluation also indicated a lack of strategy and action plan in managing waste has been considered as the main source of waste related to the material.

Literature demonstrates how the metal sector is divided into the basic metal and engineering industries, both of which contribute to the advancement of sustainable development. The manufacturing of pure metal goods or alloys, as well as the production of ferrous and non-ferrous metals, will be included in the metal industries. These products will be used in building, as equipment accessories, or as parts for various items. High foreign exchange rates reduced as well, although data reveals that the majority of metal exports came from abroad. Steel firms, for example, are not performing as well as they may be, despite a number of issues, including worker under-awareness for the job, a lack of training, a lack of training for waste minimization, etc.

2.4. Factors for development of metal industries

The rise of the global economy and sustainable development are major considerations in the metal manufacturing process. As a result of several circumstances, businesses experience a variety of issues. The majority of these issues have the same sorts across all businesses, such as talent gaps, technological issues, machine issues, time management issues, raw material issues, and financial issues. Solid waste, defective products, and issues with improper solid waste management are the main issues that arise during the process, making this an unsustainable component for the system.

Waste can be classified by a multitude of parameters. It has been classified on its physical state; solid, liquid or gaseous. Sometimes it is classified by materials that forms the waste: glass, paper, etc. Waste is also classified according to it physical properties (combustible, compostable, recyclable) or by origin (domestic, commercial, agriculture, industrials, etc.) and by safety level (hazardous, non-hazardous) (Wan-Ramle ; Wan-A-Kadir, 1997).

Waste is any byproduct that results from consumer-based lifestyles (Hoornweg, 2012) also it comprises municipal solid wastes, industrial wastes, medical wastes, radioactive wastes, etc.

Waste in economics refers to the overall poor performance of a plant from different perspectives such as underutilization of resources, improper assignment of resources to the wrong position, process inefficiency, and ineffectiveness of transforming the right input to the right output (Tsegay, 2013 ; Demissie, 2020).

According to (Norazli, 2015) Waste is a useless by-product of human activities that physically contains the same substance that is available in the useful product. (Demirbas, 2011) Waste can be defined as any inappropriate use of equipment, materials, labor, or resources that causes inefficiency. Also, Wastes have also been defined as any product or material which is useless to the producer (Basu, 2009). Although waste is an essential product of human activities, it is also the result of inefficient production processes whose continuous generation is a loss of vital resources (Baird1 E. A., 2016 ; Cheremisinoff, 2003).

Effective SWM depends on upon the appropriate distribution of functions responsibilities, authority and revenues and requires the integration of many organizations and groups into a partnership (Shubeler, 1996). Local government is normally responsible for SWM, even if private sector contractors are engaged to provide such services. Small family-based enterprises and informal sector rag pickers are often very involved with SWM. Non-governmental organizations (NGOs) and community-based organizations (CBOs) can have the important impact in organizing local services, raising awareness and supporting vulnerable individuals (Coffey & Coad, 2010).

Currently, Africa is generally characterized by a weak manufacturing industry and low industrial activity that is attributable to the continent's poor infrastructure, low levels of technological development and productivity, inadequate provision of power, water, and transportation, shortage of skills, difficult business environments and bureaucratic hurdle (UNECA, 2014 ; FDRE, 2017). moreover, African countries involved in industries such as food, textile, furniture, clothing, iron and steel, chemicals, printing, and food industry are ranked first for the generation of waste that harms the health and environment (Bello, Ismail, ; Kabbashi, 2016 ; Moges Hagos, 2019).

According to Teku (2006), these are wastes that include a highly heterogeneous mass of discarded materials from different scales of industrial activities. These types of waste are common in Addis Abeba. The sources for these industrial wastes include food industries (Kality Foods), metal production industries, (Kality Metal Products Factory and Ethiopian Iron and Steel Factory), paper production industries (MAMCO Paper Products Factory), chemical industries and pharmaceuticals (Kadisco Chemical Industry and Pharmaceuticals), and others. Similarly, wastes from small scale industries also contribute to solid wastes in both Hossana and Gondar Town (Same, 2017).

Solid waste is non-hazardous domestic, commercial, municipal, and institutional waste, such as food waste, paper, cardboard, plastics, textiles, glass, and metals (Leslier Valenzuela-Fernández, 2022). Generally, solid waste is categorized into agricultural waste, municipal waste, industrial waste, household waste and special waste (e-waste, medical waste, plastic waste, and construction waste) have shown in Figure (J. Nimita Jebaranjitham a, 2022) ; (Alabi et al., 2019).

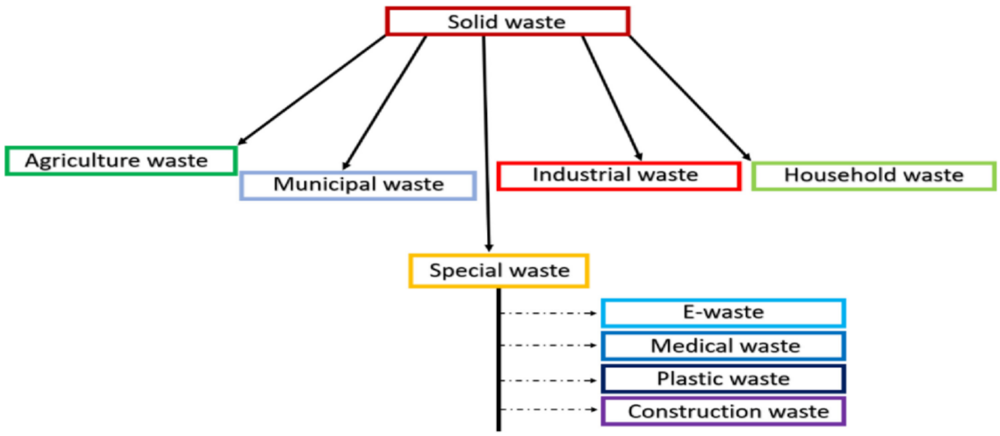

Figure.2.2. Categorization of Solid Waste.

The diverse sources of solid waste generation and the complex nature of its composition make the management of solid waste difficult. As a result, governments and municipalities are facing considerable difficulties in providing adequate solid waste management (SWM) services in Ethiopia (Hailemariam, 2014).

Types of solid waste

A. **Industrial waste** is the waste produced by industrial activity which includes any material that is rendered useless during a manufacturing process such as that of factories, mills, and mining operations. Types of industrial waste include dirt and gravel, masonry and concrete, scrap metal, oil, solvents, chemicals, scrap lumber, even vegetable matter from restaurants. Industrial waste may be solid, semi-solid or liquid in form. It may be hazardous waste (some types of which are toxic) or non-hazardous waste. Industrial waste may pollute the nearby soil or adjacent water bodies, and can contaminate groundwater, lakes, streams, rivers or coastal waters.

B. **Municipal waste** is defined as waste collected and treated by or for municipalities. It covers waste from households, including bulky waste, similar waste from commerce and trade, office buildings, institutions and small businesses, as well as yard and garden waste, street sweepings, the contents of litter containers, and market cleansing waste if managed as household waste. The definition excludes waste from municipal sewage networks and treatment, as well as waste from construction and demolition activities. This indicator is measured in thousand tones and in kilograms per capita.

C. **Agricultural waste** is unwanted or unsalable materials produced wholly from agricultural operations directly related to the growing of crops or raising of animals for the primary purpose of making a profit or for a livelihood. **Some example of agricultural waste** are include, grape wines, fruit bearing trees, vegetable, date palm, etc.

D. **House hold waste** also known as domestic waste or residential waste, is disposable materials generated by households. This waste can be comprised of non-hazardous waste can include food, scraps, papers, bottles, etc.

Literature demonstrates that a number of problems, including a lack of talent, technological issues, equipment problems, waste and waste management issues, have emerged in the metal productive business system as a result of unsustainable development. The primary problem is waste, which is defined as any product or material that is useless to the producer and can be classified as solid, liquid, or gaseous. According to the EPA 2018 study, the metal trash increases year over year. In the industry of metal manufacture, solid waste is nonhazardous household, commercial, and institutional waste from this metal.

2.5. Impacts on socio - economic and the environment for the metal manufacturing industry

Effective SWM system is influenced by waste handling patterns and underlying attitude of the urban populations, and people's social and cultural context. Programmers to disseminate knowledge and skills or to improve behavior patterns and attitudes regarding waste management require the sound understanding of the social and cultural characteristics (Shubeler, 1996). Social problems encountered include lack of public awareness, illegal dumping, poor condition of waste workers, and lack of private sector and social involvement Public awareness-raising and attitudes to waste can affect the whole solid waste management system.

All steps in SWM starting from household waste storage, to waste segregation, recycling, collection frequency, the amount of littering, the willingness to pay for waste management services, the opposition to the sitting of waste treatment and disposal facilities, 20 all depend on public awareness-raising and participation. Therefore, this is a crucial issue which determines the success or failure of SWM system (Zurbrug, 2003).

According to Shubeler (1996) and (Un- Habitat, 2013) access to social and health care service should be ensured. Proper equipment and protective clothing can reduce health risks. By contributing to the professionalization of the waste worker's role, proper clothing and equipment may also help to alleviate the social stigmatization which is often associated with waste workers.

Most studies on the impact of solid waste management on the environment have considered one Or two specific solid waste management practices, yet there is no single urban center that utilizes only one solid waste management practice (Andersen et al., 2011; Foday et al., 2013). More so, The attempts to assess the impact of solid waste management practice have yet to be complete i.e., *Environmental and Socio-Economic Impact Assessment of Solid Waste Management Practices* They have either provided only a negative impact or only a positive impact of the practices on the environment (Nyakaana, 1997)

Those that have tried assessing both positive and negative impacts have assessed the impacts on the only biophysical environment and ignored the socio-economic impact assessment hence leaving the environmental impact assessment of solid waste management practice incomplete (Kalama, 2016; Michael and Amir, 2016).

According to Gumisiriza and Kugonza (2020), a complete assessment of the impact of solid waste management practices on environment should assess both socioeconomic and biophysical (both positive and negative) impacts on the environment and should consider more than two solid waste management practices. This paper contributes to the literature by assessing the impact of solid waste management practice on the biophysical and socio-economic environment of urban areas.

According to the case company, solid waste (reject products) has accumulated in various working areas with a large surface area, and over time it will corrode and, like dust, be distributed by the wind, affecting the environment and causing health issues, and people have a limited understanding of the causes of metal dust health issues, etc.

2.6. Solid metal waste and its effects for the manufacturing industry

Solid metal waste or defective products in industries occur in a variety of situations that occur during the processing of manufacturing, including design issue problems, electric interruptions at production time, composition problems in melting processes, machine problems at production time, quality measuring instrument problems, operator problems, laboratory machines that are not effectively working, raw material problems, use of expired chemicals, sand washing problems, and pattern making problems. The manufacturing sector is plagued by the aforementioned problems as well as additional fundamental ones involving solid metal waste or defective goods.

This solid metal waste and defective products have an economic, financial, and environmental effect on an industry because it takes time, knowledge, money, and energy to produce a product, from the design to the final products. In addition to this, the work is damaged, which brings a loss to the company, and the customer does not receive it on the day it is supposed to be delivered. Reject products are stored in unnecessary space, and totally wasted products have effects on sustainable development.

The generation and composition of industrial waste depends on various factors, such as the degree of expansion of industrialization and the type of industrial settlement in a country. Mining activities to provide raw materials for energy production and the manufacture of goods generate enormous amounts of waste, often non-hazardous waste (Singh, Laurenti, Sinha, Frostell, 2014).

According to (Awuchi, 2019), Industrial wastes are produced as a result of industrial activities, which include any materials rendered useless during manufacturing processes such as those of the food and chemical industries, mills, mining operations, and factories. Types of industrial waste are dirt and gravel, scrap metal, scrap lumber, oil, solvents, masonry and concrete, plastics, chemicals, and even vegetable matter from restaurants, which may be released into the environment and cause harm.

Industrial waste is a key factor to consider when assessing the sustainability of a manufacturing process or a company. Defining the term 'waste' is essential for improving material efficiency, controlling waste, and protecting health and the environment. Defining waste facilitates the determination of whether a material constitutes waste and whether it should be managed as waste. According to the EU Waste Framework Directive, waste is any substance or object that the holder discards, intends to discard, or is required to discard but is not a product of the operation (European Commission, 2008).

Industrial solid wastes are mostly visible, unusable materials generated and derived from industrial activities in a given industrial area (Hoornweg, 2012). These unwanted industrial wastes are of various types and are categorized according to their origin and products (Same, 2017; Mekonnen ; Gokcekus, 2019). They are one of the most harmful pollutants, and if they are uncollected, they lead to environmental pollution (Hoornweg, 2012).

Addis Ababa, like other cities in developing countries, is one of the main cities in Ethiopia where industrialization is thriving. Most of the medium- and large scale industries in Ethiopia (more than 65%) are located in Addis Ababa and the nearby town of Akaki (Central Statistic Authority, 1999). As a result, industrial wastes and their impact on the environment are widely prevalent in Addis Ababa compared to other parts of the country (Firdissa et al., 2016).

Table. 2.3 Basic metals and engineering industries and regional distribution.

Types of sectors	Regional distribution							
	Tigray	Amhara	Oromiya	SNNPR	Harery	Addis Ababa	Dire Dawa	Total
Basic metal industry	8	3	10	-	-	16	2	39
Engineering industry	30	9	33	15	1	63	4	155
Total	38	12	43	15	1	79	6	194

Source: (Alemu, Solomon, and Tekeste, 2014) & (ASTU, 2018)

According to the table, the total of basic metals and engineering industry 79 industries in Addis Abeba have the highest rate of industries and in the case of industrial waste rate in Addis the same thing also is high.

The diverse sources of solid waste generation and the complex nature of its composition make the management of solid waste difficult. As a result, governments and municipalities are facing considerable difficulties in providing adequate solid waste management (SWM) services in Ethiopia (Hailemariam, 2014).

According to (Baird1 E. A., 2016 ; Cheremisinoff, 2003) there are various approaches to waste management. He added that waste streams with different characteristics may require a different management approach. For instance, industrial waste might contain more hazardous materials than municipal waste streams. Hence, the management of these two waste streams might differ. (Vergara, 2012) Found that, although waste management might differ between countries, there are some basic processes or paths that waste management needs to follow.

According to (Sellitto, 2018) industrial waste management must follow a logical sequence. Companies avoid waste by changing product design to reduce loss. Industries such as wood, lumber, and metal-mechanic create new products whose processes reduce waste by utilizing raw materials delivered in rolls, sheets, or plates more effectively.

Waste management is the systematic assessment of potential hazards, disposal, and proper utilization of waste. Improper waste management can increase manufacturing costs while also causing environmental concerns and resource constraint (Baird1 E. A., 2016 ; Ebikapade Amasuomo & Jim Baird, 2016); Sunil Kachhap, 2010).

Waste management, basically, involves the collection, transportation, processing, disposal, management, and monitoring of waste materials. The management of waste treats all materials as a single class, be they solids, liquids, gases, or radioactive substances. It also strives to reduce the harmful environmental impacts of each using the most appropriate methods. What waste management measures to adopt will depend on the sources, since waste characteristics and composition differ according to source (Tchobanoglous, 1993).

Literature indicates when evaluating the sustainability of a manufacturing process or a business, industrial waste is an important aspect to take into account. In this situation, identifying waste makes it simpler to decide whether a substance should be treated as a waste or not. The basic steps in the so-called "waste management" process include collecting, transporting, processing, removing, managing, and monitoring waste products. In another instance, all materials—solids, liquids, gases, or radioactive substances—are treated as belonging to the same class when it comes to waste management. There are claims that before humans started residing in communities, waste management and production were not significant problems. So, it has become crucial to organize solid waste management properly in order to protect the environment. Asserts that waste processing is a necessary step in protecting public health. Although waste management might differ between countries, there are some basic processes or paths that waste management needs to follow.

2.7. Solid waste management tools and technique

2.7.1 Lean management on waste

James Womack, Daniel Jones, and Daniel Roos coined the term "lean production" in their 1990 book *The Machine that Changed the World* to describe the manufacturing paradigm established by the Toyota Production System. In the 1950s, the Toyota Motor Company pioneered a collection of advanced manufacturing methods that aimed to minimize the resources it takes for a single product to flow through the entire production process (agency, 2003).

Lean is a management approach for process improvement as well as a methodology that is focused on reducing cost, cycle time, waste in processes, and increasing productivity. (MAHLET, 2019 ; Sundar, R., Balaji, A. N., and Kumar, R. M. S. 2014)

The Lean philosophy was driven by some main ideas: customer values, the elimination of non-value- added activities and waste, and the ideology of the workforce by involving people in the production process so that they become part of the community (Tourki, 2010).

The impact of Lean Practices (LP) on business success cannot be neglected. Lean tools and techniques have allowed companies to be more flexible and profitable. Several companies invest in the implementation of LP to remain competitive (MAHLET, 2019 ; nzouri, M., Ab-Rahman, M., Zain, C.Jamsari, E., 2014).

There are numerous methods and tools that organizations use to implement lean production systems. Eight core lean methods are described briefly below. The methods include: (agency, October 2003)

- **Kaizen**: Lean production is founded on the idea of kaizen, or continual improvement. This philosophy implies that small, incremental changes routinely applied and sustained over a long period result in significant improvements.

- **5s**: 5S is a system to reduce waste and optimize productivity through maintaining an orderly workplace and using visual cues to achieve more consistent operational results.
- **Total productive maintenance (TPM)**: Total Productive Maintenance (TPM) seeks to engage all levels and functions in an organization to maximize the overall effectiveness of production equipment. This method further tunes up existing processes and equipment by reducing mistakes and accidents. Whereas maintenance departments are the traditional center of preventive maintenance programs, TPM seeks to involve workers in all departments and levels, from the plant-floor to senior executives, to ensure effective equipment operation.
- **Cellular manufacturing / one- piece flow production**: In cellular manufacturing, production work stations and equipment are arranged in a product-aligned sequence that supports a smooth flow of materials and components through the production process with minimal transport or delay.
- **Just- in- time production/ kanban**: Just-in-time production, or JIT, and cellular manufacturing are closely related, as a cellular production layout is typically a prerequisite for achieving just-in-time production. JIT leverages the cellular manufacturing layout to reduce significantly inventory and work-in process (WIP).
- **Value Stream Mapping** is a best way to eliminate wasteful steps and maximize customer value. Most companies looking to transition to a Lean operation will start with a Value Stream Mapping event to start up the change. The current Value Stream Map highlights information that possible hasn't been considered previously. The future state Value Stream Map assists as a goal for future lean actions. These actions can help decrease processing times and advance product quality (Chen et al. 2010).
- **Pre-production planning (3p):** Whereas other lean methods take a product and its core production process steps and techniques as given, the Pre-Production Planning (3P) focuses on eliminating waste through "greenfield" product and process redesign.
- **Lean enterprise supplier networks**: To fully realize the benefits of implementing advanced manufacturing systems, many companies are working more aggressively with other companies in their supply chain to encourage and facilitate broader adoption of lean methods.

There are seven commonly identified wastes which are non-value-adding activities in the Toyota production system this are; waste of overproduction, waste of waiting, waste of transportation, waste due to over-processing, waste of unnecessary inventory, waste of unnecessary motion and waste of manufacturing defects (MAHLET, 2019 ; Ajit Kuma, R., K.M. Mithilesh, N.S. Narahari and Girish Kumar, 2015; S ternberg et al., 2012) or eight forms of waste (McAdam, 2003).

The eight wastes are uncovered through the determination of what the customer values. The list of the wastes that has been modified and expanded by various practitioners of lean manufacturing includes (Ayisha, 2014).

- **Over-production** – is unnecessarily producing more than demanded or producing it too early before it is needed. In this case, different products like trash plates, scraper plates, other products, etc. are producing more than what is needed or producing faster than what is needed. So these products may not be ordered by the customer for a long time; it looks like a waste.
- **Defects** – In addition to physical defects that directly add to the costs of goods sold, this may include errors in paperwork, production to incorrect specifications, the use of too many raw materials, or the generation of unnecessary scrap.
    - In case the company has different product defects during processing (due to electric interruption, molten metal solidifies, improper assembling of mold, improper use of molten metal fill in the mold, etc.), and after finishing defects occur like porosity, under dimension, over dimension, miss matching pattern, etc.
- **Over-processing** – is unintentionally doing more processing work than the customer requires in terms of product quality or features, such as polishing or applying finishing to some areas of a product that won't be seen by the customer.
    - In the case of company casting products, the machining allowance is mostly above their standards, and at machining time, the process is increased, a waste of time happens above the scheduled time, etc.

- **Inventory** - means having unnecessarily high levels of raw materials, WIP, and finished products. Extra inventory leads to higher inventory financing costs, higher storage costs, and a higher defect rate.
    - Some of the causes of this are due to the above-mentioned company over products, a high rework rate, a large minimum order quantity, and excessive process inventory.
- **Transportation** - includes any movement of materials that does not add any value to the product, such as moving materials between workstations.
    - Also, defective products in case company accumulate in one place and then change to another place by transport or manpower, so this is also not value-added.
- **Waiting** – is idle time for workers or machines due to bottlenecks or inefficient production flow on the factory floor.
    - Waiting results in a significant cost so far as it increases labor costs and depreciation costs per unit of output, and one of the cause unsynchronized process like inflexible force, unscheduled machine down time, long setup, material shortage or delay.
- **Correction (rework)** – is when something has to be re-done because it wasn't done correctly the first time

The figure 2.4 shows that the number of published papers on lean approaches was increasing from 2000 to 2015 and then started decreasing after 2016, however many industries still know waste has not Decreased all over the globe.

