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SCHOOL OF MECHANICAL AND INDUSTRIAL ENGINEERING

Design and Analysis of Solid Waste Collector Conveyor

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Abstract

This research aims to design and analyze automatic Solid waste collector conveyor to use on shallow surface of the water. This method includes; Analysis of a belt collector which requires specific software.

The problem of waste generation and management has become a serious issue of concern to many scholars in the field of environmental studies. The most common litter in a household is trash, including plastic cups, plastic bags and wrapping materials, as well as fast-food wrappers, plastic bottles, and other plastic containers.

The main purpose of this thesis is to solve or minimize the problems, i.e. on how to clean the river, and minimize animal dieses by collecting the solid garbage from the water, to increase land fertility etc. the main method employed in this is by collecting the necessary data, and by analyzing the effects of the solid garbage in the river. In the end, we got the clean, shine, attractive and healthy water.

This has made discussion on design calculations, analyses and considerations of collector belt conveyor system for solid waste in terms of size, length, capacity, and speed. Also power, tension, type of drive unit diameter, location and arrangements of pulleys, angle, product to be handled as well as its maximum loading capacity for fast, continuous, and efficient movement of solid waste have been discussed.

The main potential application areas are on the urban and rural stagnant water. Drawings of Two-dimensional, Three dimensional, Assembly drawings of belt conveyor, as well as boat assembly were applied for the analysis of material using CATIA V5R19. Finally, conclusions and recommendations, based on the analysis outcomes are for further researches.

Keyword: Belt Conveyor system, Finite Element Analysis (FEA), Loading, Material handling equipment,

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First and foremost, I would like to thank the Almighty God for giving me good health and patience throughout my studies; and more particularly for successfully completing this thesis.

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Nomenclature

Symbols	**Description**
T_{ss}	Belt tension at steady state
f	Coefficient of friction
L	Conveyor length;
G	Acceleration due to gravity;
Ɵ	Inclination angle of the conveyor; and
h	Vertical height of the conveyor
Π	Pi
F_e	Equipment friction factor
C	Belt conveyor capacity
V	Belt speed;
t_f	Terminal friction constant;
W	Weight of material and belt in;
G	Acceleration due to gravity
M_b	Load due to belt
M_m	Load due to conveyed materials;
A	Cross-sectional area of the belt
σ_1	Tight side tensile stress
σ_2	Loose side tensile stress
σ_c	Centrifugal tensile stress
T	Tension
M	Torque
F_U	Total tangential force at the periphery of the drive pulley;

g	Acceleration due to gravity
L	Lift
T_s	Belt tension while starting;
K_s	Startup factor
T_e	Effective tension
F_e	Equipment friction factor
D	pulley diameter
μ	Coefficient of friction
W	weight of the material and belt
C_r	Frictional factor
P_p	Power at driven pulley
C_v	Breaking strength loss factor

CHAPTER ONE

1. Introduction

1.1. Background of the study

The term “Conveyor belt” describes belts used to convey all kinds of Semi- finished and finished industrial products from one point to another. They are mainly used for handling of unit goods, both in the food and non-food production and packaging sectors and in general materials handling for storage and distribution.

A belt conveyor is a Rubber or Textile structure with a belt shape closed ring, with a vulcanized or metallic joint, which is used for material transportation. Belt Conveyors are mostly used for transport of solid objects and for bulk materials at great speed, covering long distance. A conveyor system is a common piece of mechanical handling equipment that moves materials from one location to another. Conveyors are especially useful in applications involving the transportation of heavy or bulky materials. Conveyor systems allow quick and efficient transportation for a wide variety of materials, making them very popular in the material handling and packaging industries. Many kinds of conveying systems are available and are used according to the various needs of different industries. There are chains of conveyors (floor and overhead) as well. Chain of conveyor systems are used across a range of industries, with numerous benefits thereof. They are able to safely transport materials from one level to another, where if human labor is for the same, it becomes more strenuous and expensive. They can be installed almost anywhere, and are much safer than using a forklift or other machine for moving materials. They can also move loads of all shapes, sizes and weights. Many of them have advanced safety features for preventing accidents. There are a variety of options available for running conveying systems, including the hydraulic, mechanical and fully automated systems, which are equipped to fit individual needs. Conveyor systems are commonly used in many industries, including the mining, automotive, agricultural, computer, electronic, food processing. They are also applicable in aerospace, pharmaceutical, chemical, bottling and canning as well as, print finishing and packaging industries. Although a wide variety of materials can be conveyed, some of the most common include food items such as beans and nuts, bottles and cans, automotive components, scrap metal, pills and powders, wood and furniture and grain and animal feed. Many factors are important for accurate selection of a conveyor system. It is important to know how the conveyor system will be used beforehand. Some areas where conveyor operations are required include transportation, accumulation and sorting, material sizes, weights and shapes and where the loading and pickup points need to be. Conveyors consist of enclosed tracks, I-Beam, towline, power & free, and hand pushed trolleys. A conveyor system is often the lifeline to a company's ability to effectively move its product in a timely fashion. The steps that a company takes, assuring that it is performing at peak capacity include regular inspections and system audits; close monitoring of motors and reducers, keeping key parts in stock, and proper training of personnel.

Increasing the service life of a conveyor system involves: selecting the right conveyor type and, the right system design and paying attention to regular maintenance practices. A conveyor system which is designed properly will last a long time with proper maintenance. Here are six of the biggest problems to watch for in overhead type conveyor systems including I-beam monorails, enclosed track conveyors and power and free conveyors. Overhead conveyor systems have been used in numerous applications from shop displays, assembly lines to paint finishing plants and the likes. [1] Poor take-up adjustment: this is a simple adjustment on most systems; yet it is often overlooked. The chain take-up device ensures that the chain is pulled tight as it leaves the drive unit. As wear occurs and the chain lengthens, the take-up extends under the force of its springs. And as they extend, the spring force becomes less and the take-up has less effect. If you simply compress the take-up springs, your problem goes away. Failure to do this can result in chain surging, jamming, and extreme wear on the track and chain. Take-up adjustment is also important for any conveyor using belts as a means to power rollers, or belts themselves are being the mover. With poor-take up on belt-driven rollers, the belt may twist into the drive unit and cause damage, or at the least, a noticeable decrease or complete loss of performance may occur.

Conveyors are durable and reliable components used in automated distribution and warehousing. In combination with computer-controlled pallet handling equipment, this allows for more efficient retail, wholesale, and manufacturing distribution. If we consider a labor saving system, it allows large volumes to move rapidly through a process, allowing companies to ship or receive higher volumes with smaller storage space and with less labor expense.

Belt conveyors are the most commonly used powered conveyors in use because they are the most versatile and the least expensive. Product is conveyed directly on the belt. So both regular and irregular shaped objects, large or small, light and heavy, can be transported successfully. These conveyors should use only the highest quality premium belting products, to reduce belt stretch, resulting in less maintenance for tension adjustments. Belt conveyors can be used to transport product in a straight line or through changes in elevation or direction. In certain applications, they can also be used for static accumulation or cartons.

The conveyors which are used in industrial settings include tripping mechanisms such as trip cords along the length of the conveyor. This allows for workers to immediately shut down the conveyor when a problem arises. Warning alarms are included to notify employees when a conveyor is about to turn on. In the United States, the Occupational Safety and Health Administration have issued regulations for conveyor safety, as OSHA 1926.555. [7]

Conveyor types and conveyor systems:

I. Aluminizes frame conveyors: Aluminum Frame Conveyors, constructed of an assembled extruded aluminum frame, are very strong yet light-weight.

II. Belt conveyors: Belt conveyors: The smooth, continuous surface of a conveyor belt is ideal for many product handling applications. Some of the benefits of belt conveyors include:
    - ✓ Small or delicate part handling
    - ✓ Accumulation
    - ✓ Inclining and elevating with high friction or cleated belts
    - ✓ Clean room environments
    - ✓ Small parts transfer
    - ✓ Back lighted inspection
    - ✓ Quiet operation

III. Cleated belt conveyors: Cleated belt conveyors are commonly used to control product on a horizontal or inclined conveyor. The key attributes for cleated conveyors are the accuracy of the cleat spacing and durability of the cleat in the application. Cleats are applied to the conveyor belt at any spacing and in a variety of heights and cutouts.

- ✓ Contains small parts for elevation changes.
- ✓ Creates pockets for controlled separation of product.
- ✓ Available in urethane belt and plastic chain styles.
- ✓ Fixed guides or integral sidewalls are available

IV. Modular conveyors for curves and turns: Modular plastic chain curve conveyors can be used to create a product turn or a mainline conveying system in almost any configuration. Conveyors those are pre-engineered to meet any situation and offer the tightest radius curves in the industry.

V. Plastic chain conveyor: For heavy loads, accumulation, drainage or air flow, and transporting around a straight and curve design. Achieving the tightest turning radius using plastic chain belts.

VI. Food quality conveyor: Conveyors is designed for fast and effective sanitation, from wipe down to daily high-pressure wash down.

VII. Stainless steel frame conveyor: Stainless Steel Frame Conveyors: Many models feature a complete stainless steel construction for hygienic applications or harsh environments.

VIII. Steel frame conveyor: Steel Frame Conveyors: The durability of steel is hard to surpass. Our steel framed models are used in the harshest of environments.

IX. Lift gate: A standard conveyor can be mounted to a lift gate base creating a conveyor gate that is easily lifted open for the purpose of walk through access.

X. Magnetic belt conveyors: Magnetic belt conveyors are created by placing permanent ceramic magnets in the bed of a standard conveyor.

- ✓ Holds ferrous parts fast to the belt.
- ✓ Ideal for elevation changes or part holding.
- ✓ Can be used in upside down applications.
- ✓ Strength and size of magnetic field is designed per application

XI. Vacuum belt conveyor: Vacuum belt conveyors are made by perforating the belt and drawing air through grooves in the bed of a standard conveyor.

- ✓ Holds flat parts of any material fast to the belt.
- ✓ Ideal for elevation changes or part holding.

- ✓ Can be used in upside down applications.
- ✓ Vacuum area required is designed per application.
- ✓ A variety of vacuum sources can be used

XII. Z – Frame conveyors: Z-Frame conveyors provide the flexibility necessary to match production line height. Z-frame conveyors with both aluminum and stainless steel construction, covering industries from packaging and assembly, to food processing.