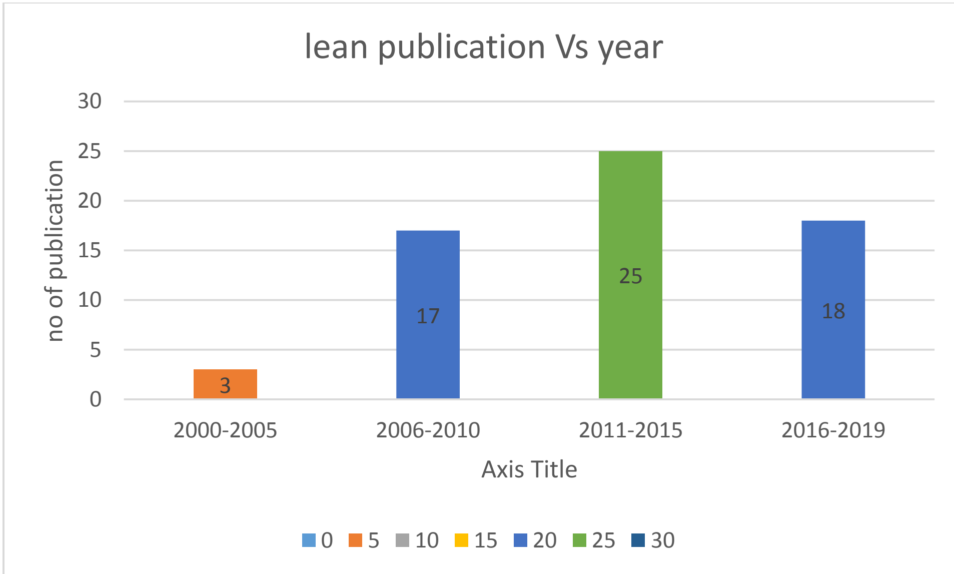

Figure.2.3. Lean Publication vs. Year (Mahlet Zebenay, 2020)

According to the literature, at the beginning of the expansion of industrialization, various problems involving waste and its management arose. So lean is one of the main and biggest ideas proposed at the moment. At now, lean is a philosophy and management approach that focuses on reducing cost, cycle time, waste in process, increasing productivity, creating customer value, eliminating non-value-added activities and waste through the use of numerous methods and tools, like kaizen, 5S, TPM, cellular manufacturing, just-in-time manufacturing, etc. to implement the system. Also, there are seven and above commonly identified wastes that are non-value-adding activities: overproduction, waiting, transportation, over processing, unnecessary inventory, unnecessary motion, correction (rework), manufacturing defects, and knowledge disconnection through the system. All of the above waste minimization and defect issues involve the metal manufacturing industries. The systems have mostly involved in processing, so it has its own gaps, before and after processing issues happen, what should we do for the beginning of designing, reuse, repurposing, reducing, others?

2.7.2 Zero waste management and its hierarchy

The term "zero waste" was first used by Paul Palmer in 1973 for recovering resources from chemicals (Ali, January 2021) ; (Palmer, 2004). In a zero-waste system, material flow is circular, which means the same materials are used again and again until the optimum level of consumption.

No materials are wasted or underused in circular system (Qingbin Song J. L., 2014 ; Murphy and Pincetl, 2013; Mason et al., 2003, Colon and Fawcett, 2006).

Accordingly, Toyota was the first company to achieve “zero waste to landfill” in the worldwide automotive industry (alen fercoq, 2016) and (Farish, 2009). As such, the 3R hierarchy can be regarded as a reference method for operating a waste management progress plan. In addition, conceptual frameworks for waste minimization have been developed (Hicks et al, 2004).

The Zero waste focuses on *waste prevention, minimization and reusing by considering* waste as valuable resource rather than a problem for factories. It aims to utilize the concept material efficiently and uses all material inputs in the final product or changes it into other inputs for another process. Matching input and output of different industries is one of the key challenges that need to be solved, possibly by industrial ecology through eco-industrial parks, industrial symbiosis, and new technologies (Shahbazi S., 2013).

In terms of the global provision of “residual disposal” (i.e., the supposed least priority, at the bottom of the 5R waste hierarchy) the efficacy and outcome to date of the conventional waste management paradigm and practice, also raises questions. The International Solid Waste Association’s (ISWA)—“Global Waste Management Outlook” (GWMO) bring into line with other similar reporting, in estimating that, between 2 and 3 billion people live below the most basic waste management system benchmarks of collection and controlled disposal (Qingbin Song J. L., 2014 ; Wilson *et al*., 2015).

Achievements, accomplishments and events related to Zero Waste development can be seen in Table Applying zero waste means eradicating all disposals in soil, water or air which is a threat to the planet, human health, animals or plants (ZWIA, 2013).

Zero waste represents a shift from the traditional industrial model in which wastes are considered the norm, to integrated systems in which everything has its use. It advocates an industrial transformation, whereby businesses minimize the load they impose on the natural resource and learn to do more with what the Earth produce (Qingbin Song J. L., 2014).

The period from the generation of waste to its final disposal is called waste management. The technique is based on the "hierarchy of waste management". These techniques related to the idea of prevention, reuse, reduction, recycling or recovery of waste are preferable to disposal (Abdullah L. M., 2019 ; Sivakumaran, 2015).

Zero Waste means designing and managing products and processes to reduce the volume and toxicity of waste and materials, conserve and recover all resources, and not burn or bury them. Implementing Zero Waste helps reduce waste entering the soil, water, or air that poses a threat to human, animal, and plant health, and mimics sustainable natural cycles in which all discarded materials are resources that others can use (Conlon, 2023).

The five Zero waste hierarchy steps are shown below.

A. REFUSE: By refusing, a lot of waste is eliminated at the source. The idea is to refrain from accepting free stuff that becomes instant waste. In order to find and actively incorporate reusable alternative in to your daily life, a bit of practice and preparation is required.

- Here, waste from the company is removed at the source: design flaws, buying sand to make sand casting, cleaning the sand preparation, inspecting the making of pattern wood, ensuring that laboratory test machines are operating correctly, regulating melting temperatures, control pouring molten metal into molds, inspecting the melting machine, and so on. All of these processes are inspected and controlled by quality control and quality assurance.

B. REDUCE: Before making purchases, ask yourself whether you actually need the products. When you do, consider its quality for what is available within your budget. A well-made product will last longer, meaning you won't have to repurchase as often. Reducing is also about engineering that your possessions last a long time.

- For foundry workshop raw materials such as sand, chemicals (resin, catalyst), and so on, as well as for raw materials (round bar, sheet metal, plates, and other input for machining purposes), before making a purchase, inbound inspection is performed to reduce waste.

C. REUSE: Reuse is the work or technique of employing waste another time as raw material, semi-finished product or finished product. Readiness into reuse interests testing cleaning or reforming recovering processes, and the outputs which became wasted can be reused without the need for different manufacturing operations (Abdullah L. M., 2019 ; Jacqueline V., 2009).This third principle – reuse- works in conjunction with the word repair. In cases where you are considering throwing something away for new materials, consider whether it could be reused or repaired; both in its current use and in another creative way.

- Most defective products, such as heavy-size client items with porosity, under-dimension, and other defects, are repaired by welding. During the machining process, products with under-dimension are welded and re-machined.

D. REPURPOSE: If you can't refuse, reduce or reuse a particular item, try repurposing it instead. The 'green' community often refers to this method as 'up cycling'. You will quite often be surprised to learn how many everyday objects in the office can serve more than one purpose.

E. Recycle: It is a recovery process in which waste materials are converted into feedstock, as the main or other objectives. Recycling includes the reprocessing of essential materials without energy recovery and the reprocessing of materials that can be used as fuels and in manufacturing processes (Abdullah L. M., 2019) and (UN-Habitat, 2009). Recycle all the basics you can such as paper, plastic, metal and glass

- Sand, like defective or waste items, is occasionally reused as raw material for other products in the casting process. After the finished products, sand disassembles the mold like waste but is reused for future product mold preparation.

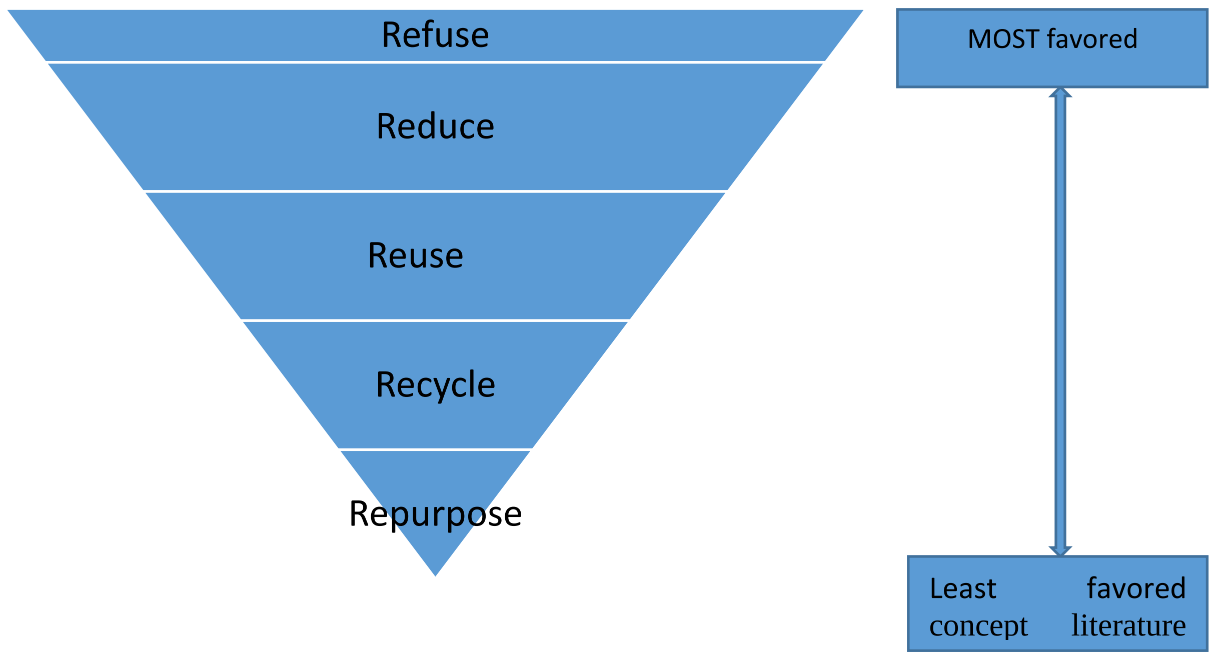

Figure.2.4. Waste Management hierarchy (Shelby-bell, 2021) (Jamaludin, et al., 2017) & (moges hagos; 2020)

According to the literature, zero waste is a management concept first used by Palmer in 1973 to recover resources from chemicals. Through time, waste minimization has been developed from the 3R to the 5R waste hierarchy, focusing on waste prevention, minimization, and reusing through possible industrial ecology through an eco-industrial park, industrial symbiosis, New technologies also shift from the traditional industrial model, which involves redesigning and managing metal products and processes to reduce the volume and toxicity of waste and material. Systems were mainly involved before and after production, so there are their own gaps, a processing management problem has occurred, what should we do for the manufacturing time?

2.8. Finding gaps and summary

2.8.1 Summary

The literature review summary demonstrates that articles pertaining to the research title have been searched in various journals and that some theoretical components, such as the concept of waste, solid waste in the metal manufacturing industry, waste management, and methods approaches to waste minimization (zero waste and lean manufacturing), are discussed.

The key topic of the research review on the waste effect and management for sustainable development in the case company is the journal articles and other publications that demonstrate the waste minimization system has its own waste management methodology. Lean manufacturing and zero waste management are implemented in the waste management system, but other meanings of the approach include industrial ecology, cleaner production, pollution prevention, the 5 R's, minimizing, preventing, reducing, recycling, zero-emission, elimination, etc.

2.8.2 Finding Gap

Lean manufacturing and zero waste management have been demonstrated after taking into account various points of view, which is indicative of the fact that many researchers have discussed minimizing the impact of waste on the manufacturing industry.

- Different researchers said that as per his visual and more work on the waste area, despite the variation, the most widely held consensus among academics is that lean systems are designed to eliminate waste (Womack and Jones, 1996; Shah and Ward, 2003; Hopp and Spearman, 2004; de Treville and Antonakis, 2006; and Narasimhan et al., 2006). Shah and Ward (2003) describe Lean as a philosophy of identifying and eliminating inefficiencies like non-value-added (waste) costs or unneeded wait times within the process caused by defects and excess production. In lean waste, elements such as waiting time, inventory, overproduction, transportation, rework, and loss of employee potential were not included in the zero-waste concept. The lean management approach considered employee potential loss to be a waste (Womack & Jones, 2003).Zero waste is a concept that focuses on waste problems and includes different strategies to manage sustainable waste (Welsh Assembly Government, 2010). These sustainable solutions come with the 5 Rs of zero waste: refuse, reduce, reuse, repurpose, and recycle, but they do not include lean waste management.
- The zero waste mindset has been accepted as a guiding principle by numerous government agencies as well as enterprises, yet the topic lacks adequate literature (Snow & Dickinson, 2001; Townend, 2010). However, many manufacturing sectors in Ethiopia do not use this

approach, particularly in our case company, which lacks a zero waste or lean waste minimization system.

- To begin, some of the aforementioned literature indicates that lean with zero waste management concept to minimize solid waste and how to avoid solid waste as a raw material, how to repair and use functional trash, or how to safeguard waste at the start of waste occur. The majority of academics write under various names about the example firm (ABMI), but they do not identify waste problems and the industry-wide causes that contribute to them, nor do they inform recommendations or implementations in the case of waste problems in the current environment.

- Aside from the top key success elements influencing the successful installation or rollout of lean with zero waste management, management commitment, and worker integration have gained significant attention in various research. What distinguishes this study is that it employs the solid waste management improvement technique and creates a model of the concept of solid waste minimization to strengthen the lean improvement method with zero waste management integration.

2.9. Conceptual frame work

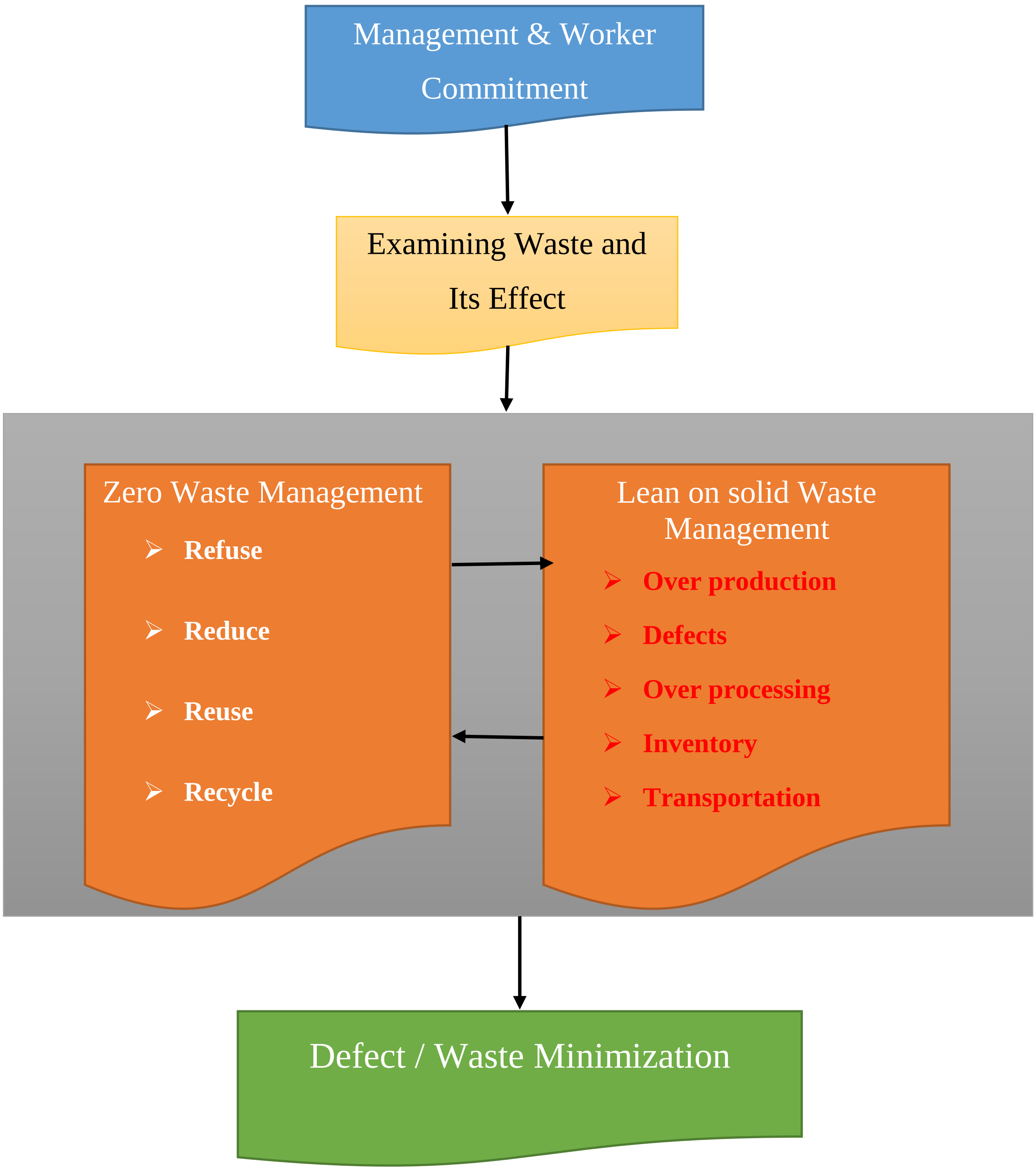

Figure.2.5. conceptual frame work for solid waste management in metal industry.

Chapter Three

3. Methodology

3.1. Introduction

The techniques for gathering and analyzing data to address the research questions are covered in this chapter. This study included a combination of qualitative and quantitative research approaches.

3.2. Research Design

The overall goal of this research is to reduce waste and defective products in the Akaki Basic Metals industries. To that end, a survey analysis was conducted to examine the industries' waste management concept, waste minimization practices, associated issues, and improvement initiatives. Following that, an investigation into the current waste products was conducted using a case manufacturing company. To do that, a suitable method has been developed in a way that guarantees the result in accordance with waste / reject product amount in the company. Both qualitative (to determine the nature of the causes of the problems) and quantitative (for quantification of variables) data were used. Literatures were reviewed to explore the concepts and find reasons and gaps in analysis of manufacturing enterprises' waste / defective products. The framework or blueprint of the research is necessary for achieving research objectives and answering questions; it assists the researcher in dictating the type of research that should be used (Kothari, 2004).

3.3. Data type

The process by which the study outlines the techniques employed in the data collecting and analysis to address the research questions is known as the research methodology. Both qualitative and quantitative research methodologies are used in this study.

To analyze waste and defective product levels and the potential causes of this environment, the aforementioned primary and secondary data were gathered from various metal manufacturing businesses, literature, and case companies. Primarily include the following: types of manufacturing products, working time spent, Downtime (waiting period), Machinery used, Products production line, Defective or rejected products, and Raw material used and cost rate.

3.4. Data collection method

A. Primary data collection method

The major sources of the primary data gathering techniques used for this research were observation of the work area, interviews, and question design.

Observation on working area.

The study uses a direct observation method, which allows the observers to study real-world events, which is seen to be a major advantage in case studies (Yin, 2012). With this approach, you can take pictures of various waste products, including waste that rusts over time and affects the environment, and periodically observe the company's various workshops, such as the fabrication, forging, and assembly workshops, as well as the machinery, working process, and accumulation of rejected products inside and outside the workshops.

Interviews

One of the methods chosen for collecting the empirical data is through interviews. The quick response and the opportunity for the interviewed person to clarify their response during an interview are major advantages compared to answering a questionnaire (Bell, 2012). Face-to-face interviews and discussions are held with a variety of individuals, including managers, work shop supervisors, and heads of departments (quality, marketing, production process control, etc.) to better understand the topic at hand as well as the current practices regarding metal waste and waste management in the case company. The results of the interviews indicate that defective products arise for a variety of reasons, with the primary effects being felt by the company, the customer, and the socioeconomic situation.

Questionnaire Design

The survey consisted of three main sets of closed-ended and open-ended questions about the sources and causes of product waste and the company's waste minimization strategies. The questions were designed to capture various waste issues such as defective product type, working process, and cause of waste. The question response incorporates a variety of workshops (supervisor, worker, engineers), as well as department head and worker (maintenance, quality management, marketing, production process control, etc.).

B. Secondary data collection method

Recorded data

The study is also trying to collect important documents such as monthly and annual reports, company profile, and inspection data in order to perform the quantitative analysis. Historical development of ABMI, background of the factory, review of market incompetence, productivity, defective products and quality products, waste of raw material and others.

Literature review is one of the secondary data collection methods. In addition to those in published and unpublished reports, articles, academic journals (Elsevier, research gate, reports, and conference), books, the internet, and other publications firmly focusing on the metal manufacturing industry's waste management issue, etc.

3.5. Sampling

Target Population, Sample Size and Sampling Technique

The population of the data is from Akaki Basic Metals Engineering (ABMI). The study is conducted on the workers for the position who are working in foundry workshops, part manufacturing workshop, PPC, quality departments, maintenance, forging and surface plating, marketing, research and development.

To get a representative and reasonable **sample size** that supports the research findings, the following equations are used. Equation (1) is applied to compute the initial sample size. Since the population is finite (less than 50,000), Equation (2) is used to compute the new sample size. These equations developed by Johnson et.al, (2009) and Freedman et al., (2007) according to (Othman, 2014).

$n_o = \frac{z^2}{c^2} * p\,(1- p)$..................... (1) $n_f = \frac{n_o}{1+\frac{no-1}{N}}$.......... (2)

Where no = initial sample size, nf = target sample size

Due to the fact that the confidence levels are all standardized, most researchers actually memorize the required z-score for most of the commonly used confidence levels:

Z = Z-values for confidence levels are (1.645 for 90% confidence level, 1.96 for 95% confidence level and 2.576 for 99% confidence level) p = percentage picking a choice, expressed as decimal 0.5 used for sample size needed c = confidence interval, expressed as decimal; 0.08 = ±8 N = Population = 292 workers (foundry workshop, quality department, PPC, maintenance, part Manufacturing work shop, fabrication and marketing management).

$n_o = \frac{1.96^2}{0.08^2} * 0.5\,(1- 0.5) = 150.063$...... $n_o = \frac{150.063}{1+\frac{150.063-1}{292}} = 100$

Since, total sample size of 98 responses are considered from the case industry.

Table .3.1 Target respondent

No	Department	Total staff	Sampling size
1	Foundry work shops	120	$120 *(\frac{98}{292}) = 40$
2	Quality management	12	$12 *(\frac{98}{292}) = 4$
3	Production planning control	7	$7 *(\frac{98}{292}) = 3$
4	Marketing management	8	$8 *(\frac{98}{292}) = 3$
5	Maintenance workshop	35	$35 *(\frac{98}{292}) = 12$
6	Part production work shop	72	$72 *(\frac{98}{292}) = 25$
7	Fabrication workshop	26	$26 *(\frac{98}{292}) = 9$
8	Research and development	12	$12 *(\frac{98}{292}) = 4$
	total	292	100

According to table 3.1 shows that, the questioner response department total staff & response sample size are indicated.

3.6. Data Analysis and presentation

The data analysis is based on the concept of productivity analysis in manufacturing systems and is carried out through the use of various books, publications, researches, articles, class discussions, and experience sharing with qualified personnel who have worked experience on various manufacturing system applications. The analysis is done to identify major waste / defective products & related problems, and waste minimization methods were also proposed before a conclusion and recommendation were finally reached. The collected primary and secondary data are presented on bar-graphs, pie-charts, Pareto charts, and cause and effect diagrams via MS-Excel & SPSS.

3.7. Ethical consideration

When collects the various information taken during the research i.e. questionnaires, interviews, and organization reports are compiled from industries managers up to low-level workers informs to the case of research use. In case of taking from other similar studies respecting the law of the university, Ethical Considerations can be specified as one of the essential parts of the research. From other similar studies, copy the data the universities punished academic dismissing according to the regulation of plagiarism.

3.8. Research frame work

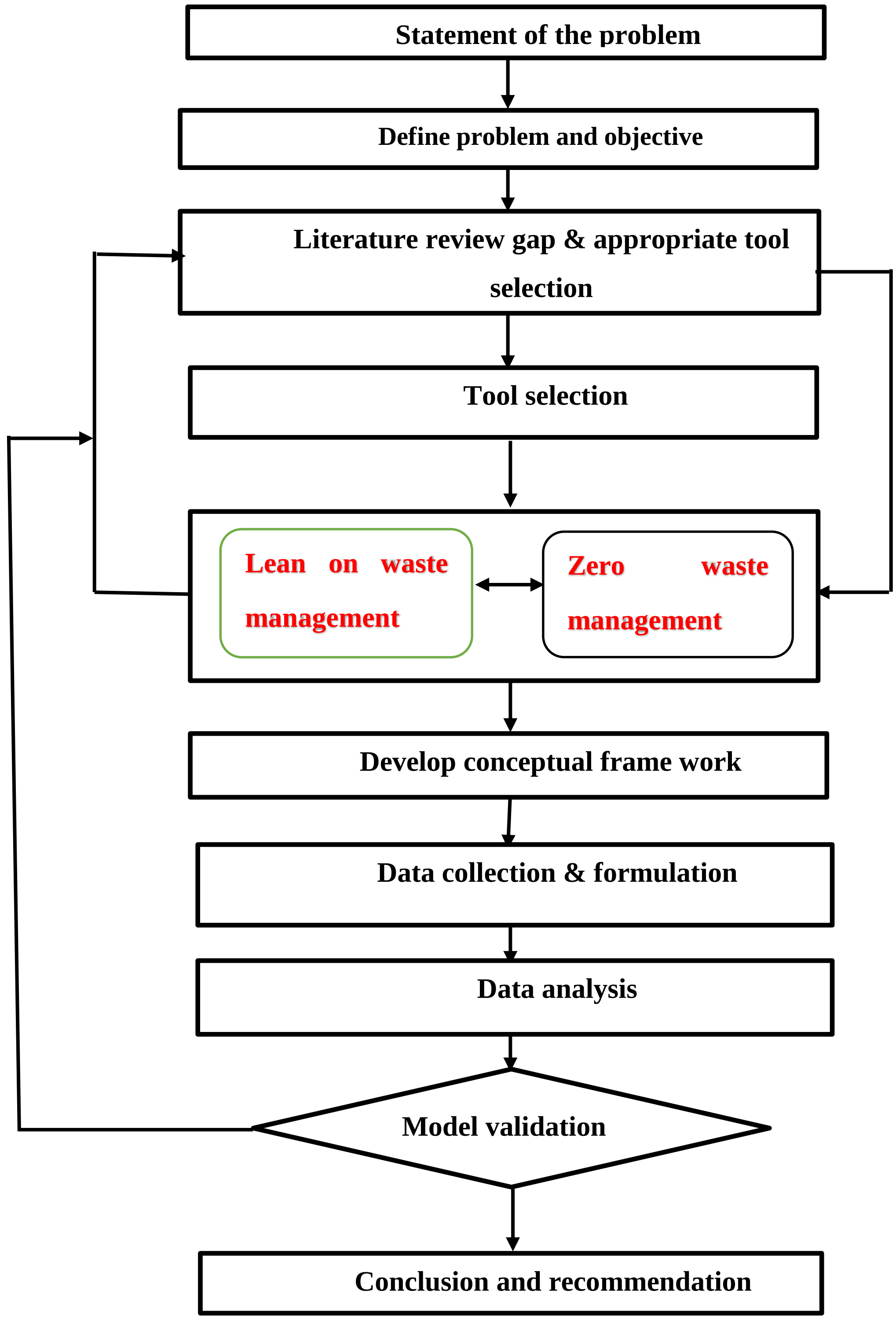

Figure.3.1. Methodology frame work

Chapter Four

4. Data Presentation and analysis

4.1. Introduction

The following section discusses the analysis of data collected from the Akaki Basic Metals Industry Different departments and observe back ground of the company, the production system, types of product and customer, the process flow from the raw material up to different products, d/t machines, three years (2020–2022) production and waste/reject product rate, how much raw material is used in the cost of reject rate, summaries the research topic and survey results according to the research methodology.

4.2. Back ground of the company

The government-owned industrial company Metals and Engineering Corporation (METEC) was founded in June 2010 in accordance with Council of Minister Regulation No. 183/2010. ABMI one of the industrial companies that make up METEC, which has made a significant contribution to Ethiopia's industrialization. As part of the National change Programmed, the corporation is currently undergoing organizational change as a result of the inefficiencies in the production facilities and METEC as a whole. The business is now known as Ethio-Engineering Group (EEG).

As the need for spare parts in Ethiopian industries grew, the idea to establish the former spare parts factory (ABMI) was devised in 1968 E.C. The construction of a facility to manufacture spare components is necessary to solve this issue. In 1969 and 1971, respectively, the German Democratic Republic (GDR) and the United Nations Industrial Development Organization (UNIDO) carried out feasibility studies for the construction of a factory producing spare components. Following this, a Swedish company (SWECO) carried out a thorough feasibility study between 1972 and 1974 with funding from the Swedish International Development Agency (SIDA). SWECO conducted a thorough research that included four important businesses (the metalworking, cement, textile, and sugar industries), even though it had been suggested that a factory for spare parts be established that could produce nearly 3600 different things. Following the decision to sign the contract in January 1976, project implementation got underway in April

1977. Between Nations Metal Works Corporation and an Italian engineering company, "FATA," The construction of "a spare parts factory" and the factory, which had a capital of Birr 142,298,000.00 and a total area of 155.000 m2, were both opened in 1981.cCurrently ABMI is under EEG group and now in the reformation stage to develop it competitiveness in the local and regional market.

The AKAKI basic metals sector uses a variety of technologies and production techniques to create completed and semi-finished goods from ferrous and non-ferrous materials. There are five factories functioning within the sector, namely: foundry and heat treatment shop, machine shop, fabrication shop, forging and surface treatment, and steel processing factory.

The industry produces a variety of parts for numerous industries. Table 4.1 below shows the primary goods produced by the ABMI and the related lead clients. The industry's products are depicted in detail in Figure 4.1, along with the sorts of raw materials that go into each one.

Table. 4.1 ABMI's Product types

Sr. no	Lead Customers	Products
1	Sugar Corporations (Fincha, Wonji, Metahara, etc)	• Trash plates, scrapper plates, sprocket gears, mill rollers, draw eye shafts, billets for cane knives, etc.
2	Construction Sectors	• Blade and ripper tip, truck shoe, manhole cover with frame, etc.
3	Cement industry(eg. Mugher cement)	• Cement balls, crusher hammers, mobile and fixed jaw plates, armor plates, different types of liner plates, dust collectors, etc.
4	Transport industries	▪ Brake drum, Central support, Sproket wheel, Front hub, 5th Wheel, Shackle ,Balance weight etc.
5	EEU & EEP	▪ Cross arm, Different types of hooks & pins, Big collar & bolts, gear boxes, etc.
6	Infrastructure Sectors	▪ Water pump, Dam gate, etc.

According to the aforementioned information, foundry workshops include (pattern work shop, molding workshop, melting workshop, heat treatment, finishing work shop), and part manufacturing workshops include (heavy duty machine shop and light duty machine shop), hence the majority of product waste has been documented in both workshops. Following that, the study only addresses the two workshops.

A. Process description of foundry workshops.

The firm now uses these processes because they are straightforward to execute, cost-effective to run, and easily produce tiny to large castings. Every stage of the creation of the finished product is failure when casting is used. It requires intricate relationships between numerous procedures and parameters related to metal composition and casting techniques.

In this factory, various operational steps, such as pattern design and creation, mold creation and assembly, sand preparation, core creation, melting and pouring, the shakeout of cast parts from the mold, and finishing operations, are typically carried out to produce cast parts. Depending on the type of metal to be cast, the company's casting manufacturing facilities are divided into sections for ferrous and non-ferrous metals. For the purpose of creating molds, each segment uses its own unique sand flow lines. According to the survey results, the casting process for both ferrous and non-ferrous metals (apart from users of non-permanent molds) follows a similar set of processes See fig bellows.

The metals are placed on the melting furnaces and heat to its melting temperature. Commonly used ferrous metals are cast iron (nodular CI, grey CI, white CI, and ductile CI) and steels of various grades (C-10, C45, etc.). There are three induction melting furnaces with capacity 3300 kg each and one induction furnace with capacity 250kg.Total melt capacity currently is 9900 kg, however, currently all the non-ferrous melting furnaces are non-functional due to breakdown and damage and three induction melting furnaces are functional for ferrous metal casting.Different alloying elements (C, Si, Mn, Phosphorus and Sulphur) of various compositions are added on pig iron to obtain nodular CI, gray CI and white CI varieties. The melt is tested for its compositional details in the testing laboratory.

The quality of products observed in foundry shop is inadequate which arises from lack of proper quality control mechanisms at each stages of the process. Inspection of the final cast products is conducted to accept or reject a product is a traditional quality control approach. For example, in casting of mill rollers frequently observed casting defects namely surface cracks, structural discontinuity, porosity and shrinkage as shown in Fig. 3.8. The same problems are observed in other cast products as well. One of the main causes for defective cast parts is absence of implementation of quality control system at each stage of casting namely pattern design & making, mold, core, melt, pouring conditions, etc.

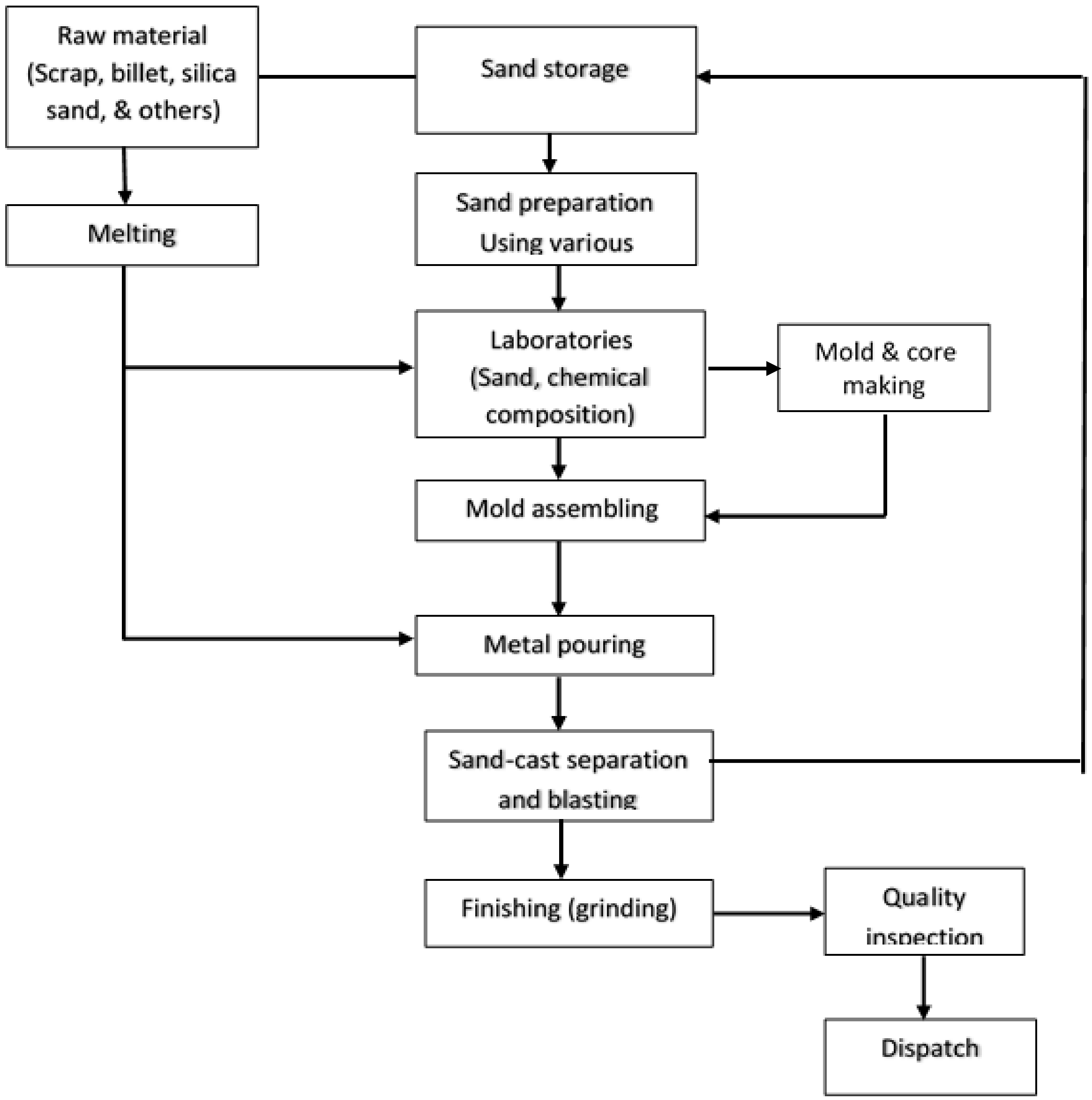

Figure.4.1.the several stages of the foundry process for metal manufacturing.

As depicted in Fig. 4.1, the foundry workshop is presently engaged in a series of activities including sand preparation, raw material selection (scrap), melting, labs, mold assembling, metal pouring, sand cast separation, and final products output. Various waste sources can arise during the working process, such as malfunctioning laboratories (containing chemicals and sand), issues with melting furnace machinery, power outages during the melting process, incomplete pattern creation, incorrect mold assembly, incorrect pouring of molten metal, etc.

B. Process description of part manufacturing work shops

Using various workshop machines that can be light to heavy-duty, this shop creates various types of parts, primarily relying on customer orders. The items produced in this shop include gears, brake drums, different hooks, mill roller shafts, and other fabricated parts. The machine shop is divided into five sections: a lathe section, a milling section, a section for gear hoboing, a section for surface grinding, and a part for heavy-duty machines.

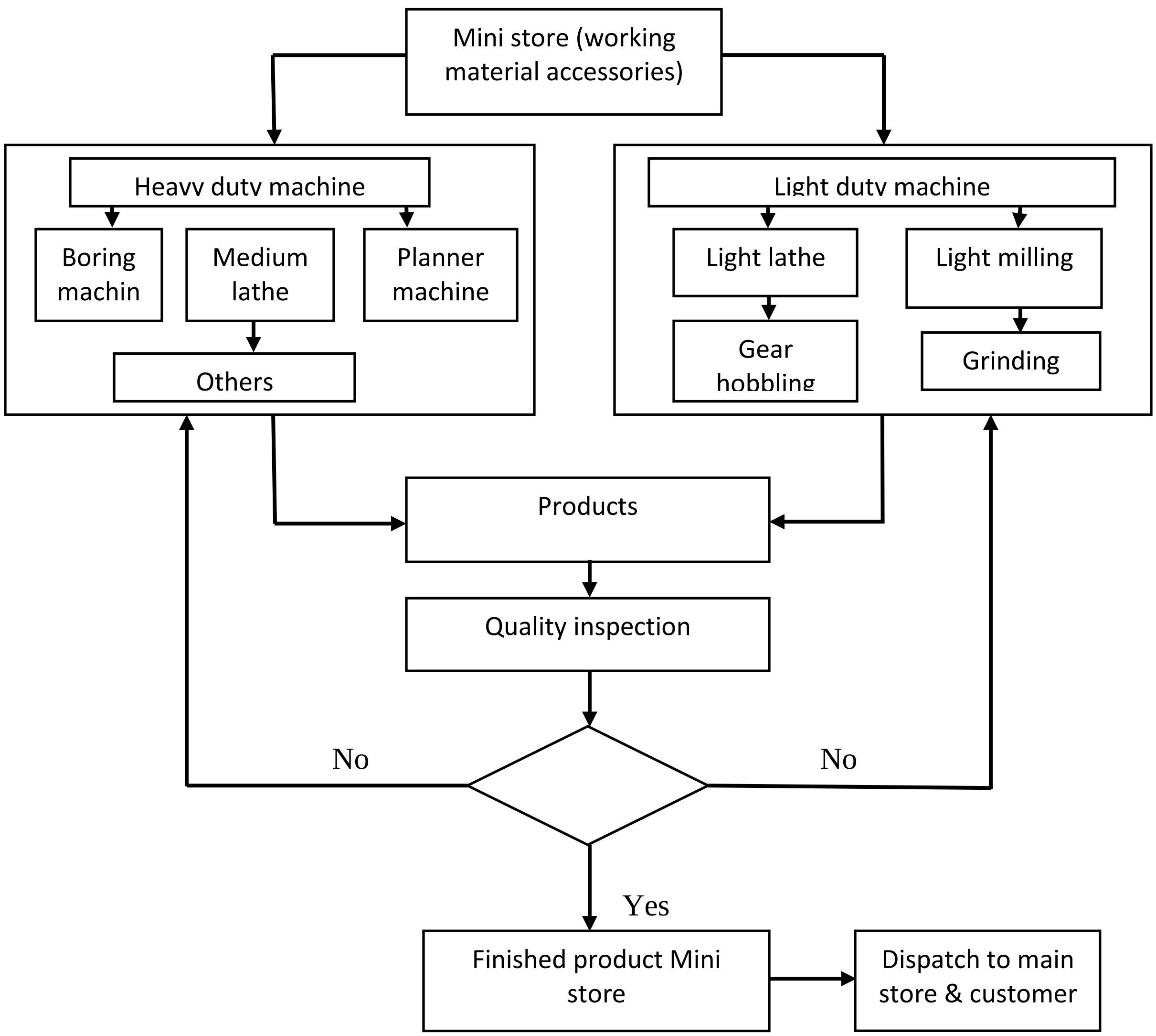

Figure.4.2.machine part work shop process description

Figure 4.2 Part manufacturing workshop manufacturing different components through the machining process. Various waste sources can occur during the machining process, starting from the bar cutting up to the finished products, such as design problems, problems with raw materials, issues with worker skill, issues with machining accuracy, issues with measuring instruments, etc.

4.3. Data Analysis and Results

The examination of the data gathered from the Akaki Basic Metals Industry is covered in detail in the section that follows. Through the collection of qualitative and quantitative primary data regarding the existing defective/waste rate measurement and improvement practices in the metal industries, the questionnaire was created to assess waste / reject rate factors, practices, and levels.

The questionnaire was divided into three sections with the intention of gathering information from the manager or executive officer, the marketing department, and the operator or workers. It focused primarily on the reasons behind waste and rejection that occur in the case company's various workshops.

The marketing department questionnaire shows material and product factors affecting about 10 questions as well as workers or operators in four workshops cause of waste happens above 15 questions in each workshop. The first section of the questionnaire is the managerial question, which contains product design issues, raw materials and products, manufacturing process, waste management issues, and different workshop factors affecting production defect/waste issues. Customers complain about the timeliness and quality of the products, each workshop requests that raw materials or accessories not be delivered on time, worker motivation is low, there is a lack of customers, a shortage of skilled labor, and not all workers are working at the same time because some workshops do not have enough work orders. As a result of all of the aforementioned issues, waste in the metal manufacturing industries is a major concern.

According to the interviewee's response and what was observed, it is defined as the situation where a company has had water shortage issues for more than three years, machinery problems, defective product issues, workers/operators raising concerns about safety materials, electric power interruption during melting time rejecting the molten metal, laboratory testing equipment breaking down as a result of guessing the amount of molten metal poured into the mold, and defective products accumulating on various shelves.