Belt Conveyor Application:

The conveyors consist of standard parts, which are advanced and simple in structure, easy to maintain. Belt conveyor are widely used in mining, metallurgical and coal industry to transfer sandy or lump materials, or packaged materials. According to different transferring equipment, the transfer system can be one independently or multi-conveyors or combined with other transfer equipment. The belt conveyor can be installed horizontally with a slope to meet the needs of different transfer lines. [8]

Fig 1.1: Inclined rolled and flat conveyor

Fig 1.2: solid waste on shallow surface of stagnant water

Fig 1.3: main effect of plastic waste

Fig 1.4: traditional solid waste and algae collect

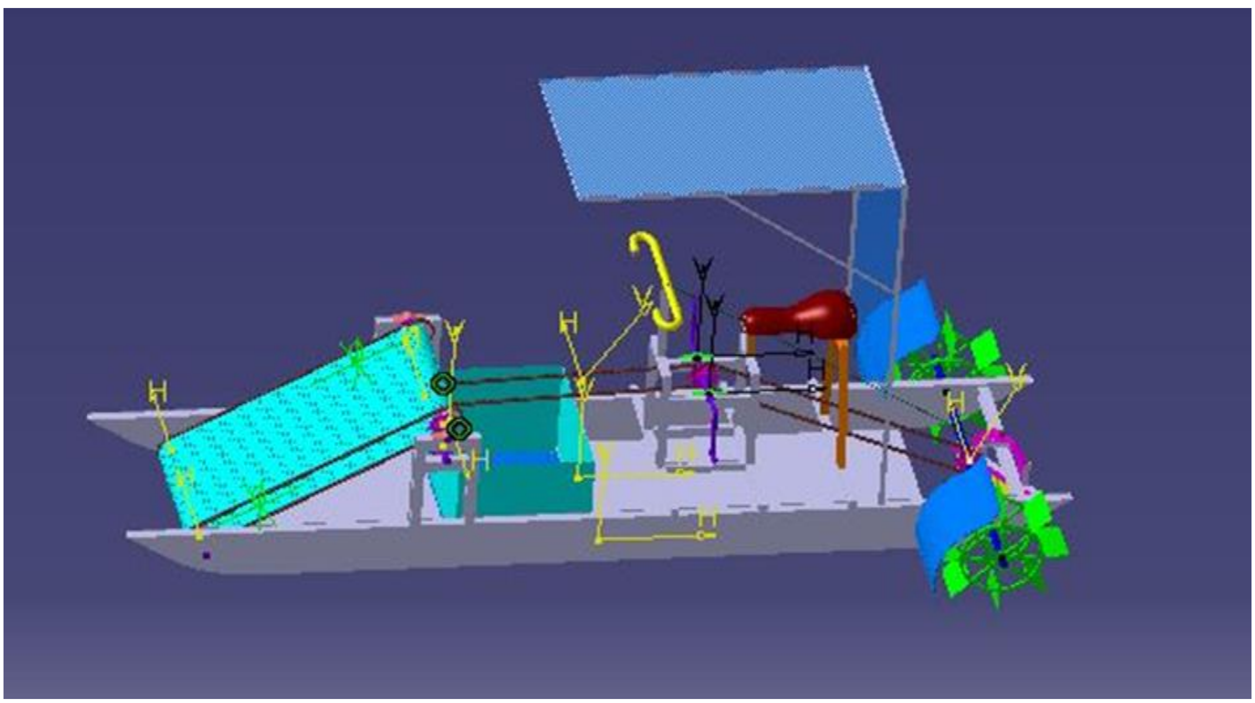


Fig 1.5: 3D model boat

1.2 Statement of the problem

Most people walking in the street do not seem to worry about their trash. They simply throw away it in the street, instead of walking a few extra steps to put it in the trash can. It is possible that when someone drops trash into a stream, this stream may flow in to a river and the river may lead into lakes. In this regard, the environmental damage of solid waste is a serious issue. When people are out in fishing boats, they carelessly dump trash into the river. Though this is illegal, no one can stop them. These people are probably not thinking about what they are doing to the environment when they put their trash in the water. For example, sea turtles like to eat jelly fish, and when they see a clear plastic bag floating in water they may mistake it for a jelly fish (and eat it). This bag is indigestible and soon will starve the sea turtle to death. Sea turtles also enjoy eating cabbages. They may mistake litter floating on top of the water for cabbage, eat it and choke on it. Another issue is that birds and other animals on beaches may get plastic netting or other kinds of solid waste tangled around them. After they struggle to get out for a long time, they will probably give up and die. Due to population growth and a number of tourists coming to the country, a large amount of solid waste is disposed everywhere, causing environmental population. Population growth will increase the amount of trash in towns. However, tourism and the population growth will suffer due to the solid waste in towns. Therefore, in order to address such problems this thesis will conduct the Design and Analysis of Solid Waste Collector Conveyor applicable on shallow surface of stagnant water.

1.3 Objectives

1.3.1. General objectives

The main objective of this project is to analyze solid waste collector.

1.3.2 Specific objectives

To meet the general objectives of the study, the research is intended to achieve the following specific objectives.

- ⇨ To select different material and different standard specification that is necessary for collector
- ⇨ To analyze the boundary condition by using software
- ⇨ To analyze the Von Misses stress
- ⇨ To analyze the translational displacement
- ⇨ To geometrically model by using CATIA V5, and to perform FEM analyses with the help of CATIAV5 software

1.4 Organization of the paper

This thesis is organized in to five chapters. In the first chapter, background, statement of the problem, objectives of the study are discussed. In chapter two a survey of literatures related to the research have been investigated. The journals, articles and publications that are related to this research work are reviewed. In the third chapter, materials used, the conditions and the methods of analysis are stated. Modeling and FEM methods for static structural analysis have been discussed clearly. In chapter four the FEA results are displayed and an appropriate discussion is performed. The conclusions, recommendations and future work of the research are stated in chapter five.

1.5 Scope of the research

The scope of the project is to prepare the documentation of an analytical model of the designed water waste collector machine at efficient working principles at an optimum cost and other considerations.

1.6 Limitation of the project

- ✓ The construction of collector conveyor system requires high capital base. This is major constraint limit this work to analysis only.

1.7 Significance of the project

Plastic waste is often ignored as a ‘problem’ pollutant. However not only is it a ‘pollutant’ that occurs globally, there is growing concern of the impact on long-lived plastic waste and bottles in particular on open oceans.

A collector conveyor in river/lake application provides the following advantages: -

- ✓ No noise
- ✓ Satisfying market demand
- ✓ Avoiding cost extravagancy
- ✓ Easy weeding and reduce competition with weeds
- ✓ Easy to operate
- ✓ Less initial cost
- ✓ Easy to assemble
- ✓ Less maintainability cost

CHAPTER - TWO

2. Literature review

Many researchers have conducted their thesis on Analysis of Solid Waste Collector applicable on the shallow surface of stagnant water. So this chapter deals with reviewing related literature where discussions made in the following sub-sections.

Materials for different belt conveyor

Leather belts

The most important material for flat belt is leather. And the best leather belts are made from 1.2 meters to 1.5 meters long strips cut from either side of the back bone of the top grade steer hides. The hair side of the leather is smoother and harder than the flesh side, but the flesh side is stronger. The fibers on the hair side are perpendicular to the surface, while those on the flesh side are interwoven and parallel to the surface. They give a more intimate contact between belt and pulley and places the greatest tensile strength of the belt section on the outside, where the tension is maximum as the belt passes over the pulley. The leather may be either oak-tanned or mineral salt-tanned *e.g.* chrome-tanned. In order to increase the thickness of belt, the strips are cemented together. The belts are specified according to the number of layers, for instance, single, double or triple layer; and they are also specified according to the thickness of hides used like light, medium or heavy. The leather belts must be periodically cleaned and dressed or treated with a compound or dressing containing neat foot or other suitable oils so that the belt will remain soft and flexible.

1. Cotton or fabric belts

Most of the fabric belts are made by folding canvass or cotton duck into three or more layers (depending upon the thickness desired) and stitching together. These belts are also woven into a strip of the desired width and thickness. They are impregnated with some filler like linseed oil in order to make the belt water-proof and to prevent injury to the fibers. The cotton belts are cheaper and suitable in warm climates, in damp atmospheres and in exposed positions. Since the cotton belts require more attention, they are mostly used in farm machinery[21].

2. Rubber belt

The rubber cover belt is for protection of carcass from damage such as the load, water, etc. It also gives the necessary friction between belt and driving pulley and between belt and material. Depending upon working conditions, various types of rubber should be among others, wear resistant, oil and/or heat resistant, antistatic, incombustible and, chemical resistant. Sometimes, cover types which combine two or more of such properties are also required. The rubber belts are made of layers of fabric impregnated with rubber composition, with a thin layer of rubber on the faces. These belts are very flexible but are quickly destroyed if allowed to come into contact with heat, oil or grease. One of the principal advantages of these belts is that they may be long-lasting. These belts are found suitable for saw mills, paper mills where they are exposed to moisture [21]

3. Balata belts

These belts are similar to rubber belts except that balata gum is used in place of rubber. They are both acid proof and water proof. They are not also affected by animal oils or alkalis. The balata belts should not be used at temperatures exceeding 40°C, for if exposed to above this temperature, they begin to soften and become sticky. The strength of balata belts is 25 per cent higher than rubber belts. [21]

Materials for the Carcass

The function of the carcass is to transmit and absorb the forces acting on the belt. It is primarily a question of tensile forces from the driving pulley. Secondly, the carcass absorbs the impact which partly appears when the material is loaded onto the conveyor. The carcass consists of one or more plies of textile fabric with rubber on each side, giving adhesion and flexibility. The longitudinal direction is called warp and the cross direction is called weft; the conveyor belt fabrics can have the same or different material in warp and weft. One letter is designating each, for instance, EP, in which E is Polyester in warp and P is Polyamide in weft. The carcass is for transmitting tensile forces from the driving pulley, absorbing the impact which occurs in loading material onto conveyor and carrying the belt with material over the carrying idlers. The most commonly used materials of carcass are nylon, polyester, vinylon, cotton …etc...

The following are the most commonly used carcass materials. [19]

a. **Nylon Fabric (NN):** Nylon fabric is the principal material of the carcass, which nearly has all necessary properties as the tension member of conveyor belt.
   - High Tensile Strength
   - High Impact Resistance
   - High Bending Resistance
   - Wide Selection Available
   - Little Flexuous Fatigue
   - Light Weight
   - High Adhesion Strength
   - Excellent Resistance to Water

b. **Polyester Polyamide (EP):** The EP fabrics have Polyester as the warp and Polyamide as the weft.

This combination gives the best possible fabric characteristics with the following advantages:

- High strength in proportion to weight
- High resistance to impact
- Negligible elongation
- Great flexibility, excellent trough ability
- Not susceptible to humidity and micro-organisms

c. **Coating/skim rubber:** Compounded for excellent adhesion between plies for protecting against ply separating, to maintain good adhesion of carcass, especially compound coating rubber is used.

There are researchers and number of literatures on the analysis of belt conveyors. Some of the researchers and literatures are:

Ryan Lemmon, paper presented on belt turnover design using finite element analysis. In this paper a finite element model is developed to validate the original analytical equations and better understand turnover stresses. A comparison is made between the analytical method and the finite element analysis. The stresses in a turnover are controlled by both twisting and bending. The analytical method [13] solves both the twisting and bending stresses in the turnover. The finite element model was completed in ANSYS. Nonlinear and orthotropic shell elements with stress stiffening capability were used to model the belt. A nonlinear model is required due to the large deformations and stress stiffening effects in the turnover. Stress stiffening is required because belt tensions increase the bending stiffness.

Rohini N. Sangolkar, et, al paper presented on modeling and analysis of industrial belt conveyor system using creo parametric and Ansys software. The modeling of the belt conveyor system is created using Creo Parametric Software. Finite element analysis (FEA) is performed to obtain the variation of stress at critical locations of the system using the ANSYS software and applying the boundary conditions to evaluate the total deformation, equivalent (von-misses) stress and shear stress. Further it can be extended for the different materials and dynamic analysis, optimization of belt conveyor system. [14]

S. Rajeshkumar, et, al paper presented on Design and Analysis of Belt Conveyor for Finishing House Pulper. The main objective of their project is to reduce the human effects and labour cost. They have planned to reduce the human effects and processing time by designing a belt conveyor for feeding the damaged papers into the pulper. Their project "DESIGN AND ANALYSIS OF BELT CONVEYOR FOR FINISHING HOUSE PULPER" is very help full for carrying the paper to the pulper machine. Today conveyors are widely used for load transmitting process. Thus their project reduces and saving the time, labour cost and manpower. Thus conveyor helps to transfer the load in inclined direction to move material for long distances.

Mr. Amol B. Kharage*, et, al presented paper on analysis and optimization of gravity roller conveyor using ANSYS software. The main objective of their study is to explore the analysis of Gravity roller conveyor to minimize the overall weight of assembly and material saving. Critical parameter which reduces the weight is C channels, roller outer diameter and roller thickness. Though value of deflection, stress is more in case of Optimized design, but it is allowable, this has entailed performing an entailed Study of existing Gravity Roller Conveyor system and optimize the critical part like roller, C-channel etc. by using composite material, so to minimize the overall weight of the assembly without hampering its structural strength. [15]

A. Mihailidis, 1E.et, al presented paper on fem analysis of a belt conveyor driving drum the aim is to test various load scenarios on a reinforced drum model and compare the results against the two types currently in service. Modelling the complete pulley assembly is the currently accepted method for drum analysis, since the stiffness is influenced by the shaft due to the locking connecting components used. The force application utilizes a user selectable distribution function along the axis of the drum and the Euler's belt formula along the circumference. The models were built in ANSA, and optimized in terms of mesh density around the high load areas, while built-in pressure distribution tools and python scripting were utilized to apply the load case.