Meanwhile, due to various strategies and programs used to negotiate the company management and worker at one line, a strong commitment at management label to solve the problems, trained workers and management for waste issue on the educational institute and other universities make partners to, the metal manufacturing industries need to develop practices to improve the above challenges and give solutions that put them at better minimization of waste occur on the company.

4.4. Research Sample/response rate

As a result, 110 questionnaires were given out in all, and 104 (98%) of them were returned. Because I've been employed by the case company for many years and informed the management team seriously that I needed their help collecting surveys to support the study topic, this was the main reason I received all of the questionnaires that had been sent out.

According to the analysis of the managers (middle and high level) respondents' relevant work experience, 37.5% of respondents had relevant work experience between 1 and 10 years, 12.5% had relevant work experience between 11 and 20 years, 37.5% had relevant work experience between 21 and 30 years, and 12.5% had relevant work experience over 30 years.

Higher and middle management positions, production and operation managers, factory managers, marketing managers, quality control managers, production planning and control engineers, industrial engineers, and research and development managers were among the respondents. Their educational backgrounds ranged from MSC, BSC, and BA degrees to others. Using SPSS and Microsoft Excel, the questionnaire is examined. The discussion and presentation of the results are as follows.

Since practically all departments are in charge of managing the effects of solid waste and their management, the responsible department is the one that is indicated in the above responses to the questioner. From the outset, marketing departments collect customer orders for samples, which are then processed by R&D (research and development) to prepare a design. PPC (production planning and control) then schedules the manufacture date and sends the sample to the appropriate location (foundry, part manufacturing workshops, etc.). Throughout the process, it's possible for machines to break down and other issues to arise; maintenance is involved and provides answers; department heads and employees are accountable for all work processes and waste product incidents; and, in the end, the crisis not only creates issues for the company but also results in complaints from customers.

4.5. Results of solid waste management in the firms

4.5.1 Factors influencing solid waste management

Based on the surveyed questionnaire the waste / reject factors which are influencing the Ethiopian metal manufacturing industries are analyzed. The table below summarizes the ratings from the respondents given to each factor

A. Management respondent for the design issue.

As table 4.2. Shows below, all causes are greater than moderate (50%), leading to the following conclusion: the product design revision is rated with the highest rating (78.1%), so this issue is resolved and the issue is minimized. Technological limitations, the need for more information in the product design, and designer skill issues in sketching drawings were also the next highest (agree) with (68.75%) rate design issues as waste issues. The need for more time for urgent design activities and the process of selecting poor input materials during design are prone to serious problems, the remaining problems being over estimation of specification tolerances and engineering the increase in products (products made to or out of customer specification). (Frequency of the respond is 8).

Table .4.2. Questionnaires Data analysis regarding manager's respondents for design issue.

Rank	Description of design cause	Percentage %
1	Product design revisions as well as changes based on need for customer cause of waste.	78.1
2	Technology limitations for perfection and accuracy of drawing (software and others problem)	68.75
2	A need for more information in the product designs.	68.75
2	Designer skill problem for sketch the drawing.	68.75
3	Poor communication with stakeholders results in mistakes and error.	65.62
3	The process of selection of low-quality input Materials during the design.	65.62

4	A need for more time for urgent design activities.	62.5
5	An excessive estimation of specification tolerances (allowances).	59.37
6	The increase in engineered products (products designed to customer specifications or outside of standards).	56.25

B. Management respondent for raw material and products.

The following conclusions can be reached from Table 4.3 shows below: The response rate (65.62%) are given to the quality of raw material to be purchased problem and choosing suppliers and subcontractors based on price were also the next higher rate of waste, and an inadequate schedule for material acquisition has been scored (62.5%) the moderate significant. The highest scored record by the respondent are shown that, material that were purchased did not meet the requirements is (68.75%) means time waste and financial crisis were happen. (Frequency of the response is 8).

Table .4.3 Questionnaires analysis regarding manager's respondents for raw material & products

Rank	Description of raw material and product	Percentage
1	Materials that were purchased did not meet the requirements	68.75
2	Choosing suppliers and subcontractors based on price	65.62
3	A inadequate schedule for material acquisition	62.5
4	Ordering too much or too little as a result of errors in quantity surveys [Lean principle regards inventory as waste]	59.37
5	Insufficient space for storage	56.25
6	nonconformance Material stock in the store	53.12

C. Management respondent for manufacturing process.

From the data presented in Table 4.4 shows below, the following conclusions may be drawn: the response rate (78.1%) is attributed to a lack of incentive and motivational programs for employees and the biggest factor contributing to a waste problem is a lack of appropriate tools and equipment. (75% of the subsequent score noted), The second significant incidence of waste propagation is caused by the depreciation of equipment and machinery, bad working relationships among employees, and a lack of new equipment and machinery. Breakdowns of equipment and machinery were consistently rated as the third and most fundamental issue of waste (71.87%). According to lean principles, operator negligence or incompetence, repetitive errors / rejects on the same goods, and wasteful movement of people and objects (materials) are all causes of waste in the case of industries that scored (65.2%). A bad floor plan (62.5%) received a moderate cause of waste affect rating. According to lean manufacturing principles, rejected products constitute waste, so the given scored results indicate that inadequate product control mechanisms, worker ignorance of the design or drawings, ineffective product handling techniques, and a high volume of product rejection have a significant impact on waste on the case company scored on (59.4%). (Frequency of the response is 8).

Table .4.4. Questionnaires analysis regarding manager's respondents for manufacturing process

Rank	Description of raw material and product	Percentage %
1	A lack of employee motivation and incentive programs	78.1
1	Lack of necessary tools and equipment	78.1
2	Depreciation of equipment and machinery	75
2	Negative relations among workers at the organization	75
2	The lack of modern machinery and equipment	75
3	Equipment and machinery breakdown regularly.	71.87
4	Operator carelessness or incompetence	65.62
4	According to lean principles, the unnecessary movement of people and items (materials) is waste.	65.62
4	Repeated mistakes/ reject on the same product	65.62
5	When it arrives, the input materials are damaged	62.5
5	Product (output material) damage	62.5
5	Over processing, also [in light of the Lean concept]	62.5
5	Hiring (new) unskilled workers for the company.	62.5
5	A poorly designed floor plan	62.5
6	Inadequate product control mechanisms	59.4
6	The workers' lack of comprehension of the design or drawings	59.4
6	Ineffective product handling techniques	59.4
6	High quantity of product rejection (according to lean manufacturing principles, rejected products constitute waste).	59.4
6	Ineffective time management [according to Lean principles, downtime equals waste]	59.4
7	Confusing production techniques	56.25
7	Reworks as a result of errors (reworks constitute waste according to Lean principles)	56.25

8	Customer-driven design or order modification	53.12
8	Overproduction [overproductions, according to the Lean approach, are wastes]	53.12
9	A labor shortage for the essential job.	50

D. Management respondent on waste management minimization.

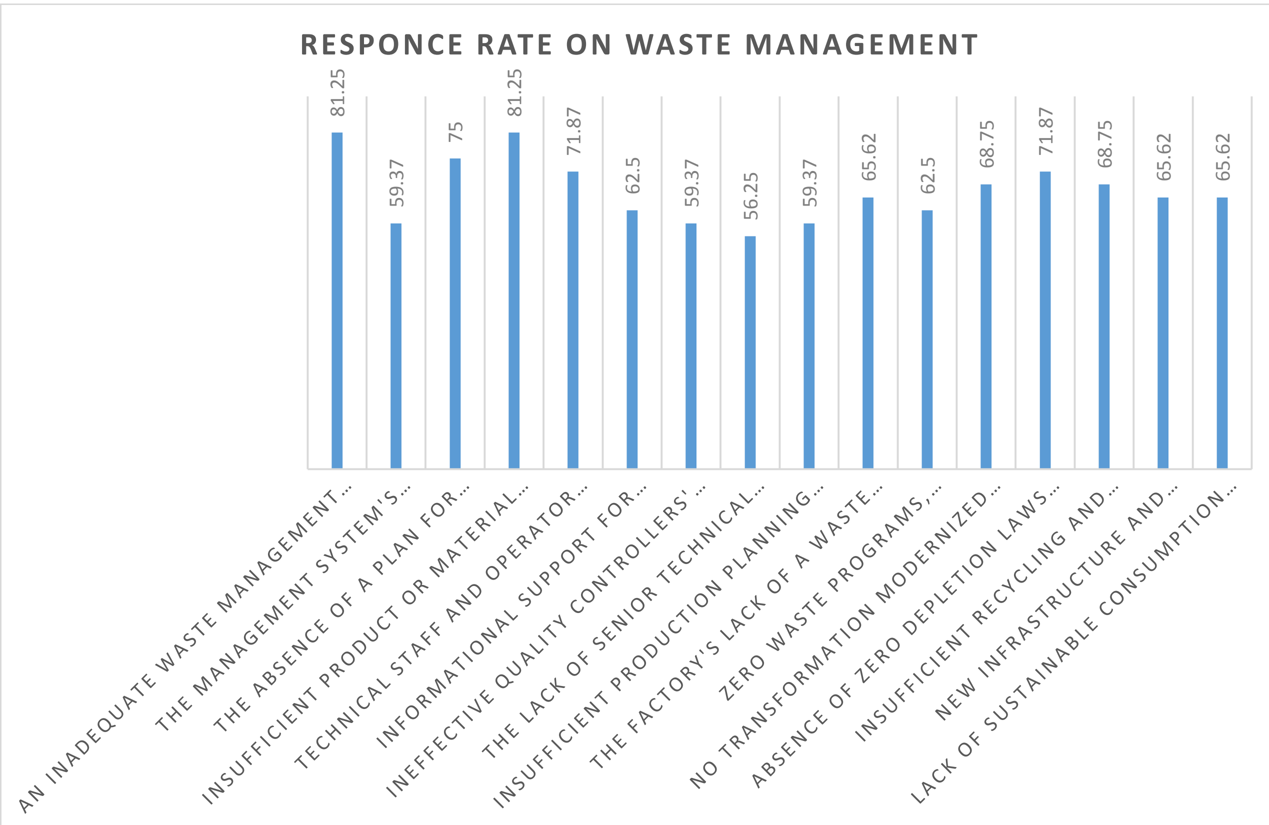

Figure.4.3. Questionnaires analysis regarding manager's respondents for on waste management.

As it can be seen from the figure 4.3, the two main reasons (An inadequate waste management strategy and control) and (Insufficient product or material transportation systems Under the Lean Principle, unnecessary transportation is waste) accounts high rate about (81.25%) and while (The absence of a plan for minimizing waste) the response rate is (75%). (71.87%) of response are (Technical staff and operator qualifications put in charge of the factory) and (Absence of zero depletion laws and regulations (For example, laws requiring zero landfills, zero incinerators, and incentives) has also the significant effects of waste management minimization. No transformation Modernized industrial design, including (Producer responsibility, cleaner production, cradle-to-cradle design) and insufficient recycling and recovery of 100% (including Reducing, repairing or reusing, recycling, and recovering has also significant effect recorded (68.75%). Moderately (65.62%) score recorded as, the factory's lack of a waste distinguishing system, new infrastructure and technology includes (New technology, new infrastructure, and zero waste governance) and Lack of sustainable consumption as well as behavior (which encompasses sustainable living, cooperative consumption, and behavioral transformation). Informational support for workers in the factory & Zero waste programs, transformational education, and research are all examples of areas where there needs to be more knowledge and all the rest are slightly significant of waste management.

E. Management respondent on Pattern work shop.

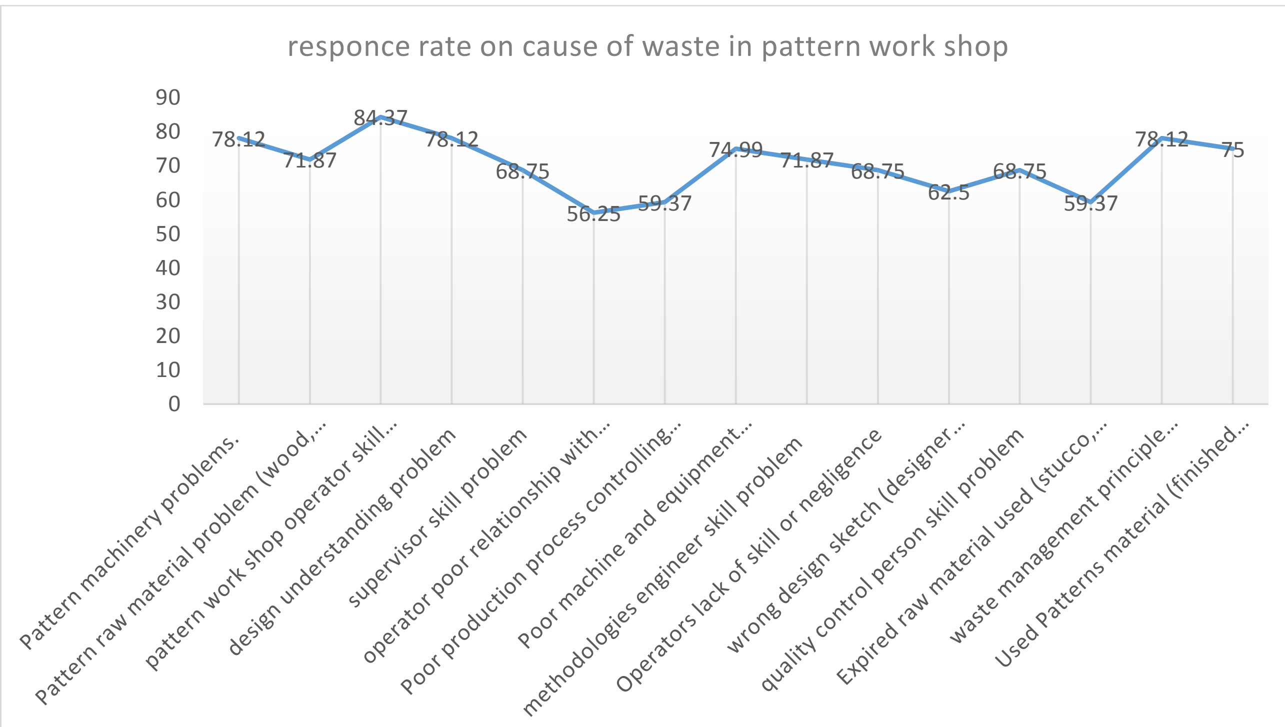

Figure.4.4. Causes of metal wastes for pattern workshops on foundry

The pattern work shop operator skill problem receives the highest score (84.37) (extremely significant) among the factors affecting waste, as shown in figure 4.4, and three other factors are rated at 78.12% (pattern machinery problems, design understanding problems, and waste management principal implementation problems). Moreover, (75% - 71.87%) account (Used

Patterns Material (Finished Pattern or Scrap Material) use for another time reuse, repurpose, or recycle for other task, Waste was mostly influenced by poor machine and equipment maintenance skills, engineer skill issues, and pattern raw material issues (wood, nails, etc.). The remainder of the seven causes are relatively influential in the waste on pattern workshops, according to the answer rate (68.75% - 56.25%).

F. Management respondent on Mold work shop.

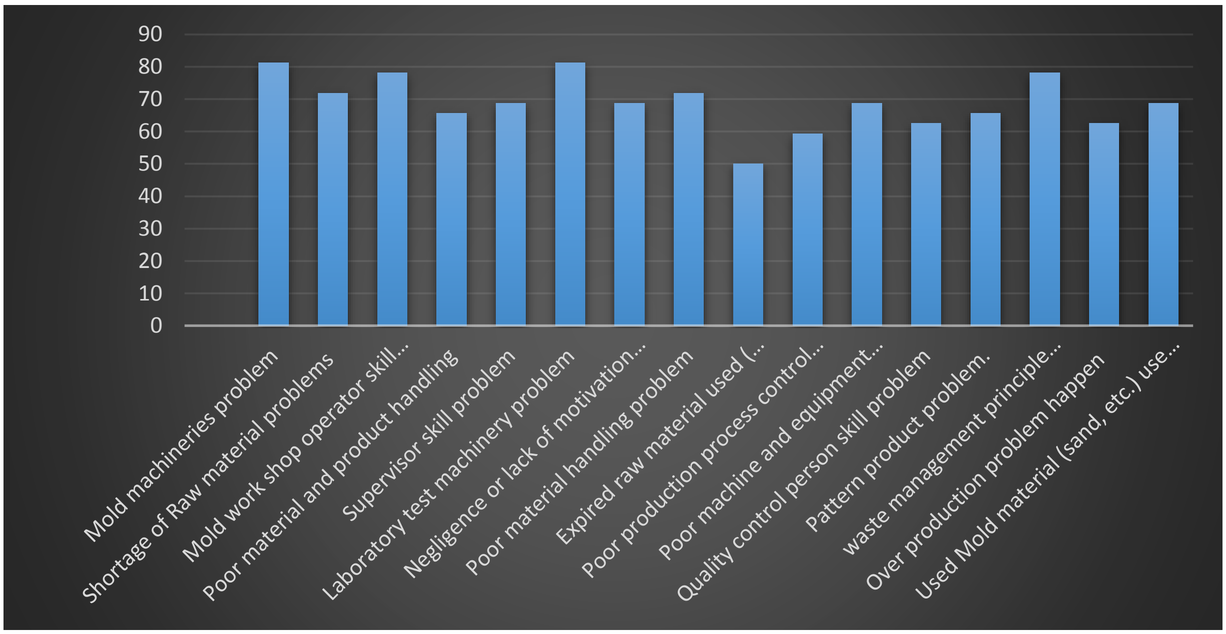

Figure.4.5. Causes of metal wastes for mold workshops on foundry

The lowest score has a (50%–59.3%) range. Figure 4.5 illustrates the use of expired raw materials (chemicals, resin, and catalyst) as well as a poor production process control system (PPC). (68.75% - 62.5%) scored rather well on eight different response-question categories, including "Used Mold material (sand, etc.) use for another time reuse, repurpose, or recycle for another job." "Supervisor skill problem," "Negligence or lack of motivation on the part of the worker," and "Poor machine and equipment maintenance skill." Extremely significant waste-related problems have been found as being caused by unskilled mold workshop operators, subpar material and product handling, a shortage of raw materials, and the usage of expired components (such as sand, resin, catalyst, etc.). (Mold machinery and laboratory test) received the highest rating for the manufacturing waste category scored (81.25).

G. Management respondent on Melting work shop.

Table 4.5 displays the Melting Furnace machines issue with the highest score (84.37%).and the second greatest difficulties are (Negligence or lack of motivation workers and Quality control person competence problems), which received scores of (78.12% & 75.62%). 8 different categories of moderate issues were rated (68.75% - 59.37%). Poor production process control system (PPC) (over planned but not implemented), Poor machine and equipment maintenance skill, Waste management principle implementation problem, Mold workshop operator skill problem, Supervisor skill problem, Shortage of Raw material problems (refractory material, scrap, (cast iron, steel, others, etc.), Electric interruption problem, and Contaminated Molten Metal Used for Reuse, Repurpose or Recycling for a Raw Material are some of these issues. the lowest rating (Poor content material handling problems, un proper place of molten metal dropping area) are (56.25% - 53.12%). (Frequency of the response is 8).

Table .4.5.Questionnaires analysis regarding manager's respondents for melting workshops.

Rank	Description of raw material and product	percentage
1	Melting Furnace machineries problems.	84.37
6	Shortage of Raw material problems (refractory material & others)	59.37
5	Mold work shop operator skill problems.	62.5
3	Scrap selection, Scrap transportation, Poor material and product handling problem.	75
5	Supervisor skill problem	62.49
3	Laboratory test machinery problem	75
2	Negligence or lack of motivation worker	78.12
7	Poor material handling problem	56.24
7	Un proper place of molten metal dropping area.	56.25
4	Poor production process control system (PPC)	68.74
4	Poor machine and equipment maintenance skill	68.75
3	Quality control person skill problem	75.62
4	Waste management principle implementation problem	68.75
6	Electric interruption problem.	59.37
8	Over production problem happen or (no order product happen).	53.12
6	Defected molten metal after cooling used for reuse, repurpose or recycle for a raw material for other job.	59.37

A. Management respondent on part manufacturing work shop.

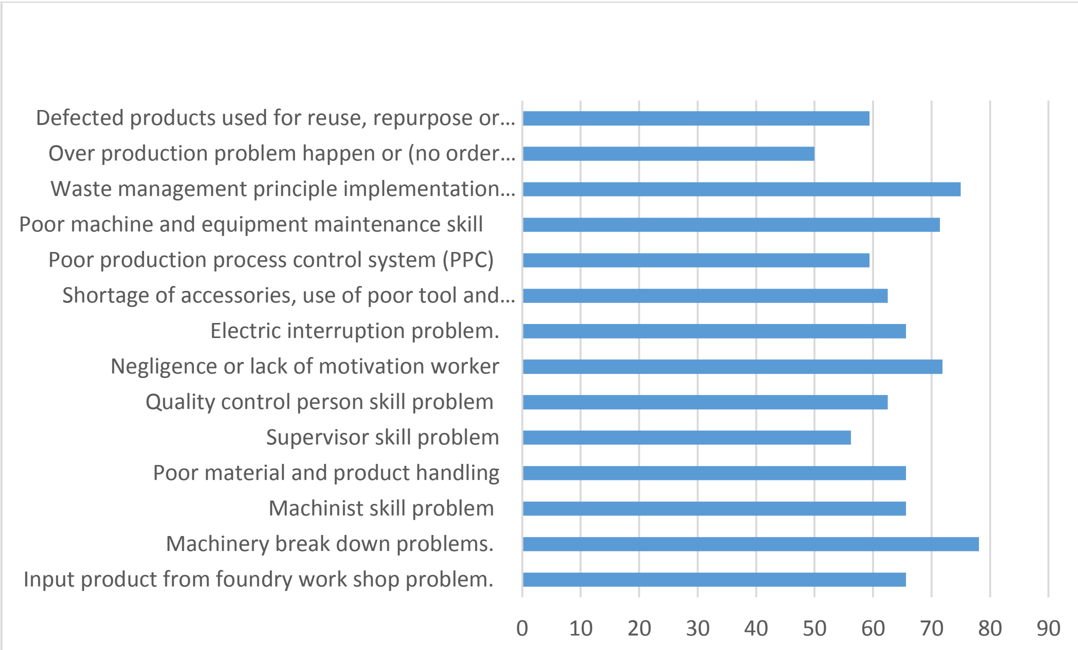

Figure.4.6.Causes of metal wastes part manufacturing workshops

The problem with the highest score (78.12%) in the part production workshops is shown in Figure 4.6 (Machinery breakdown issues). (Boring, planning, milling, lathe, and other machines). The following issues received scores of 75% to 71.45%: Waste management principle implementation issue, negligent or unmotivated worker, and poor material and product handling. And the moderate issues that scored (65.62% - 62.5) in the six categories of manufacturing waste are (Problem with input product from foundry work shop. Machinist skill issues (read design, comprehend work, etc.), Poor material and product handling, (High machining allowance, no machining allowance, hard material, and others.), Problems with the power supply, the ability of quality control personnel (during process inspection, prior to product rejection, and others), a lack of accessories, and the usage of subpar tools and equipment). Furthermore, the least four scores recorded are: Poor production process control system (PPC) (over planned but not implemented), Defective products used for reuse, repurpose, or recycling for a raw material for other jobs, Supervisor skill problem, and Over production problem happen or (no order product happen) scored (59.37% - 50%).

A. Management respondent on open ended questioner.

Most of the open-ended questions are centered on waste and how waste management affects the organization and others and are given to upper and middle label management responses were presented below.

According to the effects of metal product wastes on manufacturing compounds, various issues arise, such as the spread of poor productivity, economic failure brought on by competition with other companies, an increase in customer complaints, the accumulation of waste products over a long period of time taking up a lot of space and rusting, contaminating the air and water, and adverse effects on human health and the environment. Additionally, as most waste products need to be cleaned up from the surface, this consumes extra time, manpower, and transportation resources. Additionally, a lot of waste materials could undergo costly processes like reuse or repurposing.

Which business benefits from controlling and reducing metal waste in the metal manufacturing industry or another industry? How then? The reduction of waste in the metals business and other industries is particularly advantageous in terms of finances, health, the environment, and other factors. The rejection rate of numerous goods in the Akaki Basic Metals business is also increasing year over year; as a result, both corporate management and employees are equally responsible for trash and adhere to various waste management principles. Particularly in foundry workshops, the case firm's working process requires several inputs of raw materials, human power, time, energy, and others; as a result, it is possible that rejects or waste products grow crises for the company. As a result, all reduce waste, and they are lucrative.

Who should act to reduce metal waste? The recommendation is to reduce metal waste and focus the team's attention on waste. After receiving support from management, the team will provide a diversity of viewpoints, innovative problem-solving strategies, and possibilities for development by using various processes while setting clear, quantifiable targets and evaluating waste before putting the system into practice.

What long-term waste management and reduction strategies are in place at the Akaki Basic Metals Industry? Making kaizen and other associated waste-related training available is part of the long-term waste minimization strategy for the Akaki Basic Metals sector. Additionally, after training with a programed to begin the work minimize waste on subpar goods and all work processes revised, machine breakdown issues, motivate the worker, attend all process inspections by quality control, maintain all laboratories measurement equipment, and others work effectively.

4.5.2 Questionnaires Data analysis regarding marketing and sales

The marketing division had the highest response rate (81.75%), two waste-related problems (products purchased that don't satisfy criteria and a lack of norms and regulations), and received the lowest grade. A 75% rating was likewise given to the second waste problem (lack of incentives and technological constraints). The moderate concerns that scored (68.75%) include a poor material procurement schedule, material damage from clients' modifications in orders and designs, a shortage of raw materials, and a shortage of foreign currency. Choosing suppliers and subcontractors only on the basis of pricing resulted in the least amount of waste (62.5%).

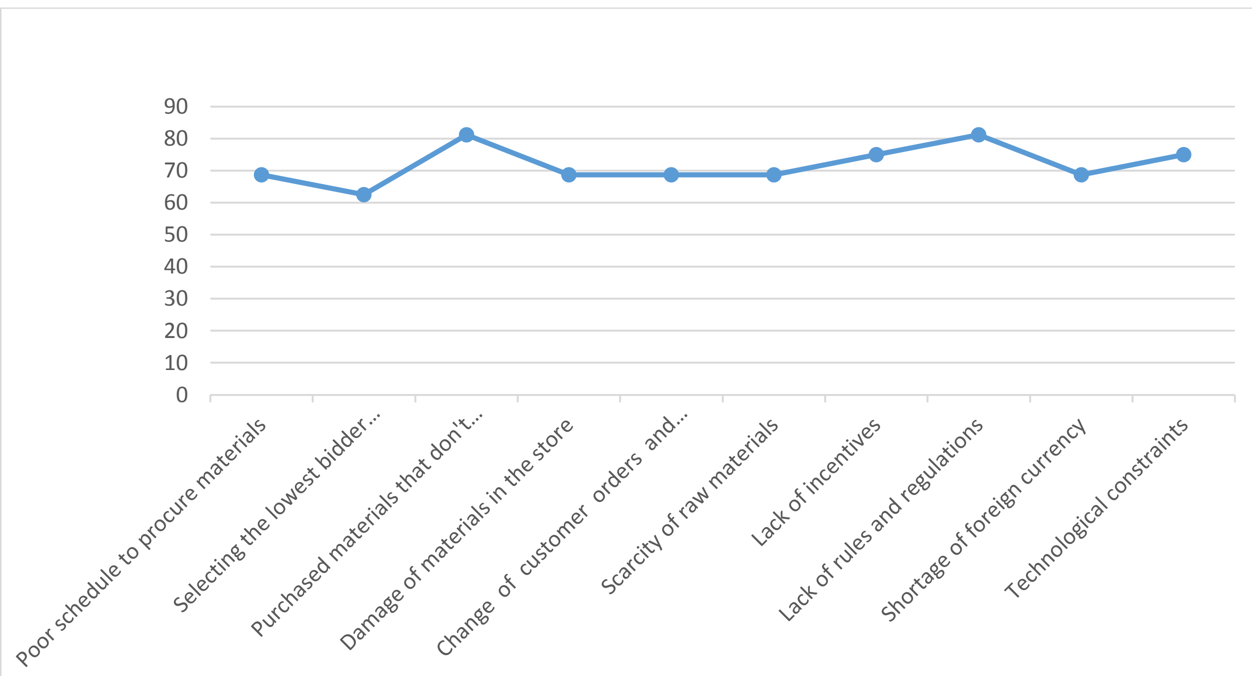

Figure.4.7. questioner data analysis regarding marketing and sales

Responses for the open questions prepared for marketing and sales, part III,

Because waste occurs in various industries, such as over processing, defective products, excess inventory, transportation issues, raw material defects resulting from various causes, waiting times, and other wastes, different responses from the marketing department have been recorded regarding the major effects of metal product waste on the case company. These wastes are primarily recorded on Akaki basic metals. Due to waste, the company experiences a decline in revenue, a rise in customer complaints, and a failure to respond to employee requests for incentives or pay raises. As a result, environmental and financial issues are often the main issues.

The business that benefits from waste management in the metal manufacturing industry is the one where all the causes of waste-related issues are minimized, including proper machine maintenance, working process control, a reduction in defective products, proper raw material purchases, according to scheduled work on time, and proper time management. Additional kaizen training is provided, and it is implemented consistently to ensure business profitability.

The organization's employees, top management, middle management, the head of the work shop, employees, and helpers are all accountable for the actions taken to reduce waste metals, but because all of the aforementioned responsible parties lack sufficient knowledge of waste and waste-related factors, it is challenging to address the issue. The majority of products on working time control by on processing time by quality inspector, machine breakdown maintenance by the maintenance department, and purchased raw material by logistics are all accountable for any waste that occurs in the company and must take immediate action to discuss the issue and provide a solution to limit the waste.

The highest rate of various wastes, including defective products, rework, delays, over processing, a lack of customers (a lack of work orders), and others, may be found in Akaki basic metals waste. These wastes can't be dealt with right once, but over time you should suggest a plan of action, use tools like lean, zero waste management, and kaizen, and follow the proper protocol.

4.5.3 Questionnaires Data analysis regarding production worker

All of the questions centered on the manufacturing workshops and the waste-related difficulties that arise in each one. A minimum of 15 questions were asked about the pattern workshops, mold workshops, melting workshops, and part manufacturing processes at each work shop. The response rate is listed below.

I. Worker’s response on pattern work shops

Before melting the molten metal and molding the sample piece in accordance with the customer's order and the drawing, the pattern work shop serves as the backbone of the foundry department. They produce the pattern using wood and other raw materials.

The response reveals that the three issues with the greatest and most significant scores (waste management principle implementation problem, Pattern machinery problems, and Poor machine and equipment maintenance skill) are (79.1% - 75%). The second significant six waste issues are (operator poor relationship with supervisor, Pattern raw material problem (wood, nail, stucco, etc.), methodologies engineer skill problem, Operators lack of skill or negligence, quality control person on process inspection skill problem, pattern work shop operator skill problem) and are scored (70.83% - 60.42%). The problems are supervisor skill issues, poor production process controlling system (PPC) (over planned but not implemented), used patterns material (finished pattern or scrap material) use for another time reuse, and moderately scored are recorded on cause of waste (59.4% - 54.16%).

II. Worker’s response on mold workshops.

The foundry consists of three molding stations: mechanized molding (NF) and manualmolding system. For large sized parts like mill rollers for sugar factory, manual molding is selected while for small & multiple parts; mechanized molding is commonly used when it is in state operational. In the case of manual molding, there is increased number of molding operators for ramming and mold manipulation that which results in higher labor cost, increased processing time, and it discourages younger men from getting into the foundry game due to repetitive natureof the task.

The cause of waste in the mold shop with the highest rate (85.4%) is (old machines and lack of skills in equipment maintenance). (Problems in implementing the waste management principle, problems with the laboratory testing machines, problems with the machines in the molding area, poor production process control (PPC) system) are the second most important problems evaluated

(79.1% - 70.81%). The mediocre issues affecting the evaluation (68.74% - 62.49%) include (quality control personnel's skill issues in process inspection, laxity or lack of motivation of employees, raw material shortage issues (sand, resin, catalyst, etc.), poor material and product handling, manager's qualification problem due to lack of experience). The lowest cause of the evaluated waste is listed in descending order (mold shop operator skill problems, poor material handling problem, expired raw material (chemicals, resin, catalyst), overproduction problem (no custom manufacturing), used mold material (sand, etc.) .) effectively reuse, reuse, or recycle for another time. The issue originates from the Pattern product) was rated (59.3% - 48.95%).

III. Worker's response on melting workshops.

The melting factories the issues with melting furnace equipment, laboratory test equipment, and poor production process control (PPC) have received the highest significance scores (82.28%, 78.12%, and 77.07%). Poor production process control system (PPC), electrical interruption issues, and poor machine and equipment maintenance skills (rated 74.99%, 64.19%) are the second most significant causes of waste. The moderate issues, which ranged from 60.4% to 53.12% on the response, are presented in descending order (carelessness or a lack of motivation on the part of the employee, contaminated molten metal utilized as a raw material for another job after cooling, improper placement of the molten metal dropping area, etc.). Problems with the skills of quality control personnel, supervisors, shortages of raw materials (including refractory materials, scrap, and others), power outages, and mold shop operators. The least score recorded factors affecting waste are Poor material handling problems (48.95%).

IV. Worker's response on part manufacturing workshops.

The problem with the highest score (88.54% & 84.36%) in part manufacturing workshops are (Machinery break down problems. (Boring machine, planner machine, milling, lathe, others) And Input product from foundry work shop problem. (High machining allowance, no machining allowance, hard material, and others). The following issue received scores 77.01% - 70.76%: Waste management principal implementation problem, Poor machine and equipment maintenance skill, Shortage of accessories, use of poor tool and equipment). And the moderate issues that scored (62.49% - 57.28%) has six types cause of waste Poor production process control system (PPC), Negligence or lack of motivation worker, Machinist skill problem (read design, understanding of work, etc.), Poor material and product handling, over production problem happen or (no order product happen), Defected products used for reuse, repurpose or recycle for a raw material for other job). The least score recorded (55.19% - 48.95%) has (Quality control person skill problem, Electric interruption problem and Supervisor skill problem).

V. Worker's response on open ended question.

The drawbacks of the waste produced during the production of metal manufacturing occurs production time waste, raw material waste, electric power waste, transportation waste, loose of labor cost, increase customer complain, depreciate profit and may be after some years it will be closed the industries, etc.

Minimizing and handling of the waste can profit the company because increase profitability, no customer complaints and order again other jobs by customer, use properly raw materials and human labor, use properly machineries and maintain it, not have accumulation of waste on the floor, the workers does not terminate the company, high motivational and incentive systems are implement, minimized un planned cost, and others due to this profitable is increase.

The organization's employees, top management, middle management, the head of the work shop, employees, and helpers are all accountable for the actions taken to reduce waste metals, but because all of the aforementioned responsible parties lack sufficient knowledge of waste and waste-related factors, it is challenging to address the issue. The majority of products on working time control by on processing time by quality inspector, machine breakdown maintenance by the maintenance department, and purchased raw material by logistics are all accountable for any waste that occurs in the company and must take immediate action to discuss the issue and provide a solution to limit the waste.

The highest rate of various wastes, including defective products, rework, delays, over processing, a lack of customers (a lack of work orders), and others, may be found in Akaki basic metals waste. These wastes can't be dealt with right once, but over time you should suggest a plan of action, use tools like lean, zero waste management, and kaizen, and follow the proper protocol.

4.6. Summary analysis of questioner response about factor influencing solid waste management.

The case company had the greatest reply rate and the lowest answer rate of all the inquiries, from management to workers, indicating that it has a solid waste impact problems. According to the company's operating system, all of the inquiries are easily comprehended by management and employees.

4.6.1. Summary analysis of the Management respondent for closed-ended response

Design issues, raw materials and products, manufacturing processes, waste management minimization, pattern workshops, mold work hops, melting workshops, and part manufacturing workshops are all covered in the closed-ended question. Has the highest response rate and is more concerned with the company's impact on solid waste management.

- Product design revisions as well as changes based on need for customer cause of waste.
- Material that were purchased did not meet the requirements
- A lack of necessary tools and equipment
- An inadequate waste management strategy and control, in sufficient product or material transportation system under the lean principle and unnecessary transportation in waste.
- The pattern workshops operators problems, pattern machinery problem and design understanding problem.
- Mold machinery problem and laboratory shop machinery problem.
- Melting furnace machineries problems and quality control person skill problem and negligence of lack of motivation worker.
- Machinery break down issues (boring, planning, milling, lathe, and other machineries) and waste management implementation issue.
- Waste related problems (product purchased that don’t satisfy criteria and a lack of norms and regulations.

4.6.2. Summary analysis of the production worker respondent's closed-ended response

Most significant scores has recorded and gives solution for that

- On pattern workshops - Waste management principle implementation problem, pattern machineries problems, and poor machine and equipment maintenance skill.
- On mold workshop – old machines and lack of skill in equipment maintenance, problems in implementing the waste management principles and problems with the laboratory testing machines.
- On melting workshop – the melting factories the issues with melting furnace equipment, laboratory test equipment problem, and poor production process control
- On part manufacturing workshop – machinery break down problems like (boring machine, planner machine problem, milling, lathe, etc.) and input product from foundry work shop problems.

The following summaries suggest that the company has had various waste and waste impact difficulties, and the questioner's response shows many waste and waste effect issues. All the difficulties point to waste management issues in the Akaki Basic Metals Industry. Shows the response and current state of the company's report status and waste accumulation on figure, reject amount, and other data are provided below.

4.7. Company Production Data, metal waste and machineries data

4.7.1. Planned product & actual product

In the table below, the three-year report (2012, 2013, and 2014 E.C.) summarizes the planned and actual reports of poor performance, demonstrating that the sector cannot efficiently use its time, machinery, labor, and so on. The three-year report also includes data on materials that were returned or discovered to be defective.

Table .4.6. Planned product & actual product

Work shops	Planed in Pcs, Ton	Actual in Pcs, Ton	Output %	Planed in birr	Actual in birr	Output %
2012 E.C(2020) planned product & actual product						
Part manufacturing	**465,777 pcs**	**51,012 pcs.**	**11 %**	**117, 206, 932**	**32,206,932**	**28%**
Foundry work shops	**621 Ton**	**98.3 Ton**	**16%**	**21,272,279**	**4,347,962**	**20%**
2013 E.C(2021) planned product & actual product						
Part manufacturing	**430,686 pcs**	**43,185 pcs.**	**10 %**	**113, 989, 714**	**28,527,940**	**25%**
Foundry work shops	**618 Ton**	**70 Ton**	**11.3%**	**21,131,491**	**2,995,877**	**20%**
2014 E.C(2022) planned product & actual product						
Part manufacturing	**144,911 pcs**	**31,100**	**14%**	**86,890,345**	**18,768,165**	**22%**
Foundry work shops	**650 Ton**	**68 Ton**	**10.4%**	**20,131,491**	**1,989,643**	**21%**

The above table 4.6 demonstrates that in 2012 E.C (2020), part manufacturing workshops were planned in pieces and output was 11%, in 2013 E.C (2021), it was 10%, and in 2014 E.C (2022), it was 14%. Almost the entire three-year average planned output report indicates 11.6%.

The data in the table also shows that in 2012 E.C (2020), foundry workshop planned in tones and output is 16%, in 2013 E.C (2021) planned in tones and output 11.3%, and in 2014 E.C (2022) planned in tones and output is 10.4%. Almost all of the three-year average planned output report shows 12.5%

4.7.2. Metal Waste / reject Products in the case company

The three-year report for Akaki Basic Metals Industries reveals underperformance to observed production units and intended goods, and data gathered from the case company reveals a reject or wasted product rate in various manufacturing units as a result of factors affecting waste improvement. Below the figure, you can see some of waste / reject products.

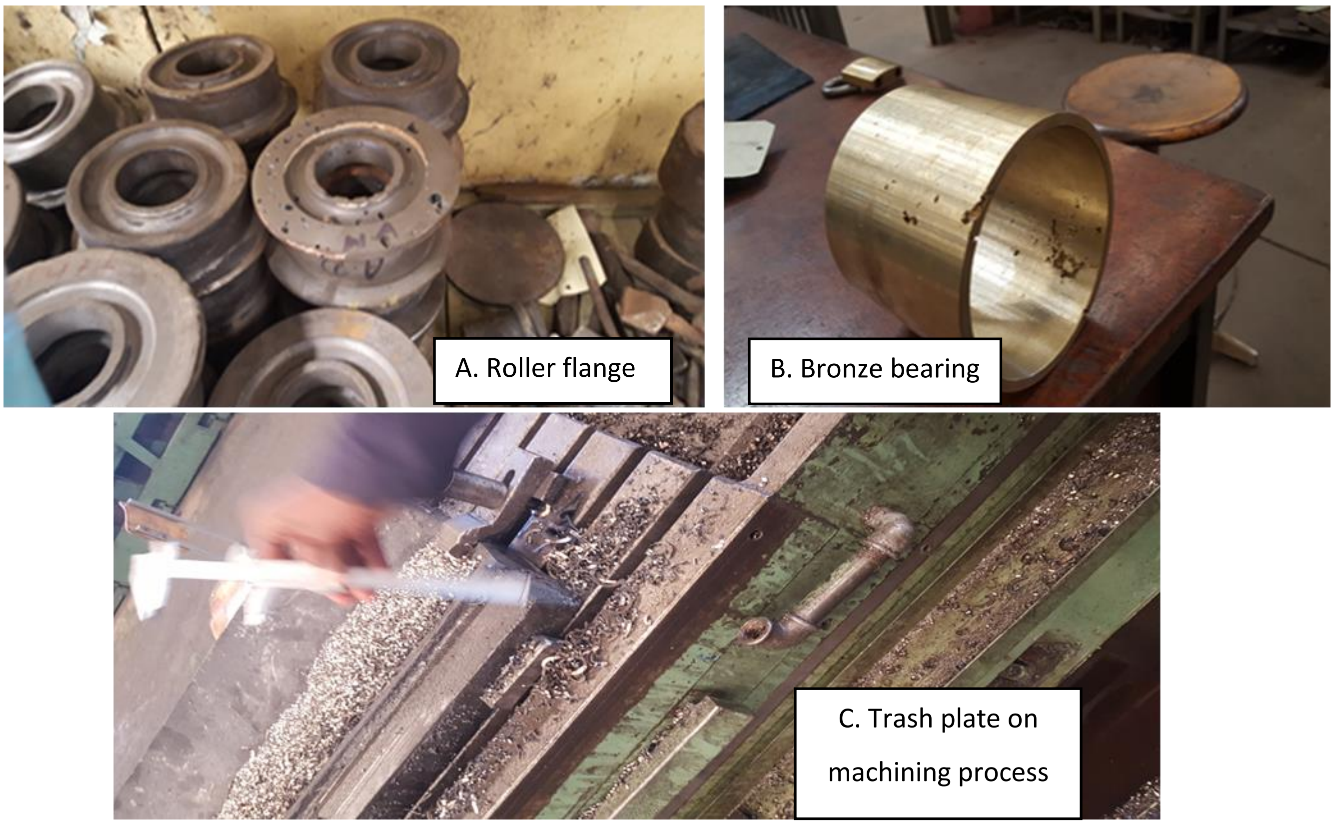

Figure.4.8. some of the defected / wasted product in part manufacturing workshops

In figure 4.8. Shows that some of the defect in the part manufacturing work shops that has occurred in different cause of problems some of the problems happen

A. One product from the sugar factory, **the roller flange**, was cast in foundry workshops before being machined in component-making workshops. As can be seen in the image, this resulted in a defective (porosity) part inside the material, and as a result, the product falls under the category of reject product.