Seema S. Vanamane*,et, al, presented paper on Design, Manufacture and Analysis of Belt Conveyor System. In their paper the study is carried out on DISA pattern moulding machine to meet the requirement of higher weight castings. From the DISA specification the belt conveyor system is designed by using different standards like CEMA (Conveyor Equipment Manufacture's Association) standards, some handbooks of belt conveyor system etc. then this parameter are verified by using Belt Comp software. The result got from the Belt Comp software is in close agreement of theoretical results. The trials are carried out on the belt conveyor system successfully and the problems occurs during the trials are overcome in the analysis by taking proper steps.

M. A. Alspaugh et. al, their paper presents latest development in belt conveyor technology & the application of traditional components in nontraditional applications requiring horizontal curves and intermediate drives have changed and expanded belt conveyor possibilities. Examples of complex conveying applications along with the numerical tools required to insure reliability and availability will be reviewed. This paper referenced Henderson PC2 which is one of the longest single flight conventional conveyors in the world at 16.26 km. But a 19.1 km conveyor is under construction in the USA now, and a 23.5 km flight is being designed in Australia. Other conveyors 30-40 km long are being discussed in other parts of the world.

Chetan Kothalkar et. al, in this paper an oscillatory type short distance gravity actuated trolley conveyer is conceptualized to be used for conveying light material to and fro to shorter distances. This is a unique conveyer which uses the gravity principle of the gravity conveyor but differs from it. It has two hinged platforms at its ends on which the wheeled trolley rests. To move the trolley, platform is to be raised by an angle more than the limiting angle of friction between the platform and the trolley wheels. Overcoming the static friction, the trolley moves in the direction of the slant and gains momentum. It covers a distance before coming to halt, which depends on coefficient of friction trolley mass, energizing length of the platform, angle of inclination etc. Analysis of GAOTC has been done using the computer program. This paper is discussing the studies on length of travel of the trolley using various combinations of the length and friction of the platform with the applications.

Prof. Balaji Nelge, et, al (2001) this paper presents study is to explore the analysis of Gravity roller conveyor. This has entailed performing a detailed Study of existing Gravity Roller Conveyor system and optimizes the critical part like roller, C-channel etc. by using composite material, so to minimize the overall weight of the assembly without hampering its structural strength. The material used for roller and C-channel frame is a composite material i.e. carbon fiber.

S.S. Gaikwad et. al, in this paper, an attempt is made to reduction in weight of existing roller conveyor by optimizing the critical parts of (e.g. Roller,) conveyor without hampering its structural strength. The existing Roller conveyor designed is considered for this project work. The dimensions being 2200 mm length, 30 inch above ground and inclined at 2 to 4 degree with the ground and the weight to be carried by the conveyor - 280Kg (350 kg with added factor of safety). This is the weight of the largest component to be transported over the conveyor. The conveyor would normally encounter gradually applied loads while the components are lowered by hoist. For the reasons of safety, a `sudden load’ is already considered during its design phase. Static analysis of roller of existing conveyor is carried out find out maximum deflection & stress. Then Optimization is carried out by modifying the dimensions of roller. Then analysis of optimized roller is carried out to find out maximum deflection & stress. 29.54 % of weight reduction is achieved due to Optimized design. About 56.18Kg Weight reduction achieved by optimized design than existing design. Actual physical model is done for validation using optimized design parameters and it is found that the design is working safely.

CHAPTER THREE

3. Materials and Methods

3.1. Introduction

3.1.2 Properties of solid waste

Several companies offer equipment to garbage out of river lakes and harbors .The water surface trash collection boat can work in river or lake, it can collect the floating garbage and some other equipment for weed cutting, it harvest the aquatic weed from lake. This is really a good solution for the aquatic weed management. Many says they could build larger dustcarts for the sea and ocean, if there was a demand of them those seen here may not be ideal for collection on large scale but it is food for thought.[11]We are making the boat which is operated by pedal and clean the waste present in the lake. In this boat the conveyor collect the waste present in lake and then collect it in box like structure present in lower side of the boat. We are trying to collect the waste like household trash, including plastic cups, plastic bags and wrapping materials, fast-food wrappers, plastic bottles, and other plastic containers. Plastics can be especially hazardous to wildlife. Depending on their form they can either be ingested, causing internal organ failure, or they can cause a slow strangulation.

The most common litter is household trash, including plastic cups, plastic bags and wrapping materials, fast-food wrappers, plastic bottles, and other plastic containers. Plastics can be especially hazardous to wildlife. Depending on their form they can either be ingested, causing internal organ failure, or they can cause a slow strangulation.

3.1.3. Materials

The choice of the material to be used depends on the type of service. The material used for belts and ropes must be strong, flexible, and durable. The preferred material for the cover solid waste collector conveyor belt is rubber and the carcass material is Nylon Fabric (NN) because of its excellent resistance to water, high tensile strength, high impact resistance, high bending resistance and light weight. And the rubber cover belt is important for the protection of carcass from damage such as the load, water, etc. Rubber belt is the cheapest system to convey bulk solid materials over any distance. The rubber used in conveyor belting, whether natural or synthetic, is compounded to protect the carcass from the material being conveyed, and from any external conditions which could shorten the belt's useful life. The conveyor belt design seeks to ensure comparable service life for both the cover and the carcass, so that they wear out at the same rate, regardless of conditions. Two rubber covers, named top and bottom covers, protect the resistant carcass. In order to guarantee safety and long life under hard working conditions, all type of rubber covers should be antistatic and ozone protected.

3.1.4 Material properties nylon 66 for conveyor belt

Nylon fabric is the principal material of the carcass, which nearly has all necessary properties for the tension member of conveyor belt.

- ✓ High Tensile Strength
- ✓ High Bending Resistance
- ✓ Light Weight
- ✓ High Adhesion Strength
- ✓ Excellent Resistance to Water

3.1.5 Conceptual process design

- ➢ **Adaptive design:** In most cases, the designer's work is concerned with adaptation of existing designs. This type of design needs no special knowledge or skill and can be attempted by designers of ordinary technical training. The designer only makes minor alternation or modification in the existing designs of the product.
- ➢ **Development design:** This type of design needs considerable scientific training and design ability in order to modify the existing designs into a new idea by adopting a new material or different method of manufacture. In this case, though the designer starts from the existing design, but the final product may differ quite markedly from the original product.
- ➢ **New design:** This type of design needs lot of research, technical ability and creative thinking. Only those designers who have personal qualities of a sufficiently high order can take up the work of a new design.

  This paper deals with improving existing designs by increasing its efficiency and quality, and application of the product and product outputs (adaptive design).

3.2 Methods and methodology

Begin with a literature review, a lot of paper and journal have been read up and a part of it has been consider in this thesis work. The mechanical properties and geometric parameters of this studied component are shown [20] [21]. The source of the data for the analysis of this belt conveyers are taken from previous thesis [13] [14] [15] [16]. Later, the two-dimensional, three dimensional and assembly drawings of belt conveyor, boat assembly and analysis of the material have been done by using CATIA V5R19

General Procedure in Machine Design

In designing a machine component, there is no rigid rule. The problem may be attempted in several ways. However, the general procedure to solve a design problem is as follows:

1. Recognition of need: First of all, make a complete statement of the problem, indicating the need, aim or purpose for which the machine is to be designed

2. Synthesis (Mechanisms): Select the possible mechanism or group of mechanisms which will give the desired motion.

3. Analysis of forces: Find the forces acting on each member of the machine and the energy transmitted by each member.

4. **Material selection**: Select the material best suited for each member of the machine.

5. **Design of elements (Size and Stresses):** Find the size of each member of the machine by considering the force acting on the member and the permissible stresses for the material used. It should be kept in mind that each member should not deflect or deform than the permissible limit.

6. **Modification:** Modify the size of the member to agree with the past experience and judgment to facilitate manufacture. The modification may also be necessary by consideration of manufacturing to reduce overall cost.

7. **Detailed drawing:** Draw the detailed drawing of each component and the assembly of the machine with complete specification for the manufacturing processes suggested.

8. **Production:** The component, as per the drawing, is manufactured in the workshop.

3.2.1 Material selection for collector

The materials for this design are selected based on the working environment, type of load applied, properties of the chain (tension) and type of the chain selected

Table 3.1 material selection of the Collector Conveyor Belt part

No	Component	Material type	Remark
1	Chain	Carbon steel	Can carry high load
2	Bearing	through-hardened materials	Alloys with various proportions of molybdenum, tungsten, chromium, vanadium, aluminum, and silicon are used to produce hardness at high temperatures.
3	Keyway	Mild steel	In expensive, can be malleable, ductile, its high durability and versatility
4	Shaft	Carbon steel	Inexpensive and can be resists for both tensile and compressive stress, its high durability and versatility
5	Sprocket	Mild steel	In expensive, can be malleable, ductile, its high durability and versatility

3.2.2 Conceptual design

Conceptual design is a part of product design and used to determine the elements mechanism, processes, configurations that in some combination or other results in design that satisfies the need to make up the whole system .conceptual design is the early stage of the design where the main decisions are made by means of design for manufacture (DFM),as a rough idea is developed as to how a product will function and what it will look like and the best is selected based on decision theories for further design analyses.

On this stage the designing process of design and analysis of semi-automatic Solid waste collector on the shallow surface on stagnant water cleaning machine starts from the principle solution design new system development in accordance with technical criteria's.

Requirements for the new design:

The general criteria's or requirements for how the final product is looks like are listed below: Small in size to transport from place to place

- ⇨ Less weight
- ⇨ Less Number of component to reduce complexity
- ⇨ Reliable working principle
- ⇨ Safe in operation
- ⇨ Easy to operate
- ⇨ Less initial cost
- ⇨ Easy to assemble
- ⇨ Less maintainability cost
- ⇨ Good cleaning capacity

The general consideration and conceptual design of the water cleaning machine on the stagnant shallow surface of the water are:

- ✓ Develop best water cleaning machine system
- ✓ To decrease energy consumption
- ✓ To reduce weight or space required

- ✓ To significantly lower cost
- ✓ To improve production time
- ✓ To protect the water from any fuel, batteries

3.2.3 Concept Generation Methods

In the concept generation phase we should ask the following questions to start with,

- ✓ What existing solution concepts, if any, could be successfully adapted for this application?
- ✓ What new concept might satisfy the establishment needs and specifications?
- ✓ What methods should be used to facilitate the concept generation process?