B. **Bronze bearing**: one of the client items that order particular dimensions and casted in nonferrous workshops after casted at the machining time the porosity part has happened & rejected by quality control.

C. **Trash plate** on machining process: excess of machining allowance gives on the designer that it takes waste of time because of process time is increase.

Figure.4.9. some of the defected / wasted product in foundry workshops.

Figure 4.9. Illustrates some defects in foundry workshops that can have a variety of causes, such as molten metals that do not fill prepared molds, molten metal temperatures that do not melt at specific temperatures, porosity that occurs repeatedly in the same products, etc. As a result, from year to year, rejects and metallic waste occur during production, increasing the cost of rejects as well as the cost of all raw materials and other costs, which seriously harm the competitiveness.

Figure.4.10. Different reject and customer not need products accumulate on workshops.

According to Figure 4.10. Various products amass at a workshop as a result of defect cases, and the buyer may not need the product because it wasn't made according to specification.

4.7.3. Machinery involvement in production

In order to find out the average operating time and downtime waste each year, considering the low production process in the industry, the availability of equipment throughout each factory was assessed. The study takes into account an entire shift (8 hours) as well as downtime from machine work piece adjustments, machine start-up and shut-down, and material and tool adjustment service times. Within ABMI, working days are currently six days a week.

Since most machines are not in operation 24 hours a day, 7 days per week, the examination of machine availability is done using the total operating hours and downtime each month. Below is a discussion of each factory's machine availability.

Table. 4.7. Overall Machines distribution across both workshops.

	Description	Total
1	Functional on part manufacturing	105
2	Break down on part manufacturing	53
3	Functional but un productive	13
4	Functional on foundry	44
5	Break down on foundry	34
6	Functional but un productive in foundry	10
	Total	259

The breakdown of the machine lists is shown in APPENDIX C. If the issue is not resolved right away, the business may be forced to close its doors. Both workshops experience delays in the delivery of their products and time wasted.

The above-mentioned machines are spread across the foundry and part manufacturing workshops, which have a total of 259 machines. Of these, 87 machines are broken down, and 23 are functional but unproductive due to this and other factors, so unproductive time-wasting occurs as scheduled during the productive year.

4.7.4. Reject /waste products records year on 2012 E.C (2020)

The table 4.8 shows below in 2012 (2020), the quality control department, production process control, and each factory reported 7220.26 kg of reject / waste product, furthermore, over 14 client items have reject ordering job, including various metals such as cast iron, low carbon steel, and high carbon steel. The types of defects that have been recorded in foundry and part manufacturing including porosity, off-center, pattern problem defect, over dimension, helix angle shift problem, and others. The type of products also include gear, trash plate, center flange, link left, scraper plate, roller flange and others.

Table .4.8. The production year on 2012 E.C (2020) waste / reject product

production year on 2012E.C (2020) Reject Product										
s/n	Customer name	Part name	Material type	Weight per piece in kg	Order quantity	Inspected quantity	Reject quantity	Defect detected	Types of defect	Total reject in kg
1	Mugger cement	Sun gear	Steel cast	60	03	03	01	Foundry	porosity	6o
2	Fincha sugar F.	Scraper P.	Cast iron	630	02	01	01	Machine S.	pitch shift	630
3	Infrastructure	Link right	Steel cast	12	180	82	82	Foundry	porosity	984
4	Infrastructure	Link left	Steel cast	12	180	107	107	Foundry	porosity	1284
5	Infrastructure	TIP	Cast iron	22	50	50	26	Foundry	porosity	572
6	Ethio pulp & paper	Refine m.s	Round B.	30	05	05	02	Machine S	Gear case	60
7	Kessem sugar F.	Center flange	Cast iron	50	02	01	01	Foundry	porosity	50
8	Akaki basic metals	Boring M. Part	Cast iron	110	01	01	01	Foundry	Improper hole	110
9	Akaki basic metals	Hydraulic sys.	c-45 steel	48	01	01	01	R & D	Dimen. Prob.	48
10	Sun shine con.	Bevel gear	Cast iron	110	02	02	02	foundry	porosity	220
11	Tana Beles Sugar F.	Tail end sprocket	Steel cast	600	02	01	01	Foundry	Improper pouring melt	600
12	Kality metal product	Reduction gear B.	Cast iron	120	04	01	01	foundry	Pattern and mold problem	120

13	Wonji sugar factory	Trash plate	Cast iron	1347.4	01	01	01	Foundry	An appropriate venting hole	1347.4
14	Misraq food complex	Helical gear	Steel cast	70	01	01	01	foundry	Incorrect helix angle	70
15	Akaki basic metals	Locker nut	42CrMn	8	05	01	01	Machine S	Over dimension	8
16	Kessem sugar factory	Scraper plate	Cast iron	630	05	01	01	Machine S	Machined pr.	630
17	Kessem sugar factory	Pressing ring	Cast iron	35	01	01	01	foundry	porosity	35
18	Metehara sugar factory	Roller flange	Cast iron	9.33	250	200	42	foundry	Offset center, hard, pattern problem	391.86
Total reject product in 2012E.C (2020)										**7220.26 kg**

4.7.5. The production year on 2012 E.C (2020) raw material utilized for rejected products

The table 4.9 shows below that raw materials utilized for rejected product in different working processes in 2012 E.C (2020) such as cast, sand, resin, catalyst, isomol, cutting disc, manpower, machine hour, mold glue, wanza, glue, stucco, nail, and others. All raw materials used are recorded in litter, kilo gram, meter, m3, pcs, hours and so on. In the production year, the following materials were used: cast 3254.2 kg, sand 13, 692 kg, resin 1371.4 litter, catalyst 95.65 litter, isomol 46.87 litter, and so on.

Table .4.9. The Production year on 2012 E.C (2020) raw material utilized for rejected products.

s/n	Customer name	Steel & Cast	sand	Resin	catalyst	Isomol	Cutting disc	Man power	Machine hour	Mold glue	wanza	Glue	Stucco	Nail
		kg	kg	Litter	litter	Kg	pcs	Hrs.	Hrs.	litter	M2	litter	Kg	Kg
1	Sun gear	27.6	121.2	0.15	0.73	0.35	0.04	10	10	0.2	0.3	0.5	0.5	0.2
2	Scraper P.	290	1272.2	15.3	7.7	3.74	0.5	15	15	0.4	3	4	4.2	0.4
3	Link right	453	1987	23.86	12	5.84	0.73	20	14	0.4	4.38	6.2	6.57	0.58
4	Link left	591	2593	31.13	15.56	7.63	0.95	26	18.11	0.47	5.72	8.1	8.57	0.76
5	TIP	263	1155	13.86	6.93	3.4	0.42	18	10	0.25	3	3.61	3.82	0.34
6	Refine m.s	27.6	121.2	1.45	0.73	0.36	0.05	10	10	0.2	0.3	0.5	0.5	0.2
7	Center flange	27	121	1.21	0.7	0.34	0.05	10	10	0.2	0.3	0.5	0.5	0.2
8	Boring M. Part	50.63	222	2.66	1.33	0.65	0.08	9	12	0.3	0.49	0.69	0.73	0.3
9	Hydraulic system	27	121	1.16	0.7	0.34	0.05	6	10	0.2	0.3	0.5	0.5	0.2
10	Bevel gear	101.2	444	5.32	2.66	1.3	0.16	12	14	0.35	0.98	1.38	1.46	0.6
11	Tail end sprocket	276.2	276	1212	14.55	7.3	3.56	10	18	0.3	2.67	3.78	4	0.35
12	Reduction gear B.	55.2	243	3	1.46	0.72	0.1	10	13	0.31	0.53	0.75	0.8	0.2
13	Trash plate	620	2720	32,66	16.33	8	1	28	19	0.5	6	8.5	9	0.8
14	Helical gear	32.2	142	1.7	0.85	0.42	0.06	10	13	0.2	0.31	0.6	0.5	0.25

15	Locker nut	3.68	20	0.3	0.5	0.2	0.03	10	8	0.1	0.1	0.1	0.12	0.1
16	Scraper plate	290	1272	15.3	7.7	3.74	0.5	15	15	0.4	3	4	4.2	0.4
17	Pressing ring	16.1	70.67	0.85	0.42	0.21	0.03	10	10	0.2	0.3	0.5	0.4	0.2
18	Roller flange	180.4	791	9.5	4.8	2.33	0.3	15	15	0.4	2	2.5	2.62	0.23
	Total utilized material	**3254.2**	**13,692**	**1371.4**	**95.65**	**46.87**	**8.61**	**244**	**234**	**5.38**	**33.68**	**47**	**49**	**6.31**

4.7.6. Reject /waste products records year on 2013 E.C (2021)

The table 4.10 shows below In 2013 E.C (2021), the quality control department, manufacturing process control, and each factory reported **43,364.27 kg** of reject / waste product. Furthermore, over 15 client items have reject ordering jobs, including various metals such as cast iron, low carbon steel, and high carbon steel. The types of defects that have been recorded in foundry and part manufacturing include porosity, design problem, over hardness casting, material problem, machinist problem, and mold problem, low melting temperature problem, crack, and others. The types of products also include 15 KV hook, cross tee, gear, trash plate, center flange, link left, scraper plate, roller flange, and others.

Table .4.10.Production year on 2013 E.C (2021) waste / reject product.

Production year on 2013 E.C (2020) Reject rate										
s/n	**Customer name**	**Part name**	**Material type**	**Weight per piece in kg**	**Order quantity**	**Inspected quantity**	**Reject quantity**	**Defect detected**	**Types of defect**	**Total reject in kg**
1	Metehara sugar factory	Flange Roller	Cast	9.33	300	72	72	Foundry	Over hardness	671.76
2	Akaki Basic Metals	B.M lead screw	Steel R.B	60	01	01	01	Machine S.	Drawing problem	60
3	Kospi Steel	Crank press key	Steel c-45	1.62	05	02	05	Foundry	Drawing problem	8.1
4	Ethiopia electric U.	15 KV Hook	Steel c-10	2.5	-	1000	1000	Machine S.	Material problem	2500
5	Ethiopia electric U.	15 KV Hook	Steel c-10	2.5	-	740	740	Machine S.	Material problem	1850

6	Ethiopia electric U.	15 KV Hook	Steel c-10	2.5	-	200	229	Machine S.	Machinist problem	572.5
7	A.A.Road con.	Spur gear	42Cr Mo	38.2	02	02	01	Machine S.	Machinist problem	38.2
8	Wonji sugar factory	Cross tee	Cast iron	140.97	12	10	07	foundry	Mold is not required quality	986.79
9	Metehara sugar F.	Trash plate TA3.	Cast iron	821.1	01	01	01	foundry	porosity	821.1
10	Wonji sugar factory	Mill roller	Cast iron	15177	08	01	01	foundry	Crack	15177
11	Wonji sugar factory	Mill roller	Cast iron	15177	08	01	01	foundry	Low melting temp	15177
12	Ethio pulp and paper	v- belt pulley	Cast iron	120	02	01	01	Foundry	porosity	120
13	Metehara sugar F.	Trash plate TA1.	Cast iron	821.1	02	02	02	foundry	porosity	1642.2
14	EEU	15 KV Hook	Steel c-10	2.5	-	710	710	Machine S.	Rework	1775
15	Metehara sugar F.	Trash plate TB M 4&5	Cast iron	854	02	01	01	Foundry	Deep small hole	854
16	Metehara sugar F.	Trash plate TB M 1&2	Cast iron	821	02	01	01	Foundry	Deep small hole	821
17	Metehara sugar F.	Trash plate TB M 3	Cast iron	840	02	01	01	Foundry	Deep small hole	840
16	Wonji sugar F.	Journal sealing ring (split)	Cast iron	120	20	01	01	Foundry	Hole and porosity	120
17	Kessem sugar factory	Top roller left side scraper arm	Cast iron	76	05	05	05	foundry	Under dimension	380
18	Kessem sugar factory	Top roller right side scraper arm	Cast iron	76	05	05	05	foundry	Under dimension	380
19	Metehara sugar factory	Flange Roller	Cast iron	9.33	500	89	89	Foundry	Under dimension and Over hardness	830.4
20	Akaki Basic Metals	Bending machine	Steel c-45	60	01	01	01	Heat T.	Thread crack	60
21	Wonji sugar F.	Mill top roller bearing liner	Bronze cast	326.67	04	01	01	Design problem	Hole dimension problem	326.27
22	Wonji sugar F.	Mill top roller bearing liner	Bronze cast	326.67	04	01	01	Design problem	Hole dimension problem	326.27
	Total reject rate in 2013E.C (2021)									**46,364.03 kg**

4.7.7. The production year on 2013 E.C (2021) raw material utilized for rejected products

The table 4.11. Shows below that raw material utilized for rejected product in different working processes in 2013 E.C (2021) such as cast, sand, resin, catalyst, isomol, cutting disc, manpower, machine hour, mold glue, wanza, glue, stucco, nail, and others. All raw materials used are recorded in litter, kilo gram, meter, m3, pcs, hours and so on. In the production year, the following materials were used: cast 17682.2 kg, sand 17, 103.6 kg, resin 924.52.4 litter, catalyst 457.68 litter, isomol 225.27 litter, and so on.

Table.4.11. the Production year on 2013 E.C (2021) raw material utilized for rejected products.

s/n	Customer name	Steel & Cast	sand	Resin	catalyst	Isomol	Cutting disc	Man power	Machine hour	Mold glue	wanza	Glue	Stucco	Nail
		kg	kg	litter	litter	Kg	pcs	Hrs.	Hrs.	litter	M2	litter	Kg	Kg
1	Flange Roller	309	1357	16.3	3.98	0.5	0.49	15	15	0.25	4.24	4.48	4.5	0.4
2	Cross tee	454	1993	24	12	5.86	0.7	25	16	0.36	4.39	6.2	6.6	0.58
3	Trash plate TA3.	378	1678	20	9.95	4.87	0.61	22	15	0.3	3.65	5.18	5.5	0.48
4	Mill roller	6986	30647	368	184	90.1	3	60	120	5.63	67.6	96	101	9
5	Mill roller	6986	30647	368	184	90.1	3	60	120	5.63	67.6	96	101	9
6	V- belt pulley	55.2	242.3	2.9	1.45	0.71	0.1	10	9	0.04	0.53	0.75	0.8	0.07
7	Trash plate TA1.	378	1678	20	9.95	4.87	0.61	22	15	0.3	3.65	5.18	5.5	0.48
8	Trash plate TB M 4&5	393	1725	10.4	5	5.1	0.63	22	15	0.32	3.8	5.4	5.71	0.5
9	Trash plate TB M 1&2	378	1678	20	9.95	4.87	0.61	22	15	0.3	3.65	5.18	5.5	0.48
10	Trash plate TB 3	387	1696	20.4	10.2	5	0.62	23	17	0.31	3.74	5.3	5.6	0.5
12	Top roller left side scraper arm	148	767.3	9.21	4.6	2.25	0.28	15	12	0.14	1.69	2.4	2.54	0.23

13	Top roller right side scraper arm	148	767.3	9.21	4.6	2.25	0.28	15	12	0.14	1.69	2.4	2.54	0.23
16	Flange Roller	382	1677	20.1	10.1	4.93	0.62	23	18	0.31	3.7	5.24	5.54	0.49
17	Mill top roller bearing liner	150	659	8	3.95	1.93	0.24	12	15	0.12	1.45	2.1	2.2	0.2
18	Mill top roller bearing liner	150	659	8	3.95	1.93	0.24	12	15	0.12	1.45	2.1	2.2	0.2
	Total utilized material	**17,682.2**	**77,103.6**	**924.52**	**457.68**	**225.27**	**12.03**	**358**	**429**	**14.27**	**172.83**	**243.91**	**256.73**	**22.84**

4.7.8. Reject /waste products records year on 2014 E.C (2021)

Table 4.12. In 2014 E.C (2022), the quality control department, manufacturing process control, and each factory reported 5,806.18 kg of reject / waste product. Furthermore, over 08 client items have reject ordering jobs, including various metals such as cast iron, low carbon steel, and high carbon steel. The types of defects that have been recorded in foundry and part manufacturing include porosity, design problem, dimension problem, tooth depth problem, long holes, deep small hole, crack, and others. The types of products also include gear, trash plate, brake holder, pinion rack gear, bronze bushing, roller frame, stud bolt, master cylinder and others.

Table.4.12.Production year on 2014 E.C (2022) waste / Reject product.

production year on 2014 E.C (2020) Reject rate										
s/n	**Customer name**	**Part name**	**Material type**	**Weight per piece in kg**	**Order quantity**	**Inspected quantity**	**Reject quantity**	**Defect detected**	**Types of defect**	**Total reject in kg**

1	Dugda agro industry	Brake holder	Cast iron	18.67	04	04	04	Foundry	Dime. problem	74.68
2	Dugda agro industry	Spur gear	Cast iron	64	04	04	04	Foundry	Tooth depth prob.	256
3	Gonder bikil factory	Pinion rack gear	Cast iron	42.8	20	02	01	Foundry	Small hole & por.	42.8
4	Metehara sugar F.	Trash plate TB.MN4&5	Cast iron	864	02	01	01	Foundry	Hole & bending due to cast	864
5	Metehara sugar F.	Trash plate TB.MN1&2	Cast iron	840	02	01	01	Foundry	Long holes	840
6	Air craft industry	Bronze bushing	Bronze	0.3	01	01	01	Foundry	porosity	0.3
7	Dugda Agro Industry	Spur gear	Grey cast	64	04	03	01	R & D	Tooth thick,prb.	64
8	Metehara sugar F.	Trash plate TB.M4&5	Steel 46Mn Si4	821.1	02	01	01	foundry	Porosity & pouring problem	821.1
9	Metehara sugar F.	Trash plate TB.MN4&5	Steel 46Mn Si4	821.1	01	01	01	foundry	Porosity & pouring problem	821.1
10	Metehara sugar F.	Roller frame	Nod. Cast	7	04	01	01	Foundry	Porosity	7
11	Durban cement	Stud bolt	Steel C-45	10.2	01	01	01	R & D	Design problem	10.2
12	Fincha sugar F.	Dewatering T1.	Cast iron	980	01	01	01	Foundry	Porosity	980
13	Fincha sugar F.	Dewatering trash plate MN2	Cast iron	980	01	01	01	Foundry	Porosity	980
14	Horizon Addis	Master cylinder	Cast iron	45	02	01	01	Mach. P	long hole	45
									Total reject rate in 2014E.C (2021)	**5806.18 kg**

4.7.9. The production year on 2014E.C (2022) raw material utilized for rejected product.

Table 4.13. Shows below that raw materials utilized for rejected product in different working processes in 2014 E.C (2022) such as cast, sand, resin, catalyst, isomol, cutting disc, manpower, machine hour, mold glue, wanza, glue, stucco, nail, and others. All raw materials used are recorded in litter, kilo gram, meter, m3, pcs, hours and so on. In the production year, the following materials were used: cast 2664.5 kg, sand 11, 612.6 kg, resin 138.99 litter, catalyst 70.24 litter, isomol 34.36 litter, and so on.

Table.4.13.the Production year on 2014 E.C (2022) raw material utilized for rejected products.

s/n	Customer name	Steel & cast	sand	Resin	catalyst	Isomol	Cutting disc	Man power	Machine hour	Mold glue	wanza	Glue	Stucco	Nail
		kg	kg	litter	litter	Kg	pcs	Hrs.	Hrs.	litter	M2	litter	Kg	Kg
1	Dugda agro industry	32.2	142	1.7	0.85	0.42	0.06	10	13	0.2	0.31	0.6	0.5	0.25
2	Dugda agro industry	101.2	444	5.32	2.66	1.3	0.16	12	14	0.35	0.98	1.38	1.46	0.6
3	Gonder bikil factory	27	121	1.21	0.7	0.34	0.05	10	10	0.2	0.3	0.5	0.5	0.2
4	Metehara sugar F.	387	1696	20.4	10.2	5	0.62	23	17	0.31	3.74	5.3	5.6	0.5
5	Metehara sugar F.	387	1696	20.4	10.2	5	0.62	23	17	0.31	3.74	5.3	5.6	0.5
6	Air craft industry	3.82	16.76	0.2	0.1	0.05	0.006	5	5	0.003	0.036	0.052	0.05	0.005
7	Dugda Agro Industry	27.6	121.2	0.15	0.73	0.35	0.04	10	10	0.2	0.3	0.5	0.5	0.2
8	Metehara sugar F.	378	1678	20	9.95	4.87	0.61	22	15	0.3	3.65	5.18	5.5	0.48
9	Metehara sugar F.	378	1678	20	9.95	4.87	0.61	22	15	0.3	3.65	5.18	5.5	0.48
10	Metehara sugar F.	3.82	16.76	0.2	0.1	0.05	0.006	5	5	0.003	0.036	0.052	0.05	0.005
11	Durban cement	3.82	16.76	0.2	0.1	0.05	0.006	5	5	0.003	0.036	0.052	0.05	0.005
12	Fincha sugar F.	454	1993	24	12	5.86	0.7	25	16	0.36	4.39	6.2	6.6	0.58
13	Fincha sugar F.	454	1993	24	12	5.86	0.7	25	16	0.36	4.39	6.2	6.6	0.58
14	Horizon Addis	27	121	1.21	0.7	0.34	0.05	10	10	0.2	0.3	0.5	0.5	0.2
	Total utilized material	**2664.5**	**11612.5**	**138.99**	**70.24**	**34.36**	**4.24**	**207**	**168**	**3.1**	**25.86**	**36.9**	**39.01**	**4.58**

4.7.10. The production years (2020-2022) raw material utilized for rejected products.

Some total cost of raw materials used in the three years reports 3,405,634 birrs has been lost only defective products, according to Table 4.14. Additionally, enterprises have lost not just birr but also consumer complaints, decreased profitability, maybe the same product again being rejected, high power consumption, and so on.