The structured approach to concept generation consists of the following five steps:

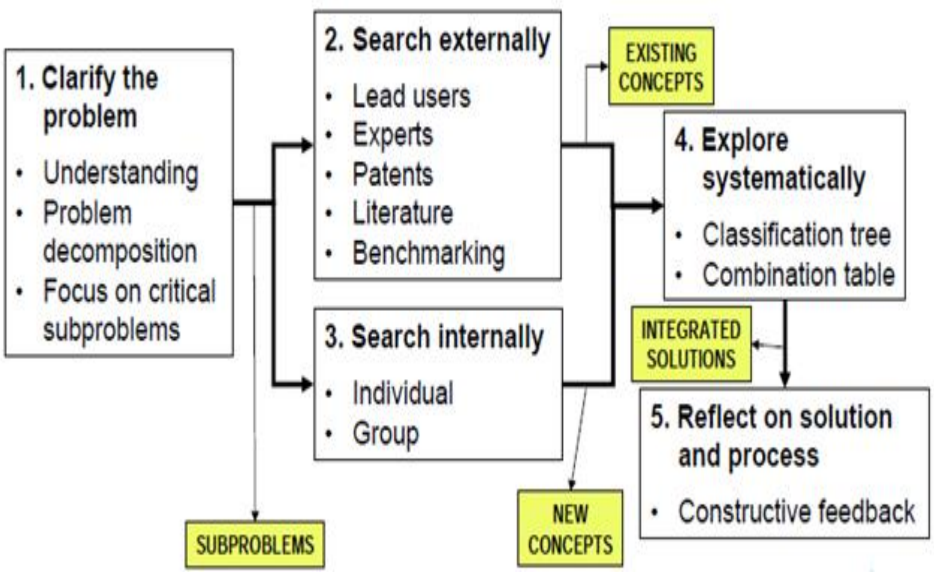


Figure: 3.1.Concept generation steps diagram

3.2.4 Concept generation function for solid waste cleaning machine

The concept generation process begins Based on the assumptions, customer need and target specification it decomposed all problems in to sub problems and also interpreted in to general and sub-function.

i. General function

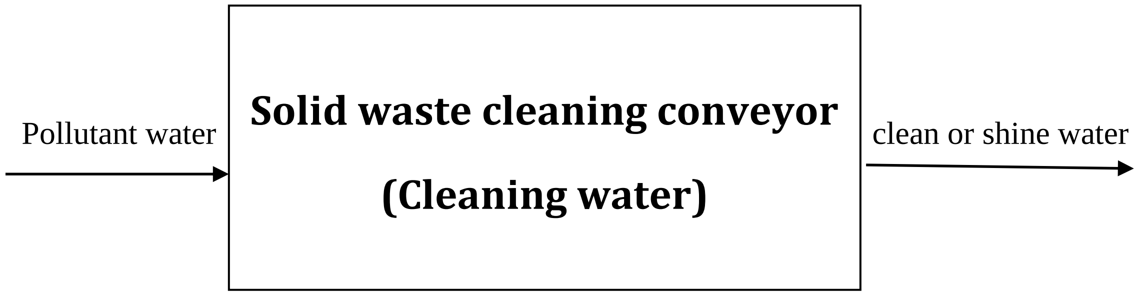


Fig 3.2 general function of boat water cleaning machine

ii. Decomposed sub functions

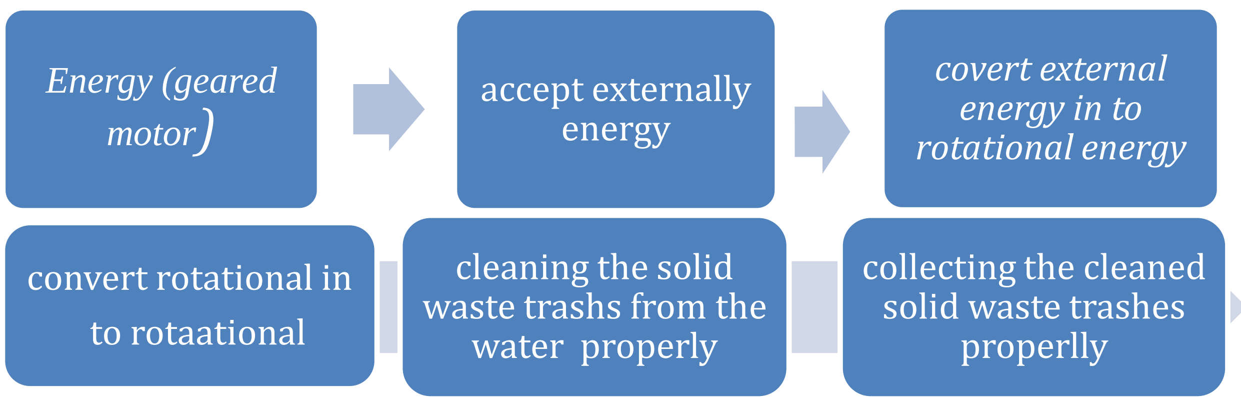


Fig 3.3 Sub function of boat water cleaning machine

3.2.5 Functional structure

Process Synthesis is a structured method in the area of Conceptual Process Design. It allows systematic development of the most economical process flow sheets. To simplify the concept generation, the energy resources that assumes in which they are convenient to this project as shown below.

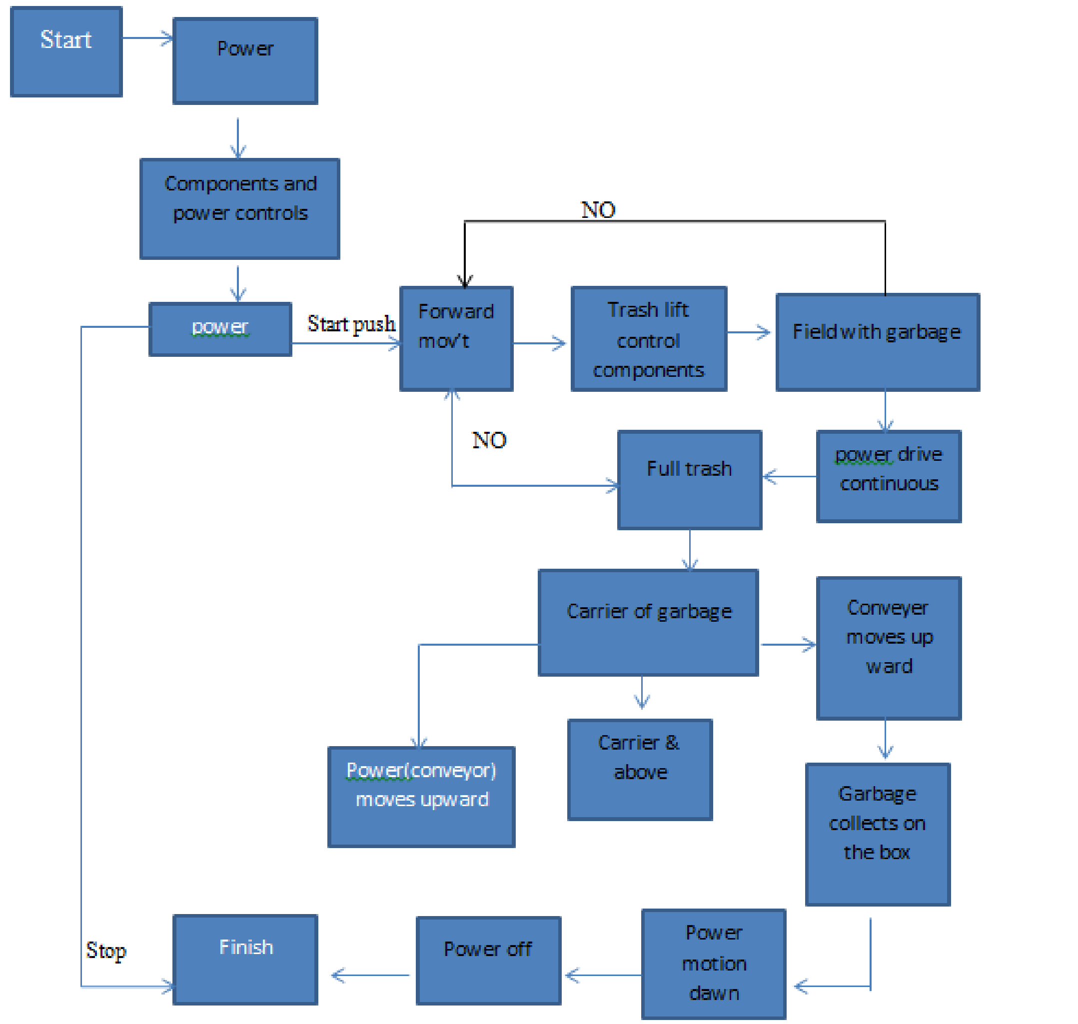


Fig 3.4: boat functional structure

3.2.6 Mission statement

It is required to design and analysis of automatic Solid waste collector on the shallow surface on stagnant water cleaning machine pedal and turbulent operated, which has the following estimated Specifications (Customer needs).

Dimensions (Lx Wx H) : 18*12*5(cm)

Weight with garbage : 100N up to 1000N

No.of blades of the wheel: 16

Number of wheel : 2

No of rudder : 2

Power source : geared motor mechanism

Conveyor alignment : inclined

Conveyer : length 100cm width 70cm angle @ 45 degree

Trash box : length 80 cm, width 40cm thickness (depth) 40cm

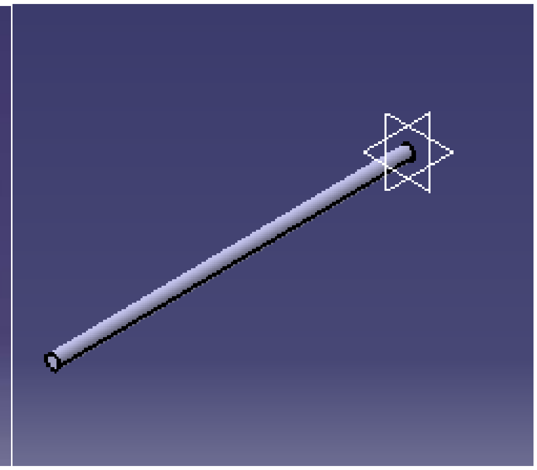
3.2.7. Embodiment design of solid waste collector conveyor

Embodiment design is the part of the design process in which, starting from the principle solution or concept of a technical product, the design is developed in accordance with technical and economic criteria and in the light of further information, to the point where subsequent detail design can lead directly to production.

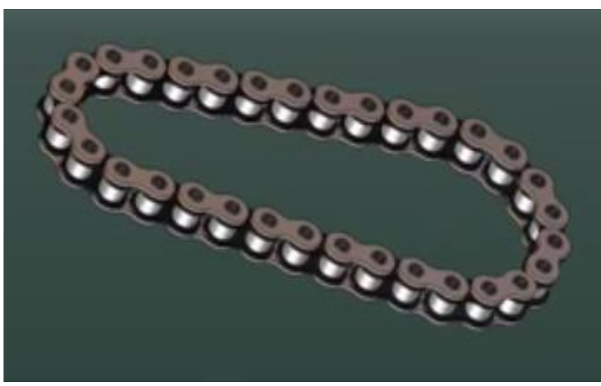
- Basic Rule of Embodiment design

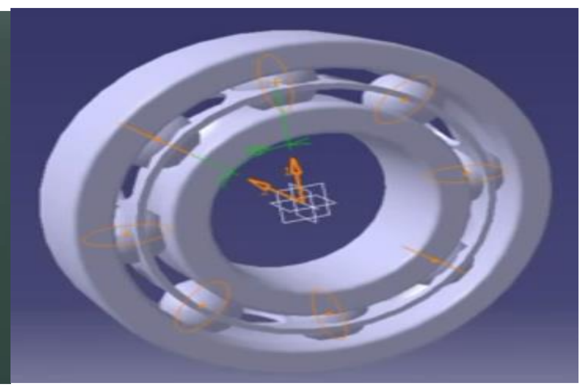
There are basic rules that we must follow in embodiment design of solid waste collector conveyor belt machine.

i. Clarity – the functions of solid waste collector conveyor belt machine is clearly stated in chapter two.
ii. Simplicity – the components the solid waste collector conveyor belt are simple and their shapes also are not difficult for production and the economic feasibility also is assured by market analysis that it have so many customer if the product is distributed.
iii. Safety- the solid waste collector conveyor belt does not have any accident on humans may some components will get broken but never have effect on the person. In addition this machine does not have any consequence on environment pollution and no hazard exhaust gases that are emitted from the machine.

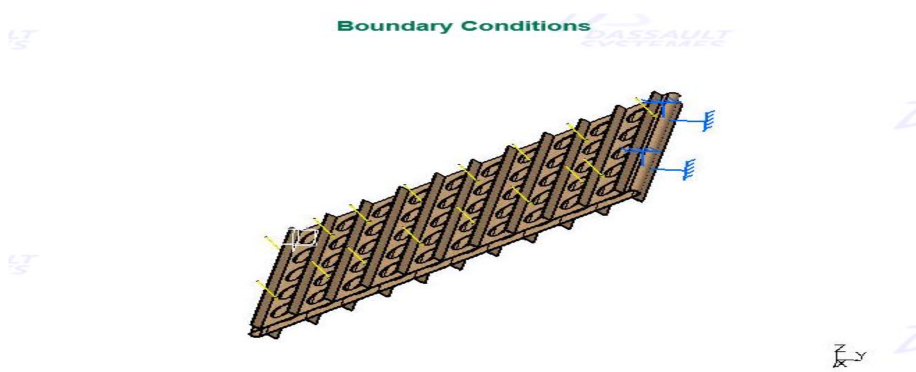


a) Sprocket b) shaft





c) Chain d) Bearing



e) Collector belt

Fig 3.5 Components of solid waste Collector Conveyor Belt

3.2.8 Method of analytical calculation of belt conveyor system

Belt drives analysis:

Figure 3.7 shows the belt forces on both sides of the belt in static conditions, i.e. the belt is not working, when the belt moves, it has a tight side and a loose side. The tight side tension increase from F_0 to F_1 the loose side tension decrease from F_0toF_2.

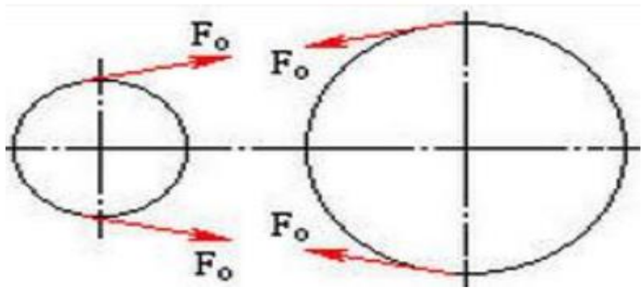


Fig 3.6: tension in the belt

Effective tension (F):

Effective tension F is the effective circumferential force the belt drive can transfer effectively. It is not the concentrated force acting in a fixed point, but the sum of the friction generated by the contact surface of the belt and pulley, i.e. [20]

$$F_0 = \frac{1}{2}(\boldsymbol{F_1} + \boldsymbol{F_2})$$

$$F = F_1 - F_2$$

$$F_1 = \mathrm{F} + \frac{F}{2}\ ,\ F_2 = \mathrm{F} - \frac{F}{2} \text{……………………………………………... (eq}^{\underline{n}}\text{.1)}$$

The relationship between the circumferential force F (N), the belt speed v (m / s) and the transmission power P (KW): [20]

$$P = \frac{FV}{1000}\ kw \text{…………………………….... (eq}^{\underline{n}}\text{.2)}$$

Euler's formula:

The relationship between the tension forces F_1 and F_2 on both sides of the belt are given by the following Euler’s formula: [20]

$F_1 = F_2 e^{f\alpha}$................................ (eq$^{\underline{n}}$.3)

Where: f is the coefficient of friction between the belt and the wheel surface;

α is the Wrap angle (rad);

e is the natural logarithms (e ≈ 2.718).

The above equation is the basic flexible friction formula, known as Euler's formula. The belt forces are shown in figure3.8 [20].

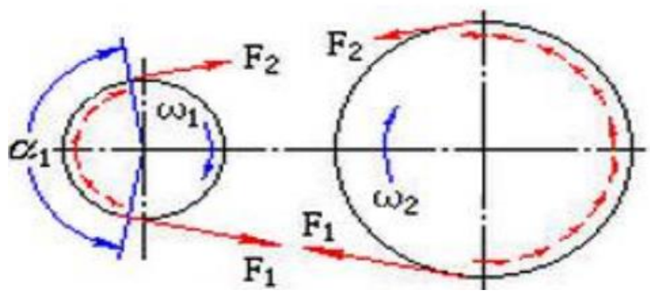
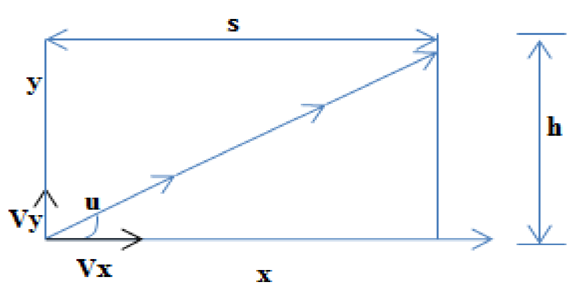


Fig 3.7: tension in the belt work condition

The equation of inclined belt motion:



Since all motion components are directly expressible in terms of horizontal and vertical coordinates, a rectangular set of axes x-y will be employed.

With the neglecting of atmospheric resistance

$a_x = 0$

$a_y = -g$

$v_x = \frac{d_x}{\mathrm{dt}}$

$d_x = v_x$ dt

$\int d_x = \int v_x$ dt

x = $\int_0^t u \cos\theta$ dt

x = utcos θ………………………………………… (eqn.4)

$a_y = \frac{dv_y}{dt}$

$d_{v_y} = a_{y}dt$

$\int d_{vy} = \int a_y$ dt

$\int_{u \sin\theta}^{v_y} d_{vy} = \int_0^t (-g)$ dt

$u \sin\theta$ - v_y = -gt

$v_y = u \sin\theta$ – gt………………..……………….. (eqn.5)

$d_y = v_y$ dt

$\int d_y = \int_0^t (u \sin\theta - gt)\, dt$

Y = $ut \sin\theta$ - $\frac{1}{2}gt^2$……………..………… (eq^{n}. 6)

Position B is reached when v_y = 0 which occurs for

$v_y = u \sin\theta$ – gt

0 = $u \sin\theta$ – gt

t = $\frac{u \sin\theta}{g}$………………………………………. (eqn.7)

Substitution of this value for the time in to the expression for y gives the maximum added attitude

h = y = $ut \sin\theta$ - $\frac{1}{2}gt^2$

h = u $(\frac{u \sin\theta}{g})$ $\sin\theta$-$\frac{1}{2}$g$(\frac{u \sin\theta}{g})^2$

$h = \frac{u^2 \sin\theta^2}{2g}$………………………………… (eqn.8)

The horizontal distance is

$$s = \text{x} = \text{u}t\cos\theta$$

$$= \text{u}(\frac{u\sin\theta}{g})\ \cos\theta$$

$s = \frac{u^2 sin2\theta}{2g}$ ………………….…………. (eqn.9)

Stress analysis of belt drive:

When the belt is moving, the stress in the belt is composed of the following three parts: [20]

(1) Tight side and loose side tensions generate tensile stresses

- ✓ tight side tensile stress: $\sigma_1 = \frac{F_1}{A}$
- ✓ Loose side tensile stress: $\sigma_2 = \frac{F_2}{A}$

Where

A is the cross-sectional area of the belt (mm^2).

(2) Tensile stress (σ_1) caused by Centrifugal force(F_c), Centrifugal tensile stress(σ_c) is given by

$\sigma_c = \frac{F_c}{A} = \frac{qv^2}{A}$…………………………………….. (eqn.10)

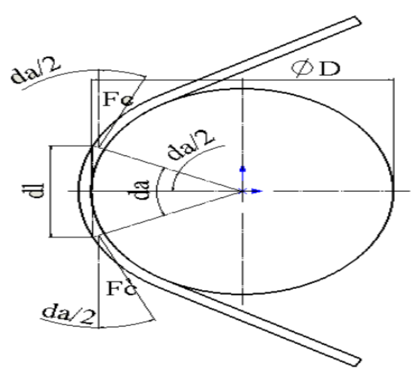


Fig 3.8: Centrifugal stress

(3) Bending stress (σ_b), shown in below figure. The stress is given by below Equation

$\sigma_2 = \frac{2yE}{D}$ ……………………………………… (eqn.10)

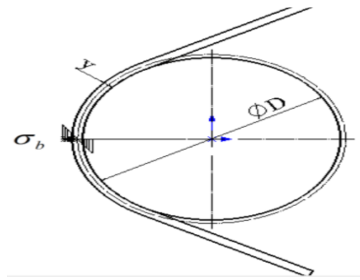


Fig3.9: bending stress

Where:

y is the vertical distance (mm) of neutral layer of the tape to the outermost layer;

E is the modulus of elasticity of the belt material (Mpa); d is the pulley diameter (for the V-belt pulley, d is the standard diameter.)

The maximum stress value is: [20]

t= $\sigma_1 + \sigma_b + \sigma_c$…………………………………….. (eqn.11)

So while the belt drive system is running, the maximum location stress varies. This means the belt works under varying stress. When the number of stress cycles reaches a critical value, the fatigue failure will occur.

- ***Mass:*** is the property of belt which determines its resistance to changes in velocity.
- ***Weight*:** **i**s the vertical force exerted by the mass acted upon by the gravitational pull.
  W=mg……………………………….……. (eqn.12)
- **Lifting:** The mass to be lifted must be accelerated from rest to the desired speed and must overcome the gravitational effect.

Example, to accelerate a mass from rest to v m/s in t seconds requires an average acceleration of v/t (m/s^{2}), and therefore force F = m •$\frac{V}{t}$ (N). But the acceleration due to gravity must be overcome too [8]

Therefore, the total lifting force

$$F = m \cdot \frac{V}{t} + mg$$

$$F = m\left(\frac{V}{t} + g\right) \text{ (N)} \quad \ldots\ldots \text{(eqn.13)}$$

- **Friction:** The horizontal force required to overcome friction is found by applying the coefficient of friction, μ, to the weight, which is the force pressing the two surfaces together.

  The formula for frictional resistance is: [8]

$$F_r = m \cdot g \cdot \mu \quad \ldots\ldots \text{(eqn.14)}$$

The frictional resistance on an incline plane must take into account the angle of ascent.[8]

$$F_r = \mu \cdot F$$

$$F_r = m \cdot g \cdot \mu \cdot \alpha \ldots\ldots \text{(eqn.15)}$$

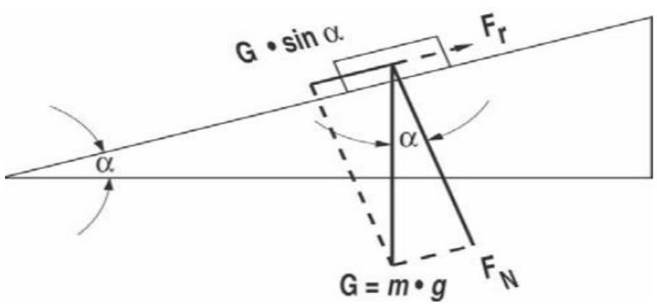


Fig 3.10: reaction of frictional force

- **Torque:** Rotational force acting through a lever arm or radius is called a torque or moment, M, unit Nm. Torque is the product of a force F and the radius r of the lever through which it acts, expressed as:

$$M = F \cdot r \quad \text{(Nm)}$$

$$T = \frac{M_2}{r_1} - \frac{M_1}{r_2} \ldots\ldots \text{(eqn.16)}$$

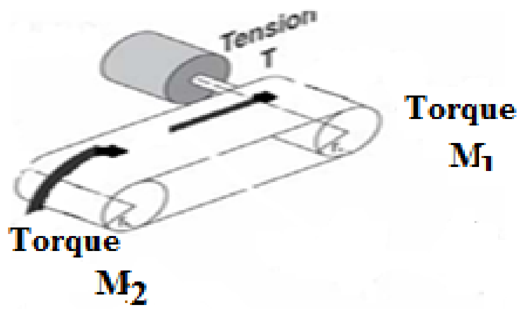


Fig 3.11: torque or moment

- **Force**

Force on the inclined plane: downhill slop force and normal force

$$\left.\begin{array}{l} \checkmark\ F_H = F_G \sin\alpha \\ \checkmark\ F_N = F_G \cos\alpha \end{array}\right\} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(\text{eq}^{\underline{n}}.17)$$

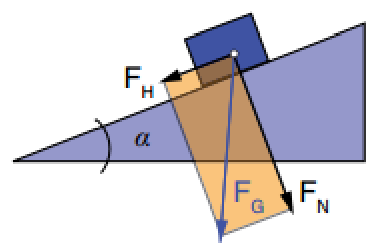


Fig 3.12: Reaction of force

From the same conveyor data [18], find the motor power if the conveyor raises the load through some height of an inclined plane adds a component of force to the forces required to start, accelerate and run the conveyor. This component is the force required to raise the load. The total force is the hypotenuse of the vector diagram of which the horizontal component is the force required to start, accelerate or drive the load at constant speed. These have already been calculated in the “conveyor” application. The additional vertical component is mg multiplied by the sine of the angle of the slope, γ. [8]