Table.4.14. For three years (2020-2022) reject / waste rate total material utilized & its cost.

Years	Steel & Cast	Sand	Resin	catalyst	Isomol	Cutting disc	Man power	Machine hour	Mold glue	wanza	Glue	Stucco	Nail
Units	**Kg**	**kg**	**litter**	**litter**	**Kg**	**pcs**	**Hrs.**	**Hrs.**	**litter**	**M2**	**litter**	**Kg**	**Kg**
2020	3254.2	13,692	1371.4	95.65	46.87	8.61	244	234	5.38	33.68	47	49	6.31
2021	17682.2	77,103.6	924.52	457.68	225.27	12.03	358	429	14.27	172.83	243.91	256.73	22.84
2022	2664.5	11,612.5	138.99	70.24	34.36	4.24	207	168	3.1	25.86	36.9	39.01	4.58
Total used	**23,600.9**	**102,678**	**2434.9**	**623.57**	**306.5**	**24.88**	**809**	**831**	**22.75**	**232.37**	**327.81**	**344.81**	**33.73**
Total cost	**944,000**	**102,678**	**532,658**	**59,239**	**20,746**	**30,527**	**16,220**	**31,129.26**	**5,255.25**	**1,500,000**	**49,171.5**	**108,615.1**	**5,396.8**
Total cost of raw material used 3,405, 634													
From three years total reject / waste report = 59,390.47 kg or 59.39 tons.													

4.7.11. The production years (2020 – 2022) other additive raw material utilized.

Table 4.15 indicates other additive materials that are employed when an additive material, such as pig iron, carbon, silicon, or others, is inserted into the molten metal during the melting process. Furthermore, one melting induction machine fernus uses melts of different compositions 16 - 20 times. After they have completed their task, rebuild the fernus machine using ramming cement, former sheet, amenities, plaster, and other materials. As a result, the above-mentioned 257,003 birr has been lost.

Table.4.15. the production years (2020 – 2022) other additive raw material utilized.

s/n	Used additive material and others used.	59.36 tones (Foundry w/s) & 2992 pcs.					
		kg	**litter**	**pcs**	**M**	**Unit cost**	**Total Cost**
1	Pig iron	3300				20.63	68,079
2	Carbon	1959.88				67.16	131,625
3	Silicon	115.82				127	14,709
4	Ramming cement	2125				10	21,250
5	Former (sheet metal)				4	210	840
6	Amentite				2	200	400
7	Plaster			1		100	100
8	Carbide insert			50		400	20,000
	Total cost					**257,003 birr.**	

4.8. Summary of the findings

From the research above, it is clear that difficulties with metal solid waste are a very delicate matter, and their causes include consumer complaints, environmental concerns, economic factors, and others. Solid waste issues can arise for a variety of causes, chief among them being issues with machinery, skilled labor, quality control process inspection, product and methodology designer engineers, waste management knowledge, and raw materials. The dedication of management, employees, and the government to their training center institute solves the aforementioned sources of solid waste issues.

The company lost 3,662,637 birr from raw material utilized throughout the course of the three-year report, Additionally, various types of defects have been caused by porosity, improper holes, drawing issues, improper pouring melt issues, pattern and mold issues, appropriate venting holes, off-center issues, overly hard materials, machinist issues, cracks, rework, over process, deep small holes, and heat treatment. The next step is where most repeat waste has been recorded, and it relates to porosity, material issues, drawing issues, and reworked item.

However, the three-year data analysis of the instance company shows that difficulties with low productivity and reject/waste output occur more frequently. The case company's annual reports show a decline in income and productivity as a result of various issues, such as product waste amounting to 59.39 metric tons of metal over a three-year period. This waste was caused by a variety of factors, including high downtime waste, raw material costs, labor costs, electric costs, and transportation costs. Additionally, the analysis reveals that from the start of the design issue, sand washing, pattern preparation, mold making, scrap preparation, melting, pouring molten metal, sand cast separation, finishing (grinding), and machining are all processes that have taken time and resources.

The study also reveals that lack of waste management contribution implementation problem, lack of recycling and recovery, lack of zero waste implementation, machine utilization time is extremely long in part manufacturing and foundry work shop, reject amount is high, lack of raw material is high, so from the issue all considered to be customer does not order new products and the company lost their income due to the above consideration. However, the analysis shows that the production environment is comprised of outdated methods and systems, low levels of employee skill and motivation, which lead to inconsistent results, such as a high level of scraps and reworks, a high number of machine breakdowns/high downtime costs, and incidents that waste time and result in increased product waste.

As a result, input/capital input elements including labor skill, motivation, materials, spare parts for machines and equipment, organizational system setups, and many other factors are to blame for the corresponding solid waste issues. The emphasis should therefore be on the difficulties at the Business level because these issues may be resolved by the firm utilizing its own capabilities, resources, and effective techniques to reduce organizational metal waste issues.

CHAPTER FIVE

5. PROPOSED WASTE MANAGEMENT STRATEGY

5.1. Selection and proposal of waste management implementation method

In this chapter, the basic approaches to waste management (lean and zero waste management) are described together with implementation suggestions for the Ethiopian metal industry's knowledge transfer system. The analysis of the example company, the information gathered from the survey of the case company's metal industry, and the literature evaluation all played a role in the development of this model and framework.

Before selecting a particular waste management technology, methodology, or approach, it is crucial to understand what managing waste comprises, including the treatment and eradication of waste materials and the output they produce. An investigation of the full intake through the combination of human actions can help to solve major issues with waste management (Lamyaa Mohammed Dawood, 2019) ; (Jacqueline V., 2009).

5.2. Proposed Model

The principles of zero-waste and lean management can be used to create a waste-free metal production company, as illustrated in figure 5.1 below. Avoiding garbage incinerators and landfills in the city is the main goal of the zero-waste concept. However, it also emphasizes getting rid of wastes or processes that don't bring value to the production of products and can't enhance customer satisfaction. The main elements of the Zero waste management system are described below.

A. Awareness, Education and Research

Zero waste initiatives, transformative learning, and waste study are all part of awareness, education, and research. They are positioned at the very beginning because they are crucial for developing a new mindset geared towards transforming existing industries into waste-free ones. Waste can be eliminated by raising public awareness through various initiative programs, such as making polluters pay more or rewarding non-polluters. Successful waste handling may result from advocating zero waste management to the community and the manufacturing sector through training and educational programs. The waste management system can be improved by using the solutions suggested by studies concerning zero waste management.

B. New infrastructure and Systemic thinking

Three essential elements have been included in new infrastructure and system thinking: new technologies, new infrastructure, and zero-waste governance. Systems enabling the separation of waste and collection, equipment, and outfitted waste plant areas are all part of the **new infrastructure**. In order to recycle or recover materials and energy while minimizing the detrimental effects on national health and environmental degradation, innovative technology and integrated thinking are crucial in minimizing waste, especially metal waste.

C. Hundred percent recycling and recovery

Implementing a zero waste metal manufacturing system through 100% recycling and recovery. The metal manufacturing sector in Ethiopia has to develop the capacity of a circular manufacturing system to achieve **100% recycling and recovery**, as well as to utilize the energy generated during the transformation of metal waste into usable metal products. However, the instance firm uses a tendering procedure to sell the metal wastes to other steel-producing companies. The company should also look at the viability of opening a waste recycling and recovery facility.

D. Sustainable consumption and behavior change

Collaborative consumption, behavior modification, and sustainable living are all examples of sustainable consumption and attitude change. Through the use of **sustainable products** and a change in behavior, they are crucial enablers of zero waste management. Reducing trash is made possible through sustainable living. The adoption of zero-waste practices such as rubbish collection in an appropriate manner and place and the belief that metal wastes are precious resources with the potential to create income results from shifting attitudes towards the conventional methods of waste management. Metal wastes have a detrimental effect on both human health and harm to the environment.

E. Transformed Industrial design

Cradle-to-cradle design, cleaner production, and producer responsibility are all examples of transformed industrial design. In order to minimize waste, **cradle-to-cradle design** takes into account every step of the product development and production process. When waste is found during the production of a product, the entire process should be reevaluated in order to prevent waste at its source and ensure the sustainability of the system. By minimizing wastes that have a negative impact on the environment and the neighboring population, **cleaner production** can significantly increase manufacturing output. Manufacturing companies are held accountable as producers for managing waste in a way that doesn't intentionally influence human health or the environment. It is the **producers' duty** to educate the public about the producer's employees about hazardous waste disadvantages and their protection methods if any.

F. The zero-depletion legislation and policies

Incentives are a crucial part of zero-depletion legislation and policies, along with **zero-landfilling**, **zero-incineration**, and **zero-waste**. There are no laws or procedures that force Ethiopia to reduce trash to zero. Waste is disposed of using landfill disposal techniques all around the city. Wastes are burned during incineration to recover energy, but there are dangerous pollutants that must be avoided. Incentives have the ability to completely eliminate waste. Governmental and non-governmental organizations that are concerned can start a variety of incentive systems.

FROM THE PERSPECTIVE OF THE LEAN MANUFACTURE SYSTEM, ELIMINATING WASTE.

A. Overproduction: creating more than the customer needs or too early before it is required is wasteful since it increases the risk of obsolescence and the risk of creating the wrong item. In different company products, their size and shape have very big, according to overproduction it's difficult to put the place for storage, and at working process time is high, high raw material use, may not be sold to the customer forever. So, remove poorer communication of production workshop, marketing and production planning control (PPC).

B. Defects: Product defects have been reported in a variety of situations, including manufacturing without specifications, incorrect design, processing issues, quality control issues during process inspection, etc. As a result, customer complaints have increased, high delays have been experienced, and the product may need to be reworked, requiring additional raw materials, time, and other resources. Case Company has extensive records of defective items and strives to reduce waste.

C. **Inventory:** The usage of excessive amounts of superfluous raw materials, the accumulation of many defective products among otherwise perfect goods for years in the store, and the refusal of some customers to accept goods because of requirements or delivery delays are all problems. Greater storage expenses and greater inventory finance costs all contribute to this inventory reduction, which also tolerates the shortest manufacturing lead time while saving money. Inventory levels will be high as a result of poor record keeping, poor communications with clients and suppliers, and inconsistent management decisions.

D. **Transportation:** Any movement in the production area adds no value, including the lengthy transportation of scrap material into melting units, the movement of raw materials from one working area to another, the lengthy transition from one product's processing stage to another, impromptu garbage collection from one location to another, and rework. To reduce this kind of waste, choose the appropriate strategy.

E. **Waiting:** Due to a variety of issues, including broken machinery, a lack of raw materials, a lack of maintenance knowledge, a lack of job orders, workers who start and stop their work late, and other issues, there is idle time for the organization. As a result, customer complaints rise and productivity efficiency declines. This kind of waste affects both the workers and the goods since it happens when the goods are not moving.

F. **Motion:** In the production workshop, various motions have been observed without adding any value, such as the movement of workers from one work shop to another, the discovery of tools and other measuring instruments from place to place, the placement of products in improper locations, and other times changing the location. All of the aforementioned motions have an impact on productivity and cause a delay in the manufacturing process.

G. **Over-processing:** is one of the waste issues that can occur during the production process and cause time delays as a result of incorrect design specifications (increased machining allowance, increased hardness of the material to be cast), incorrect understanding of the design concept, and issues with heat treatment (less hardness and high hardness, etc.). All of the aforementioned cases where erroneous processing happens result in increased delays and decreased production.

H. **Correction (rework):** When a product is defective during production for a variety of reasons, the quality assurance departments note the root of the issue and remanufacture the product in accordance with the delay time that has occurred. All of this process can require resources such as raw materials, labor costs, and electricity costs.

I. **Knowledge Disconnection:** This is when information or knowledge isn't available where or when it is needed.

5.2.1. Eliminating wastes from the zero waste manufacturing system perspective

A. **Refuse:** by refusing a lot of waste is eliminated at the source, before any metal product reject /waste due to different problems and cause of environmental and financial affects. Refuse is one in which before the problems happen each cause of waste, process check with detail preparation of the process, check all the raw material according to the specification, all lab test are functional and work properly, all the delay time happen on each process minimize and remove by optional mechanism. So accordingly the mentioned above refuse the waste/reject products.

B. **Reduce / prevention:** source reduction is used to reduce the waste generation before the product/material be wasted in production unit, so first involves different idea and working procedure, do not work with confusion, you have clear understand for design or job, may order the product 100 pcs check by 2 or 3 pcs due to come perfect product, minimize over processing (high machining allowance , material hardness, no tolerance, etc.), due to this minimize the defective rate , minimize cause of health effects and control environmental issue.

C. **Reuse:** many reject / waste metal materials are accumulate in different workshops, customer does not receive product for long time, according to design change not finish the product and stay on mini store, also wrong specification order purchase raw material, all the above mentioned are another time as reuse as a raw material for other purpose. Before reuse purpose identify the material according to their composition and accumulate in one place nearest to work area we use as a raw material.

D. **Recycling:** The size of the machine will depend on how the scrap metals, sand, wood, or other material are identified by their composition and prepared for machining or melting. It serves a purpose of recovery or remanufacturing. The majority of metal companies, including Case Company foundries, have melting furnaces utilized for sand casting techniques, and after the casting process, the sand is recycled for other jobs. Recycling is fundamental to reducing trash accumulation at a business, increasing profitability, improving product efficiency, and reducing environmental effects.

E. **Repurpose:** The waste material might be difficult to reuse or use a lot of energy, but it might also be put to use in another way if environmental concerns are taken into account, or it might be sold to another business to generate revenue.

Waste Management Model Proposal

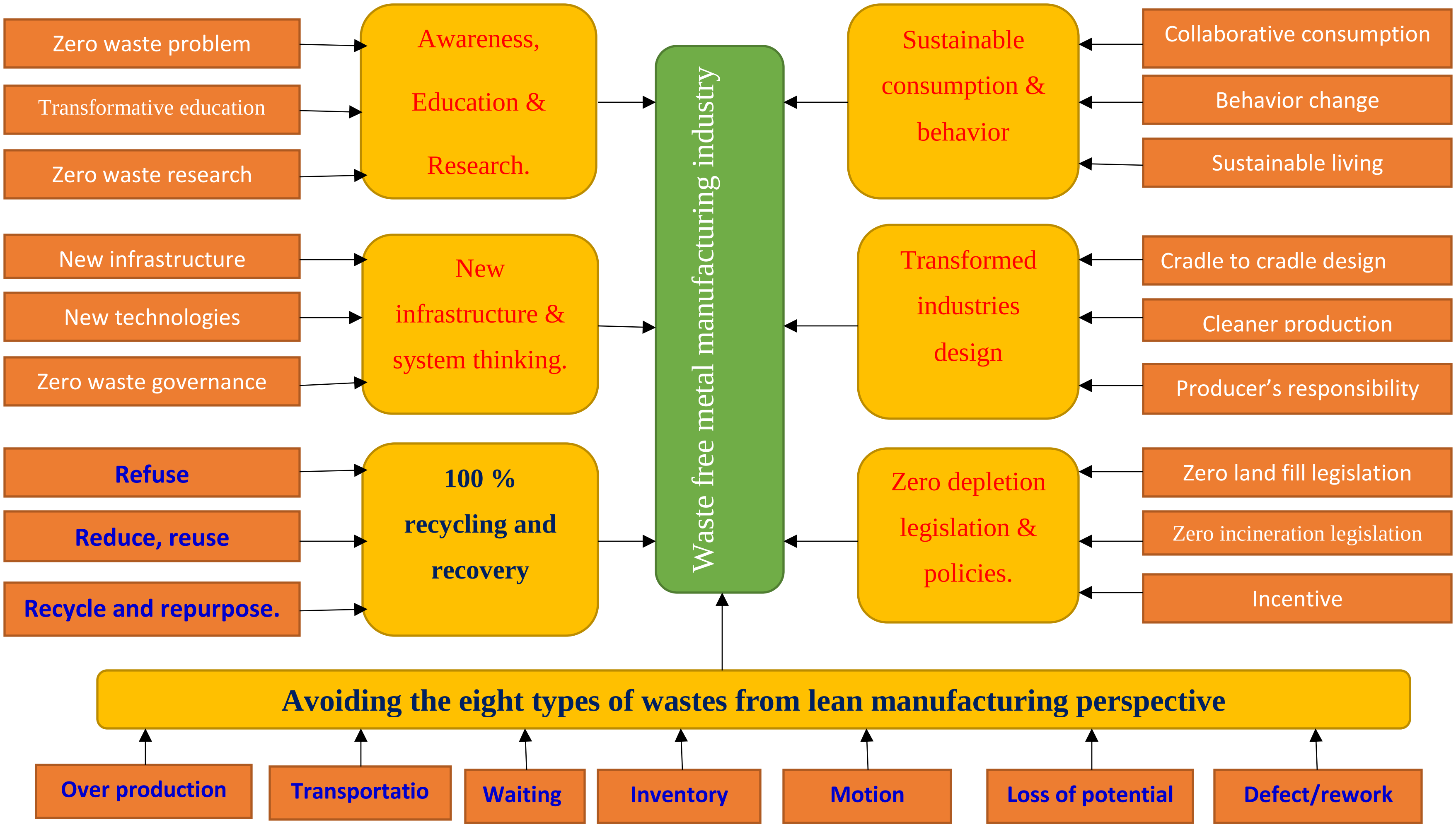

Figure.5.1. waste management model proposal

CHAPTER SIX

6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Conclusion

Solid metal wastes are unavoidably produced in metal product factories for a variety of issues. The Akaki Basic Metals industry in Addis Ababa is one of the metal-producing sectors. 80% of machine utilization delay time has been documented, along with almost 59 tons of metal trash. The issues with reject/waste rate point to a lack of/weaker waste management systems at the case company. As a result, the study presents a paradigm that combines lean manufacturing with zero waste management. The study's questionnaire divided up all of the workshop workers, high and intermediate-level management, marketing and sales departments, and departments, and asked open-ended questions and the key causes of factors impacting waste.

The key issues found include excessive delays compared to machine utilization times, rising waste product rates, poorly planned product-to-actual product ratios, high raw material consumption, and high additional costs. The three years total output productivity rate is just 12.5%, and the total amount of metal waste is 59.4 tones. The remaining time is wasted. Additionally, 257,003 birr was lost through the use of additive materials and 3,405,634 birr was lost from the use of waste products as raw materials.

The management's highest reaction rate in the product design issue is (78%) has product design revision as well as adjustments based on the demand for customer waste; on the second issue, (68.75%) has documented for technological limitations for perfection and accuracy of drawings. Lack of employee motivation and incentive programs, as well as a lack of appropriate tools and equipment, account for 78.1% of responses in the production process, while frequent equipment and machinery breakdowns account for 75% of responses. Additionally, managers or executive officers' responses to all wasteful workshops have been recorded as a cause of waste in pattern workshops, where 84.37% of responses have an operator skill problem and 78.12% have a machine problem, a design comprehension problem, and a waste implementation problem. Responses from the molding workshop (81.25%) include "mold machinery problem" and "lab test machine problem." The melting furnace machine problem (84.37%) and the workers' neglect or lack of desire (78.12%) and the quality control person's skill problem (78.12%) were scored in the melting workshops. In the workshop where parts are manufactured, problems with broken down machinery (78.12%) and issues with the application of waste management principles are the leading causes of waste.

6.2. Recommendations

The following recommendation have been made to improve the application of principles to manage metal products wastage in metal products manufacturing industry particularly for case company.

- In order to maximize customer satisfaction, product capabilities, and market competitiveness on both the local and international scales, metal waste/reject and other delays should be minimized. For a successful manufacturing system, a secure financial future, and protection of the environment, businesses must be able to control the various waste rates and causes of waste start.

- Since the implementation of lean and zero waste management is applicable at several levels, businesses should have defined procedures, measurements, modeling, analysis, and practice for minimizing waste. Companies must therefore first determine the amount of waste (measured in hours, Pcs, birr, or other methods) and the analysis improvement that will be made.

- Industries in waste management systems achieved their goals with a great deal of dedication and coordination with managers, workers, and others who should understand their duties. The success of reducing waste and waste issues in the organization is mostly due to the management's involvement and dedication, which is higher than that of the other parties.

- With mandatory rules, regulations, and incentives, the government should design waste management implementation plans.

- The implementation of the new waste-free metal manufacturing industry strategies or models in Ethiopia's manufacturing sector may be the subject of future study.

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APPENDICES

APPENDIX –A

Questionnaire Survey for the Managers for Thesis paper on Solid **Wastes Impact and their Management on Metal Manufacturing Industry for Industrial Sustainable Development: A case Study of Akaki Basic Metals Industry**

ADDIS ABABA UNVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY SCHOOL OF MECHANICAL AND INDUSTRIAL ENGINEERING

Questionnaire Survey for thesis paper *entitled:* solid waste impact and their management on Metal Manufacturing Industry for industrial sustainable development: A case Study on Akaki Basic Metals Industry.

In the School of Mechanical and Industrial Engineering at the Addis Ababa Institute of Technology (AAiT), I'm working towards a Master of Science in Mechanical Engineering (Industrial Engineering Stream).

This research will help study the impact of solid waste and its management in the metal manufacturing industry. The questionnaire was prepared for research purposes only and greatly depended on your voluntary and honest responses. The survey responses are entirely voluntary; your identity will be kept private, and data from this study will be shared for academic purposes only. Your participation is valuable for the success of this research. The following questions will be circulated, and the data gathered will be analyzed to determine the impact of solid waste and its management on the metal manufacturing industry.

Thank you in advancing for your time and kind cooperation

Yours Faithful

Gebeyehu Ayele (Mobile. +251 922342416)

Supervised by: **(Assoc. Professor) *Kassu Jilcha***

March 2023, Addis Ababa, Ethiopia.

Questionnaires for Managers (executive officers) only

Part I: General Information

Please circle the appropriate alternatives.