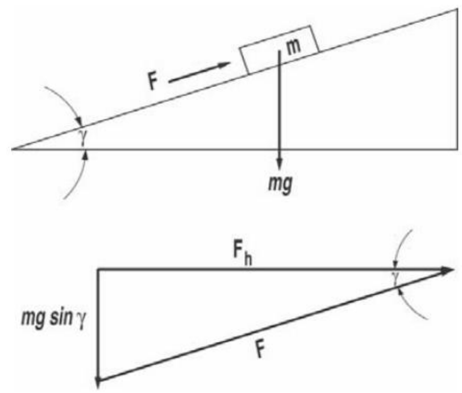


Fig 3.13: reaction force and torque

The total force, F is calculated from. (Note - calculator must be in radians mode)

F= $([Fh^2 + (mg\ sin\gamma)^2])^{1/2}$………………………. (eqn.18)

- **Motor power:** to accelerate the conveyor is the accelerating torque at the conveyor pulley multiplied by the rotational speed of the pulley at full speed, taking into account the efficiency (η) of the gearing [8].

$$P_a = M_a \omega \eta$$

Or

Power = $\frac{\text{work}}{\text{time}} = \frac{\text{force x distance}}{\text{time}}$…………………………… (eqn.19)

- **Capacity calculation (c)**

The general formula for capacity is:

Capacity (tones/hr) = 3.6 x load cross section area (m^2) x belt speed (m/s) x material density (kg/m^3) ……………………………..………. (eqn.20)

- **Belt power**

The longer the length of the belt, the more the power required for the conveyor and the higher the vertical distance of the lift, the higher the magnitude of power required. [3]

✓ The power (kW) at drive pulley drum is:

$P_p = \frac{F_U\ x\ V}{1000}$……………………………..………. (eqn.21)

Where: V: Belt speed; and

F_U: Total tangential force at the periphery of the drive pulley (N);

Power required for the conveyor to produce lift can also be calculated as:

P= $\frac{C\ x\ 3.75\ x\ L}{1000}$…………………….………………………. (eqn.22)

Where

P= power required for conveyor (kW);

C= conveyor capacity; and

L=Lift

- **Belt tension**

The belt of the conveyor always experiences tensile load due to the rotation of the electric drive, and weight of the conveyed materials. The belt tension must be great enough to prevent slippage between the drive pulley and the belt [8]. Belt tension at steady state is given as: [3]

T_{ss}=1.37 x f x $\boldsymbol{L\ x\ g}$ [(2 xM_b+M_m) Cos (θ)] + (H x g x M_m) ………………..………. (eqn.23)

Where:

T_{ss} =Belt tension at steady state (N);

f= Coefficient of friction

L=Conveyor length;

g=Acceleration due to gravity (9.81 m/sec2);

M_b=Load due to belt

M_m=Load due to conveyed materials

θ= Inclination angle of the conveyor; and

H=Vertical height of the conveyor

During the start of the conveyor system, the tension in the belt will be much higher than the steady state.

✓ The belt tension while starting is [3]

T_s=T_{ss} x K_s……………………………..………. (eqn.24)

Where:

T_s = Belt tension while starting (N);

T_{ss}=Belt tension at the steady state; and

K_s=Start up factor

✓ For inclined belt, the drive at head pulley is:

T_{max}= T_e + T_2……………………………..………. (eqn.25)

✓ While the drive at tail pulley is

T_{max}= T_e + T_2 OR

T_{max}= T_e + T_2 + T_{frs}……………………..………. (eqn.26)

Where

T_{fr} =belt tension-return side friction

T_e = effective tension

T_e Effective tension (KN)

T_e = total empty friction +load friction +load slope tension

- Total empty friction = F_e x (L + t_f) x W x 9.81e^{-3}
- Load Friction= F_e x (L + t_f) x $\frac{C}{3.6\ x\ V}$ x 9.81e^{-3}
- Return side tension= F_e x W x L x 0.4 x 9.81e^{-3}
- Load slope tension = $\frac{C\ x\ H}{3.6\ x\ V}$ x 9.81e^{-3}

Where:

F_e =Equipment friction factor;

C= Belt Conveyor capacity

V= Belt speed;

t_f =Terminal friction constant;

W=Weight of material and belt in;

Acceleration of the conveyor belt is given by:

a = $\frac{T_{ss}-T_s}{[(2*M_b+ M_m)]}$……..……………………… (eqn.27)

The breaking belt strength also given by:

B_{bs}= $\frac{C_r-P_p}{[(C_v+\mathrm{V})]}$………..………………………. (eqn.28)

$where$:

C_r = Frictional factor

P_p = Power at driven pulley

C_v = Breaking strength loss factor

The torsional moment is given by as:

M_t= $\frac{1}{2} * D * (F + \mu W g)$ ……………………… (eqn.29)where

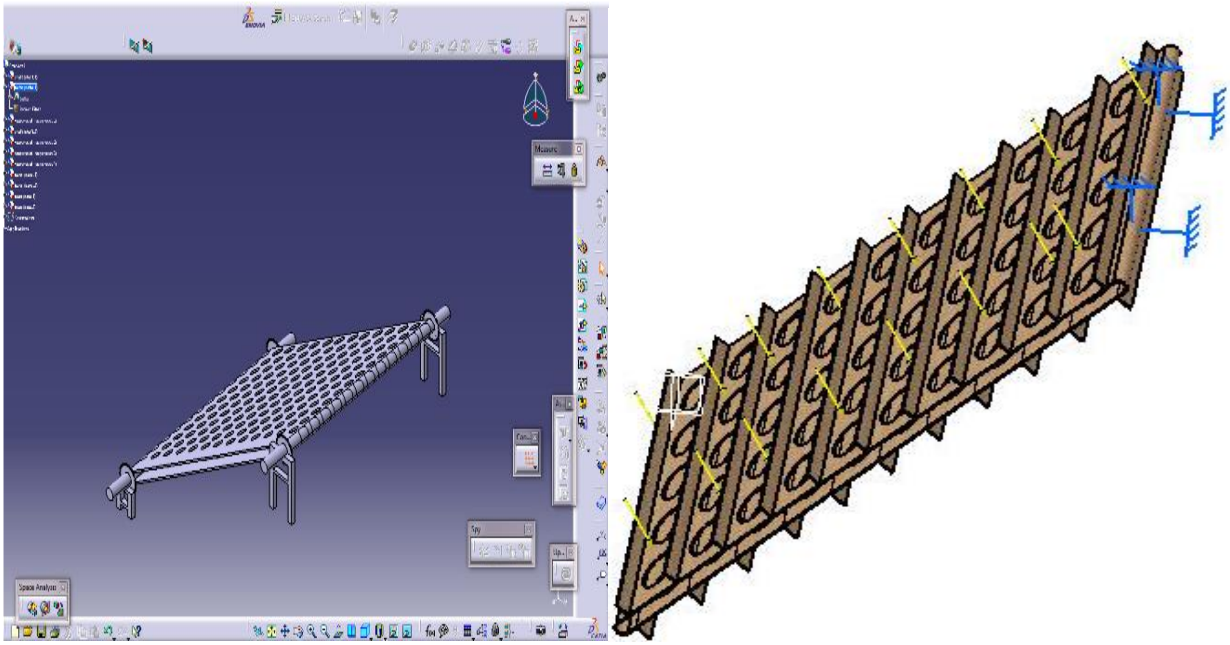
D = pulley diameter

μ = Coefficient of friction

W = weight of the material and belt

g = acceleration due to gravity

3.2.9. The structure and loading of the collector conveyor



a) 3D modeling of belt b) 3D model of belt conveyor with supporter

Fig 3.14: 3D modeling of collector conveyor

3.2.10 Mathematical modelling of collector conveyor

The general scheme of problem solving in the program CATIAV5R19 is visible in the below Figure 3.17.

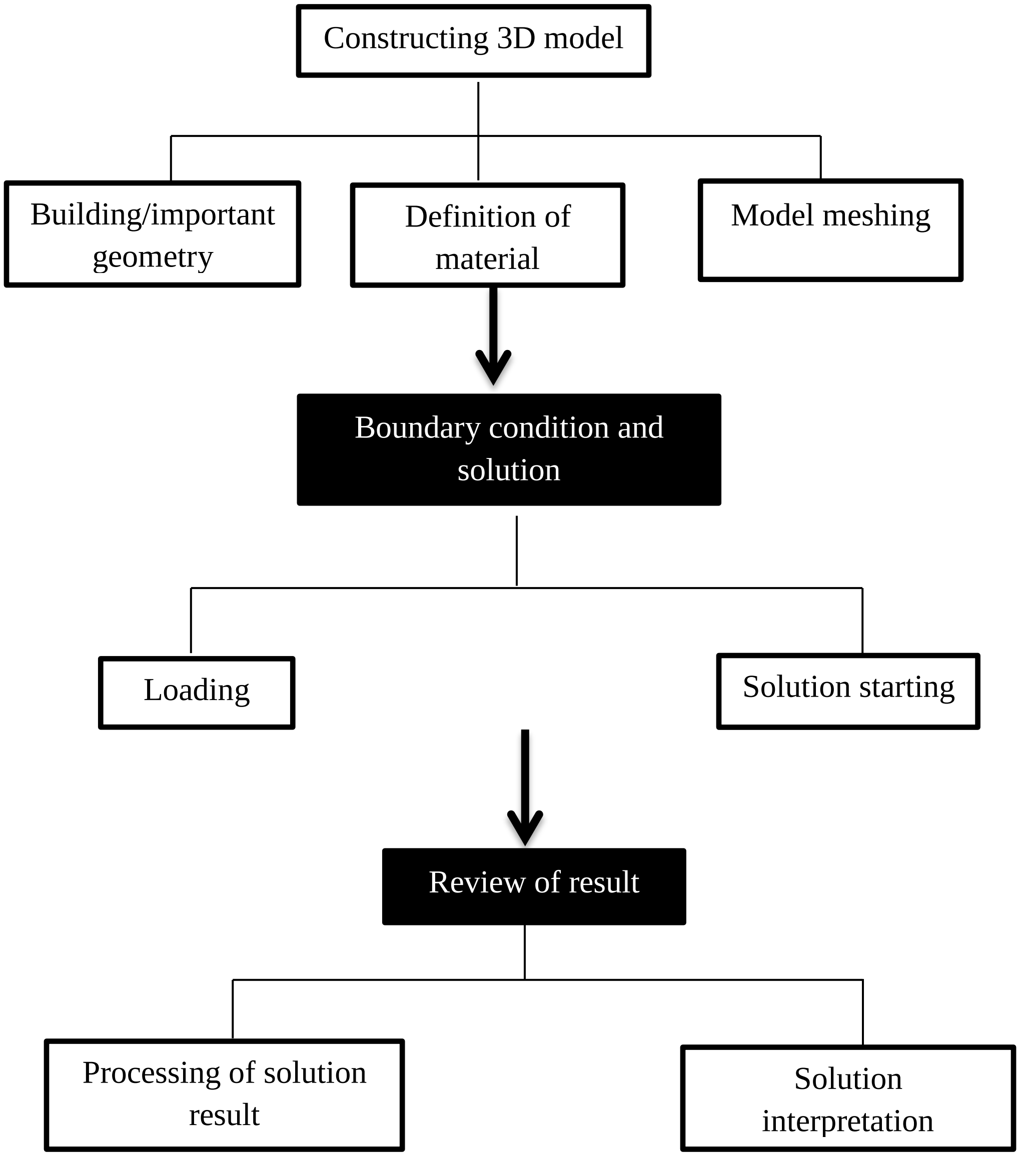


Figure 3.15: General scheme of problem solving in the CATIAV5R19 program

Mathematical modeling means the usage of the mathematical formulas and relations in order to simulate the real situation. For example, it is the simulation of the conveyor belt strains. Various parameters, for example size of density and deformation in the point of force application etc. can be the results of modeling. The all calculation is made by computer program that is based on finite element method.

Much lower costs are one of the advantages of mathematical modeling, especially in comparison with other methods (for example the experimental research). The next big advantage is based on the possibility of input data changes and on the very fast solutions of various versions of the given problem.

As we can see, in the previous scheme the first step of solution is **constructing a 3D model,** using the CATIA application software. In this step, we create geometrical shape of final model called solid model.

The next step is **the choice of element and the definition of material properties** (physical, technological and mechanical properties). The element type determines, whether the final model is plane (2-D) or space (3-D). The element was selected to model the cover layers of a conveyor belt. It is 8-node element given for the 3-D modeling of a solid hyper elastic structure. It is used for material modeling which is nearly uncompressible (for example rubber and similar materials with great displacements and deformations).

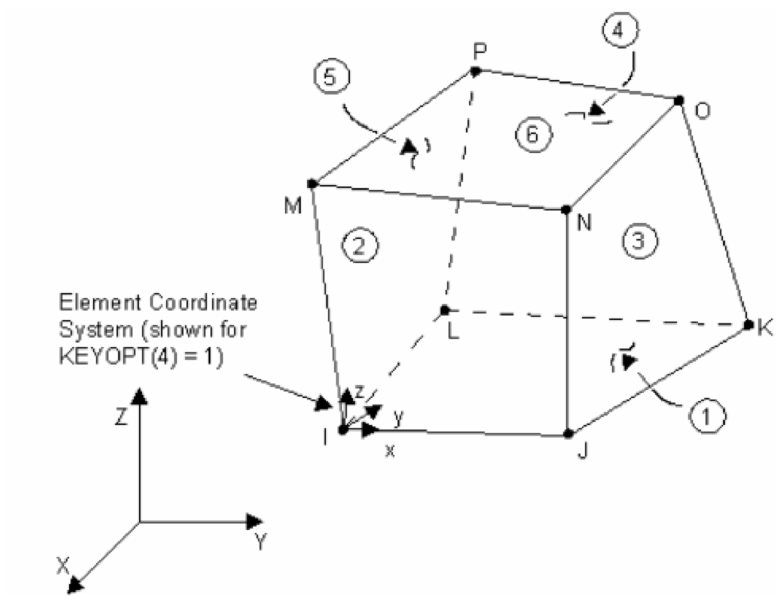


Fig 3.16: Element coordinate

3.2.11 Methods of Finite Element Analysis

The finite element method is numerical analysis technique for obtaining approximate solutions to a wide variety of engineering problems. Because of its diversity and flexibility as an analysis tool, it is receiving much attention in almost every industry. In more and more engineering situation today, we find that it is necessary to obtain approximate solutions to obtain than exact to closed solution. The finite element method has become a powerful tool for the numerical solutions of a wide range of engineering problems. It has been developed simultaneously with the increasing use of the high-speed electronic digital computers and with the growing emphasis on numerical methods for engineering analysis. This method started as a generalization of the structural idea to some problems of elastic continuum problem, started in terms of different equations. Structural analysis is the most common application of finite element analysis. The term structural implies civil engineering structure such as bridge and building, but also naval, aeronautical and mechanical structure such as ship hulls, aircraft bodies and machine housing as well as mechanical components such as piston, machine parts and tools. The seven types of structural analyses in CATIAV5R19 and each of these analysis types are listed.

In general, a finite element solution may be broken into the following three stages. This is a general guideline that can be used for setting up any finite element analysis.

- **Preprocessing**: it is about defining the problem which will be analyses by FEM. The element type, material/geometric properties and Meshing are also defined under this section.
- **Solution**: in this section assigning loads, constraints and solving the resulting set of equations the given problem are performed.
- **Post processing**: further processing and viewing of the results; in this stage one may wish to see nodal displacements, Element forces and moments, Deflection plots, Stress contour diagrams.

3.2.12 Dynamic structural Analysis

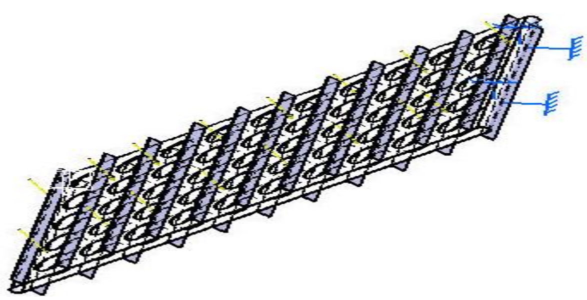
Transient dynamic analysis (sometimes called time-history analysis) is a technique used to determine the dynamic response of a structure under the action of any general time-dependent loads. One can use this type of analysis to determine the time-varying displacements, strains, stresses, and forces in a structure as it responds to any combination of static, transient, and harmonic loads. The time scale of the loading is such that the inertia or damping effects are considered to be important. Transient structural analyses are needed to evaluate the response of deformable bodies when inertial effects become significant. If inertial and damping effects can be ignored, consider performing a linear or nonlinear static analysis instead. On the other hand, if the loading is purely sinusoidal and the response is linear, a harmonic response analysis is more efficient. In all other cases, transient structural analyses should be used, as it is the most general type of dynamic structural analysis.

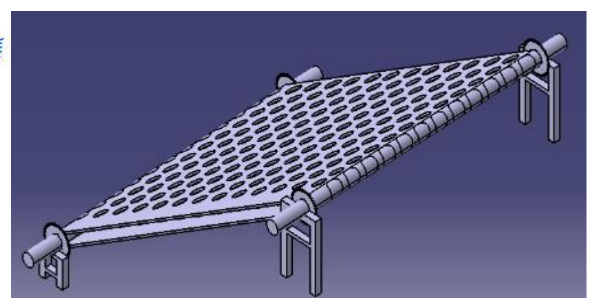
The following steps are used in the solution procedure using CATIAV5R19Workbench software for transient structural Finite Element Analysis of a mechanical problem.

1. The geometry of the panel to be analyzed is imported from modeling software to the CATIAV5R19 Workbench in an acceptable format.
2. The material type and its properties are specified.
3. Meshing the imported panel model.
4. The boundary conditions and external loads are applied.
5. The solution is generated based on these input parameters.
6. Finally, the solution can be displayed.

3.3 The model geometry

The mechanical geometry model and the finite element analysis of the belt conveyor are done by CATIA V5 R19 modeling software.





a) Collector conveyor b) 3D model of the collector conveyor

Fig 3.17: 3D model geometry CATIA V-5 R-19

3.3.1 Input the material type and properties

The material type and its properties such as density, strength, Young's modulus shear modulus and Poisson's ratio are specified under the project model geometry system. The material applied for this purpose is Nylon NN66 fiber material. The engineering data helps to input the mechanical properties of the material (Nylon NN66 fiber). The material properties can be altered or edited in this system. The important material properties are taken from the experimental investigations of previously conducted researches [23]

3.3.2 Material properties nylon 66 for conveyor belt

Nylon fabric is the principal material of the carcass, which nearly has all necessary properties as the tension member of conveyor belt. High tensile strength, high impact resistance, high bending resistance, wide selection available, little flexuous fatigue, light weight, high adhesion strength, excellent resistance to water.

Table 3.1: mechanical, physical and thermal properties of Fabric Nylon NN66

Material	Fabric Nylon NN66
Young's modulus	2e+009N_m2
Poisson's ratio	0.39
Density	1180kg_m3
Yield strength	5.27e+008N_m2
Coefficient of thermal expansion	7e-005_Kdeg

Table 3.2: design of a belt conveyor input standard dates

Material properties	Value	Unit
Belt width	800	mm
Collector length	1149	mm
Cover thickness	4	mm
Force (capacity)	100 up to 1000	N
Power	1.5	Hp
Belt speed	1500	rpm

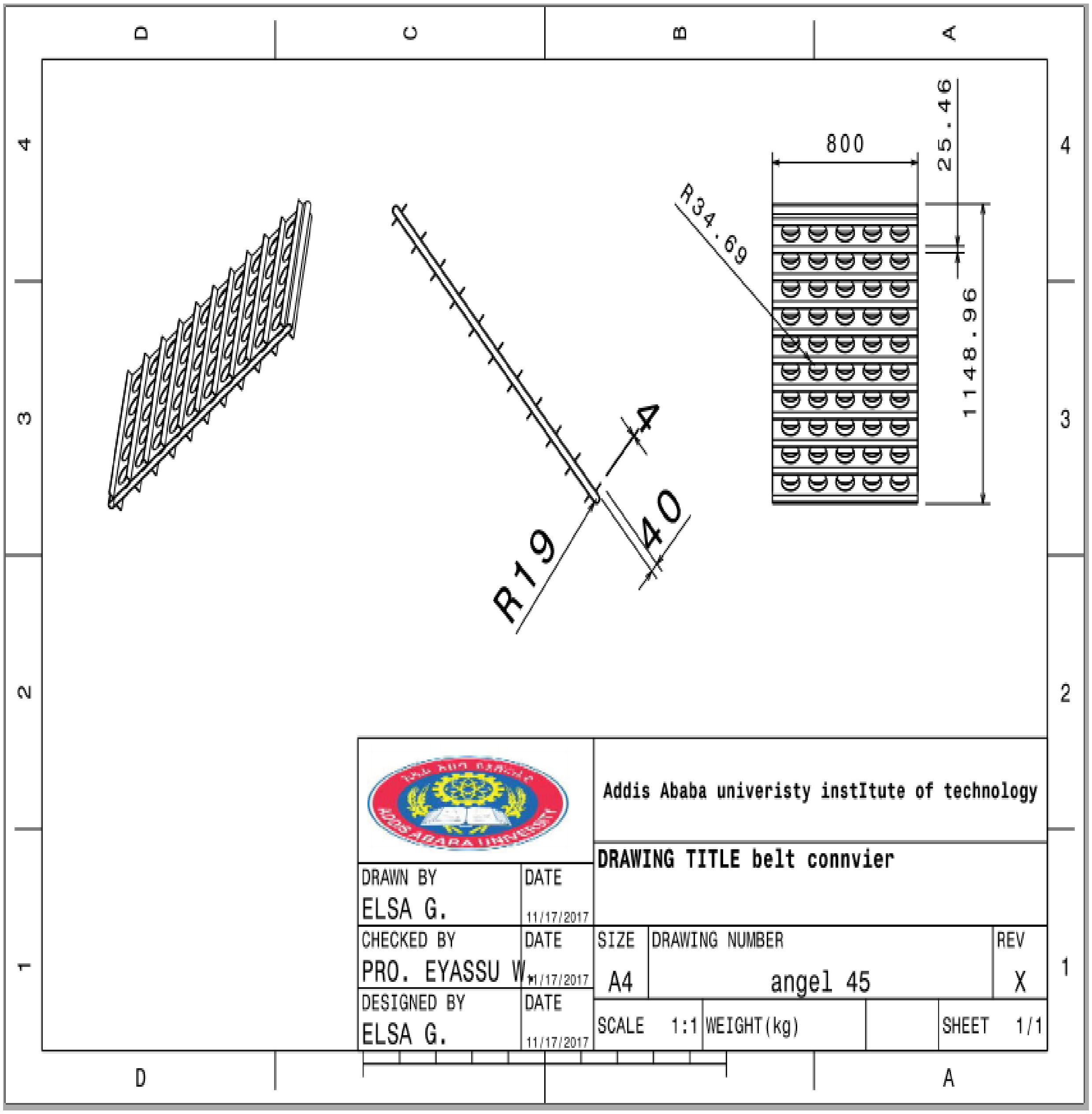
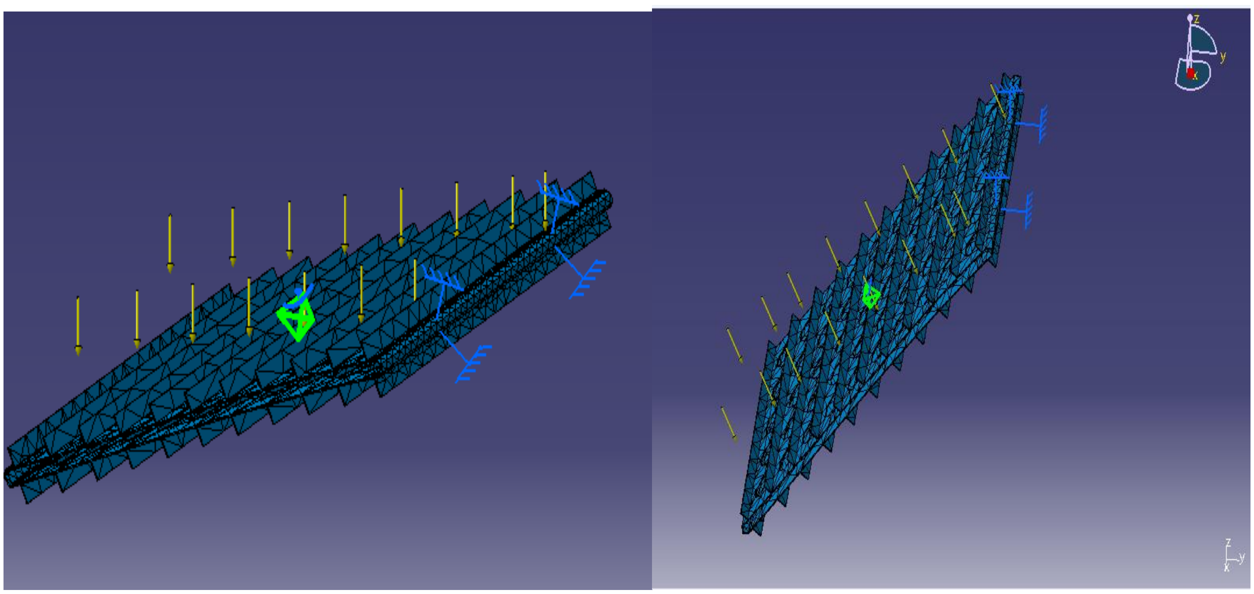