1. Sex
   A. Male B) Female
2. Age (in years)
   A. 18-30 B) 31-40 C) 41-50 D) above 50
3. Relevant work experience in years
   A. 1-10 B) 11-20 C) 21-30 D) More than 30

4. Your work Position in the company
   A. Production manager B) Marketing Manager C) Procurement Manager D) administration worker F) department / work shop head G) worker H) others.

Part II. Sources and causes of wastes / defective products in Akaki Basic Metals Industry

The data below represent the sources and factors that lead to waste and defective goods in the metal manufacturing industry. Please tick the appropriate boxes to show the importance of each factor. In the last column, make any further comments on each factor, such as the causes, crucial factors, or solutions.

You are expected to put **a tick mark (✓)** sign on the defective products / waste level of your industry conducted cause, where: 5 = strongly agree 4= agree 3= moderate/no change, 2 = disagree 1= strongly disagree.

Cause of wastes in the case company (defective product, waiting time, over production, correction (rework), over processing, etc.)	5 = strongly agree	4= agree	3=moderate	2 = disagree	1= strongly disagree	Remark
Group I. Product Design Issues						
1. Product design revisions as well as changes based on need for customer.						
2. Technology limitations for perfection and accuracy of drawing (software and others problem)						
3. The increase in engineered products (products designed to customer specifications or outside of standards).						
4. A need for more information in the product designs.						
5. A need for more time for urgent design activities.						
6. An excessive estimation of specification tolerances (allowances).						
7. Poor communication with stakeholders results in mistakes and errors.						
8. The process of selection of low-quality input materials during the design.						
9. Designer skill problem for sketch the drawing.						
Group II. Raw Materials and Products						
A. Procurement						
1. A inadequate schedule for material acquisition						
2. Choosing suppliers and subcontractors based on price						
3. Ordering too much or too little as a result of errors in quantity surveys [Lean principle regards inventory as waste]						
4. Materials that were purchased did not meet the requirements						
5. Insufficient space for storage						
6. nonconformance Material stock in the store						
7. Quality of raw material to be purchased problem.						

Cause of wastes in the case company (defective product, waiting time, over production, correction (rework), over processing, etc.)	5 = strongly agree	4= agree	3=moderate	2 = disagree	1= strongly disagree	Remark
B. Manufacturing processes						
1. When it arrives, the input materials are damaged						
2. Product (output material) damage						
3. Inadequate product control mechanisms						
4. The workers' lack of comprehension of the design or drawings						
5. Confusing production techniques						
6. Operator carelessness or incompetence						
7. Customer-driven design or order modification						
8. Depreciation of equipment and machinery						
9. Ineffective product handling techniques						
10. A lack of employee motivation and incentive programs						
11. Negative relations among workers at the organization						
12. Reworks as a result of errors (reworks constitute waste according to Lean principles)						
13. High quantity of product rejection (according to lean manufacturing principles, rejected products constitute waste).						
14. Overproduction [overproductions, according to the Lean approach, are wastes]						
15. Over processing, also [in light of the Lean concept]						
16. Ineffective time management [according to Lean principles, downtime equals waste]						
17. According to lean principles, the unnecessary movement of people and items (materials) is waste.						

Cause of wastes in the case company (defective product, waiting time, over production, correction (rework), over processing, etc.)	5 = strongly agree	4= agree	3=moderate	2 = disagree	1= strongly disagree	Remark
18. Repeated mistakes/ reject on the same product						
19. A labor shortage for the essential job.						
20. Hiring (new) unskilled workers for the company.						
21. Equipment and machinery breakdown regularly.						
22. The lack of modern machinery and equipment						
23. Lack of necessary tools and equipment						
24. A poorly designed floor plan						
Group III. Waste Management						
1. An inadequate waste management strategy and control						
2. The Management System's Contribution to Reduced Waste						
3. The absence of a plan for minimizing waste						
4. Insufficient product or material transportation systems Under the Lean Principle, unnecessary transportation is waste.						
5. Technical staff and operator qualifications put in charge of the factory						
6. Informational support for workers in the factory						
7. Ineffective quality controllers' oversight and inspectors						
8. The lack of senior technical professionals in the Factory						
9. Insufficient production planning and scheduling produced by PPC.						
10. The factory's lack of a waste distinguishing system						
11. Zero waste programs, transformational education, and research are all examples of areas where there needs to be more knowledge.						

Cause of wastes in the case company (defective product, waiting time, over production, correction (rework), over processing, etc.)	5 = strongly agree	4= agree	3=moderate	2 = disagree	1= strongly disagree	Remark
12. No transformation Modernized industrial design, including (Producer responsibility, cleaner production, cradle-to-cradle design)						
13. Absence of zero depletion laws and regulations (like (For example, laws requiring zero landfills, zero incinerators, and incentives)						
14. Insufficient recycling and recovery of 100% (including Reducing, repairing or reusing, recycling, and recovering.						
15. New infrastructure and technology includes (New technology, new infrastructure, and zero waste governance)						
16. Lack of sustainable consumption as well as behavior (which encompasses sustainable living, cooperative consumption, and behavioral transformation)						

Part III: Causes/sources of metal wastes for the key products of the case company

Please indicate the significance of each factor by ticking the appropriate boxes. Add any remarks relating to each factor on the last column e.g. as to the reasons, the critical factors or the solutions.

You are expected to put **a tick mark (✓)** sign on the defective products / waste level of your industry conducted cause, where: 5 = strongly agree 4= agree 3= moderate 2 = disagree 1= strongly disagree.

I. pattern work shop factors affecting in production defect / waste						
Cause of wastes in the case company (defective product, waiting time, over production, correction (rework), over processing, etc.)	5 =strongly agree	4= agree	3=moderate	2 = disagree	1= strongly disagree	Remark
1. Pattern machinery problems.						
2. Pattern raw material problem (wood, nail, etc.)						
3. pattern work shop operator skill problem						
4. design understanding problem						
5. supervisor skill problem						
6. operator poor relationship with super visor						
7. Poor production process controlling system (PPC) (over planned but not implement).						
8. Poor machine and equipment maintenance skill						
9. methodologies engineer skill problem						
10. Operators lack of skill or negligence						
11. wrong design sketch (designer problem)						
12. quality control person skill problem						
13. Expired raw material used (stucco, glue, etc.)						
14. waste management principle implementation problem						
15. Used Patterns material (finished pattern or scrap material) use for another time reuse, repurpose or recycle for other job.						

II. Mold work shop factors affecting in production defect / waste.						
Cause of wastes in the case company (defective product, waiting time, over production, correction (rework), over processing, etc.)	5 =strongly agree	4= agree	3=moderate	2 = disagree	1= strongly disagree	Remark
1.Mold machineries problem						
2. Shortage of Raw material problems and expired material used (sand, resin, catalyst, etc.).						
3. Mold work shop operator skill problems.						
4. Poor material and product handling						
5.Supervisor skill problem						
6. Laboratory test machinery problem						
7. Negligence or lack of motivation worker						
8. Poor material handling problem						
9. Expired raw material used (chemicals, resin, catalyst)						
10. Poor production process control system (PPC) (over planned but not implement).						
11. Poor machine and equipment maintenance skill						
12. Quality control person skill problem						
13. Pattern product problem.						
14. waste management principle implementation problem						
15. Over production problem happen (no order products manufacture)						
16. Used Mold material (sand, etc.) use for another time reuse, repurpose or recycle for other job.						

III. Melting unit factors affecting in production defect / waste.						
Cause of wastes in the case company (defective product, waiting time, over production, correction (rework), over processing, etc.)	5 =strongly agree	4= agree	3=moderate	2 = disagree	1= strongly disagree	Remark
1. Melting Furnace machineries problems.						
2. Shortage of Raw material problems (refractory material, scrap, (cast iron, steel, others, etc.))						
3. Mold work shop operator skill problems.						
4. Scrap selection, Scrap transportation, Poor material and product handling problem.						
5.Supervisor skill problem						
6. Laboratory test machinery problem						
7. Negligence or lack of motivation worker						
8. Poor material handling problem						
9. Un proper place of molten metal dropping area.						
10. Poor production process control system (PPC) (over planned but not implement).						
11. Poor machine and equipment maintenance skill						
12. Quality control person skill problem						
14.Waste management principle implementation problem						
15. Electric interruption problem.						
16. Over production problem happen or (no order product happen).						
17. Defected molten metal after cooling used for reuse, repurpose or recycle for a raw material for other job.						

IV. Part manufacturing workshops factors affecting in production defect / waste.						
Cause of wastes in the case company (defective product, waiting time, over production, correction (rework), over processing, etc.)	5 =strongly agree	4= agree	3=moderate	2 = disagree	1= strongly disagree	Remark
1. Input product from foundry work shop problem. (High machining allowance, no machining allowance, hard material, and others.)						
2. Machinery break down problems. (Boring machine, planner machine, milling, lathe, others.)						
3. Machinist skill problem (read design, understanding of work, etc.)						
4. Poor material and product handling						
5.Supervisor skill problem						
6. Quality control person skill problem (on process inspection, before reject the product and others)						
7. Negligence or lack of motivation worker						
8. Electric interruption problem.						
9. Shortage of accessories, use of poor tool and equipment.						
10. Poor production process control system (PPC) (over planned but not implemented).						
11. Poor machine and equipment maintenance skill						
12. Waste management principle implementation problem						
13. Over production problem happen or (no order product happen).						
14. Defected products used for reuse, repurpose or recycle for a raw material for other job.						

Part IV: Open ended Questions

1. What are the major impacts of metal product waste?

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2. Which company is beneficial by managing and minimizing waste of metals in The Metal Manufacturing Industry or other sector? And how?

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3. To limit metal waste, who should take action?

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4. What are the Akaki Basic Metals Industry's long-term plans for waste reduction and management?

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THANK YOU!!

APPENDIX –B

Questionnaire Survey for the Marketing department for Thesis paper on Solid **Wastes Impact and their Management on Metal Manufacturing Industry for Industrial Sustainable Development: A case Study of Akaki Basic Metals Industry**

ADDIS ABABA UNVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY SCHOOL OF MECHANICAL AND INDUSTRIAL ENGINEERING

Questionnaire Survey for thesis paper *entitled:* solid waste impact and their management on Metal Manufacturing Industry: A case Study on Akaki Basic Metals Industry.

I am presently pursing a Master of Science Degree in Mechanical Engineering (Industrial Engineering Stream) in Addis Ababa Institute of Technology (AAIT) in the school of Mechanical and Industrial Engineering.

This research will help study the solid waste impact and its management in Metal Manufacturing Industry. The questionnaire was prepared for research purposes only and greatly depended on your voluntary and honest responses. The survey responses are entirely voluntary, your identity will be kept private and data from this study will be shared for academic purposes only. Your participation is valuable for the success of this research. The following questions will be circulated, and the data gathered will be analyzed to solid waste impact and their management on metal manufacturing industry.

Thank you in advancing for your time and kind cooperation

Yours Faithfully,

Gebeyehu Ayele (Mobile. +251 922342416)

Supervised by **(Assoc. Professor)** ***Kassu Jilcha***

Questionnaires prepared for marketing and sales personnel only

Part I: General Information

Please circle the appropriate alternatives.

1. Sex

    B. Male B) Female

2. Age (in years)

    B. 18-30 B) 31-40 C) 41-50 D) above 50

3. Relevant work experience in years

    B. 1-10 B) 11-20 C) 21-30 D) More than 30

4. Your work Position in the company

A. Production manager B) Marketing Manager C) Procurement Manager D) administration worker F) department / work shop head G) worker H) others.

Part II. Sources and causes of wastes in Akaki Basic Metals Industry

The data below represent the sources and factors that lead to waste and defective goods in the metal manufacturing industry. Please tick the appropriate boxes to show the importance of each factor. In the last column, make any further comments on each factor, such as the causes, crucial factors, or solutions.

You are expected to put **a tick mark (✓)** sign on the defective products / waste level of your industry conducted cause, where: 5 = strongly agree 4= agree 3= moderate/no change, 2 = disagree 1= strongly disagree.

Cause of wastes in the case company (defective product, waiting time, over production, correction (rework), over processing, etc.)	5 =strongly agree	4= agree	3= moderate	2 = disagree	1= strongly disagree	Remark
Group. Materials and Products (For Marketing and sales Departments)						
1. Poor schedule to procure materials						
2. Selecting the lowest bidder suppliers and sub-suppliers that lead to poor quality						
3. Purchased materials that don't comply with specifications						
4.Damage of materials in the store						
5.Change of customer orders and designs						
6. Scarcity of raw materials						
7. Lack of incentives						
8. Lack of rules and regulations						
9. Shortage of foreign currency						
10. Technological constraints						

Part III: Open Questions

1. What are the major impacts of metal product waste?

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2. Which company is beneficial by managing and minimizing waste of metals in The Metal Manufacturing Industry or other sector? And how? ____

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3. To limit metal waste, who should take action?

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4. What are the Akaki Basic Metals Industry's long-term plans for waste reduction and management?

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THANK YOU!!

APPENDIX –C

Questionnaire Survey for workers / operator for Thesis paper on Solid **Wastes Impact and their Management on Metal Manufacturing Industry for Industrial Sustainable Development: A case Study of Akaki Basic Metals Industry**

ADDIS ABABA UNVERSITY

ADDIS ABABA INSTITUTE OF TECHNOLOGY SCHOOL OF MECHANICAL AND INDUSTRIAL ENGINEERING

Questionnaire Survey for thesis paper *entitled:* solid waste impact and their management on Metal Manufacturing Industry: A case Study on Akaki Basic Metals Industry.

I am presently pursing a Master of Science Degree in Mechanical Engineering (Industrial Engineering Stream) in Addis Ababa Institute of Technology (AAIT) in the school of Mechanical and Industrial Engineering.

This research will help study the solid waste impact and its management in Metal Manufacturing Industry. The questionnaire was prepared for research purposes only and greatly depended on your voluntary and honest responses. The survey responses are entirely voluntary, your identity will be kept private and data from this study will be shared for academic purposes only. Your participation is valuable for the success of this research. The following questions will be circulated, and the data gathered will be analyzed to solid waste impact and their management on metal manufacturing industry

Thank you in advancing for your time and kind cooperation

Yours Faith fully,

Gebeyehu Ayele (Mobile. +251 922342416)

Supervised by **(Assoc. Professor)** ***Kassu Jilcha***

March 2023, Addis Ababa, Ethiopia

Questionnaires for production workers (operators) only

Part I: General Information

Please circle the appropriate alternatives.

1. Sex

   C. Male B) Female

2. Age (in years)

   C. 18-30 B) 31-40 C) 41-50 D) above 50

3. Relevant work experience in years

   C. 1-10 B) 11-20 C) 21-30 D) More than 30

4. Your work Position in the company

A. Production manager B) Marketing Manager C) Procurement Manager D) administration worker F) department / work shop head G) worker H) others.

Part II. Sources and causes of wastes in Akaki Basic Metals Industry

The data below represent the sources and factors that lead to waste and defective goods in the metal manufacturing industry. Please tick the appropriate boxes to show the importance of each factor. In the last column, make any further comments on each factor, such as the causes, crucial factors, or solutions.

You are expected to put **a tick mark (✓)** sign on the defective products / waste level of your industry conducted cause, where: 5 = strongly agree 4= agree 3= moderate/no change, 2 = disagree 1= strongly disagree.

I. pattern work shop factors affecting in production defect / waste						
Cause of wastes in the case company (defective product, waiting time, over production, correction (rework), over processing, etc.)	5 =strongly agree	4= agree	3= moderate	2 = disagree	1= strongly disagree	Remark
1. Pattern machinery problems.						
2. Pattern raw material problem (wood, nail, stucco, etc.)						
3. pattern work shop operator skill problem						
4. design understanding problem						
5. supervisor skill problem						
6. operator poor relationship with super visor						
7. Poor production process controlling system (PPC) (over planned but not implemented).						
8. Poor machine and equipment maintenance skill						
9. methodologies engineer skill problem						
10. Operators lack of skill or negligence						
11. wrong design sketch (designer problem)						
12. quality control person on process inspection skill problem						
13. expired raw material used						
14. waste management principle implementation problem						
15. Used Patterns material (finished pattern or scrap material) use for another time reuse, repurpose or recycle for other job.						

II. Mold work shop factors affecting in production defect / waste.						
Cause of wastes in the case company (defective product, waiting time, over production, correction (rework), over processing, etc.)	5 =strongly agree	4= agree	3=moderate	2 = disagree	1= strongly disagree	Remark
1. At mold section machineries problem						
2. Shortage of Raw material problems (sand, resin, catalyst, etc.)						
3. Mold work shop operator skill problems.						
4. Poor material and product handling						
5. Supervisor skill problem on experience shortage.						
6. Laboratory test machinery problem						
7. Negligence or lack of motivation worker						
8. Poor material handling problem						
9. Expired raw material used (chemicals, resin, catalyst)						
10. Poor production process control system (PPC) (over planned but not implemented).						
11. old machine and poor equipment maintenance skill						
12. Quality control person skill problem on process inspection.						
13. The problem originate from Pattern product.						
14. waste management principle implementation problem						
15. Over production problem happen (no order products manufacture)						
16. Used Mold material (sand, etc.) use for another time reuse, repurpose or recycle for other job effectively.						

III. Melting unit factors affecting in production defect / waste.						
Cause of wastes in the case company (defective product, waiting time, over production, correction (rework), over processing, etc.)	5 =strongly agree	4= agree	3=moderate	2 = disagree	1= strongly disagree	Remark
1. Melting Furnace machineries problems.						
2. Shortage of Raw material problems (refractory material, scrap, (cast iron, steel, others, etc.))						
3. Mold work shop operator skill problems.						
4. Poor material and product handling						
5.Supervisor skill problem						
6. Laboratory test machinery problem						
7. Negligence or lack of motivation worker						
8. Poor material handling problem						
9. Un proper place of molten metal dropping area.						
10. Poor production process control system (PPC) (over planned but not implemented).						
11. Poor machine and equipment maintenance skill						
12. Quality control person skill problem						
13. Mold product problem.						
14.Waste management principle implementation problem						
15. Electric interruption problem.						
16. Over production problem happen or (no order product happen).						
17. Defected molten metal after cooling used for reuse, repurpose or recycle for a raw material for other job.						

IV. Part manufacturing workshops factors affecting in production defect / waste.						
Cause of wastes in the case company (defective product, waiting time, over production, correction (rework), over processing, etc.)	5 =strongly agree	4= agree	3=moderate	2 = disagree	1= strongly disagree	Remark
1. Input product from foundry work shop problem. (High machining allowance, no machining allowance, hard material, and others.)						
2. Machinery break down problems. (Boring machine, planner machine, milling, lathe, others.)						
3. Machinist skill problem (design reading, understanding of work, etc.)						
4. Poor material and product handling						
5.Supervisor skill problem						
6. Quality control person skill problem (on process inspection, before reject the product and others)						
7. Negligence or lack of motivation worker						
8. Electric interruption problem.						
9. Shortage of accessories, use of poor tool and equipment.						
10. Poor production process control system (PPC) (over planned but not implemented).						
11. Poor machine and equipment maintenance skill						
12. Waste management principle implementation problem						
13. Over production problem happen or (no order product happen).						
14. Defected products used for reuse, repurpose or recycle for a raw material for other job.						

Part III: Open ended Questions

1. Describe the drawbacks of wastes produced during the production of metal products.

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2. Does a company profit from the minimization and handling of metal waste? If the answer is "yes," please list a few advantages.

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3. Who should act to reduce the amount of metal waste as well as defective product?

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4. Kindly outline your own strategies for handling and decreasing metal waste. The organization in question is Akaki Basic Metals Industries.

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THANK YOU

APPENDIX –D

BOTH WORK SHOPS MACHINE LISTS TOTAL BREAK DOWN AND BREAK DOWN PERIOD.

LIGHT DUTY MACHINE ON PART MANUFACTURING				
s/n	**Machine description**	**Qty.**	**Break down period**	
			< 1 year	**>1 year**
1	Center lath m/n	15	02	14
2	Power hack saw	01		01
3	Combined universal milling	8		08
4	Universal shaping	03		03
5	Vertical milling m/n	02		02
6	Pedestal grinding	04		04
7	Electro discharge machine	02		02
8	Universal grinding	01		01
9	Tool maker milling m/n	01		01
10	Universal gear machine	02		02
11	Center less grinding	01		01
12	Grooved shaft grinding	01		01
13	Gear shaping machine	01		01
Heavy Duty Machine on Part Manufacturing				
s/n	**Machine description**	**Qty.**	**Break down period**	
			< 1 year	**>1 year**
14	Center lath	01		01
15	Medium center lath	01	01	
16	Horizontal boring and milling	01		01
17	Radial drill	01		01
18	Boring machine	01		01
19	Double column Plano miller	01		01
20	Pedestal grinding	01		01
	Total		**03**	**47**

Pattern work shop				
s/n	**Machine description**	**Qty.**	**Break down period**	
			< 1 year	**>1 year**
1	Band saw	01		01
2	planner	01		01
3	Belt and disc sanding	01		01
4	Belt sanding machine	01		01
Nonferrous work shop				
1	Aluminum melting furnace	02		01
2	Bronze melting furnace	01		01
3	Shot blasting cabin	01		01
4	Jib crane	01		01
5	Gravity mill casting	01		01
6	Band saw			
Mechanized molding, melting and finishing work shop.				
1	Jib crane	04		04
2	Pedestal grinding	02		02
3	Continuous mixer	01		01
4	Overhead crane	01		01
5	Wet dust separator	01		01
6	Pre heater	01		01
7	Core blowing machine	01		01
8	4 in one shot blasting	01		01
9	Induction furnace	01		01
Heat treatment work shop				
1	Endo-gas generator	03		03
2	Sealed quench furnace	02		02
3	Muffle furnace	03	01	02
4	Shot blasting machine	01		01
5	Roller table	01		01
	Total		**01**	**31**