Fig 3.18 design of solid waste collector

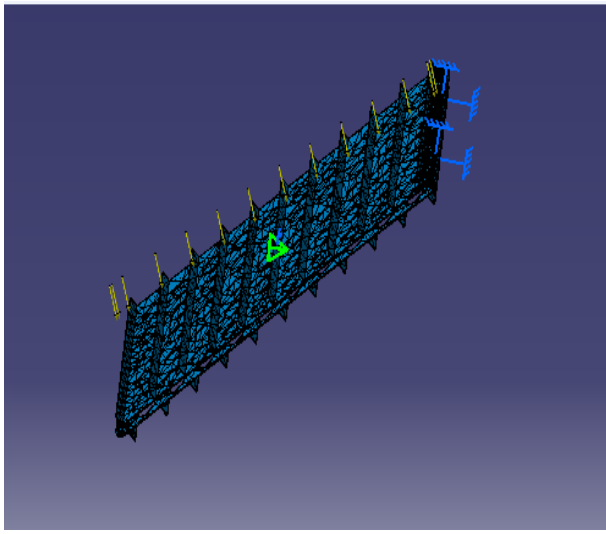
3.4 Meshing the 3D model

In the finite element analysis, the basic concept is to analyze the structure which is an assembly of discrete pieces called elements which are connected together at a finite number of points called nodes. A network between these elements is known as meshing. This is the step that divides the complex geometry model into small elements that become solvable in an otherwise too complex situation. The meshing of the geometry under consideration may be generated directly, i.e., generation of nodes and elements, one at a time. Solid Modeling constitutes a part of the finite element analysis. Thus, the sole purpose of Solid Modeling is to create the mesh of the geometry, as conveniently and efficiently as possible. The meshing process can be performed only after the specification of element type. CATIAV5R19 offers several convenient options to assist in meshing. These include Automatic Meshing, Smart Sizing, and Mapped Meshing. [22]

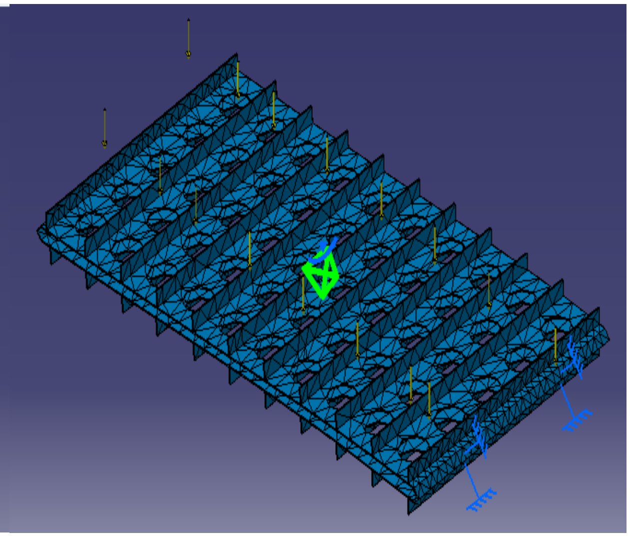
One of the most powerful features of CATIAV5R19 is automatic mesh generation. CATIAV5R19 meshes the solid model entities up on execution of an "appropriate" single command. With automatic meshing, the user can still provide specific preferences for mesh density and shape. If no preferences are specified by the user, CATIAV5R19 uses the default preferences. [22]



a) Meshing model at 30 degree b) Meshing model at 45 degree



c) Meshing model at 60 degree



d) Meshing model at 90 degree

Fig 3.19: Geometric Meshing of the model at different angle on CATIAV5R19 Workbench;

The general mesh statistical data of the collector belt conveyor after meshing of the imported models are sum

Table: 3.3: General statistics of meshing at different angle of the collector belt conveyor.

MESH:

Entity	Size
Nodes	4120
Elements	10402

a) 30degree

MESH:

Entity	Size
Nodes	3911
Elements	9326

b) 45degree

MESH:

Entity	Size
Nodes	4130
Elements	10616

c) 60 degree

MESH:

Entity	Size
Nodes	4535
Elements	11292

d) 90 degree

CHAPTER FOUR

4. Result and discussion

This chapter describes results obtained from the transient structural static analysis of the waste collector conveyor during the present study. After completion of the transient structural static analysis in CATIA V3R19 Workbench, results were reviewed. The two significant types of results were recorded from this analysis of the imported model. The categories based on: equivalent stress (von Misses stress) and total Translation displacement. Since finite element analysis procedures are invariably accompanied by an extensive output of data, it is extremely important that we interpret the results correctly.

4.1 Result

4.1.1 Equivalent (Von-Misses) stress

As shown the contour plot, maximum von misses' stress is indicating by red color and it minimum value is also indicated by blue color. Also the figure depicted that the maximum von misses stress is high at edge of the conveyor. The figure 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8 shows that magnified image of von misses stress at different angle and forces. The equivalent (Von Misses) stress values of solid waste belt collector of FEA are shown in the following figures. The maximum deformation induced in belt conveyor system at near the tail pulley side belt.

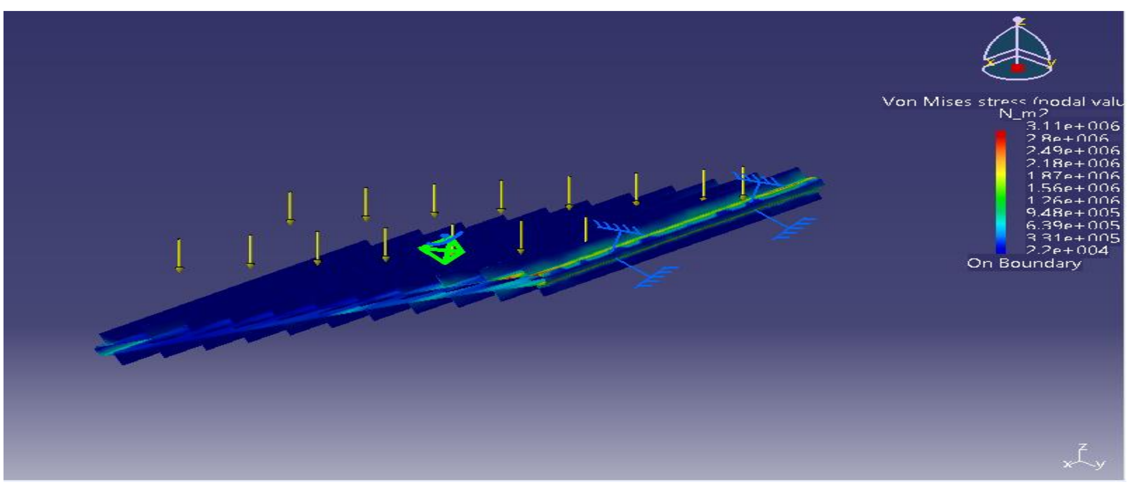


Fig 4.1: Distribution of von misses stress at 30 degree and 100N force

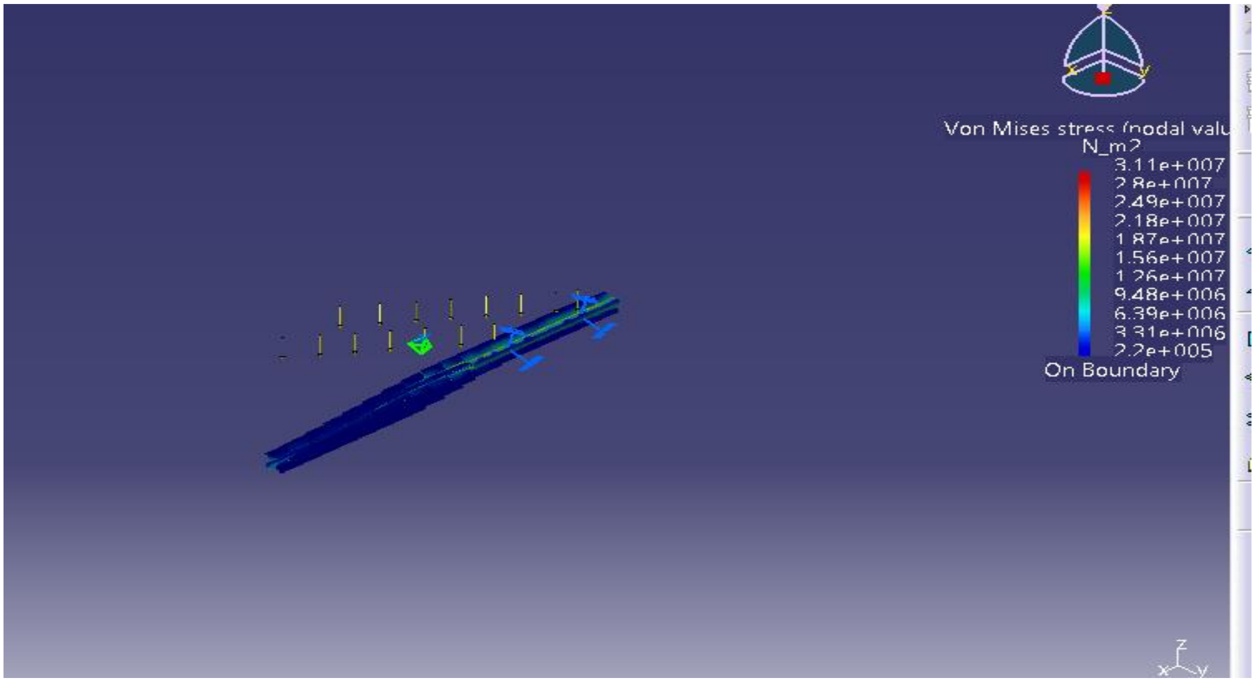


Fig 4.2: Distribution of von misses stress at 30 degree and 1000N force

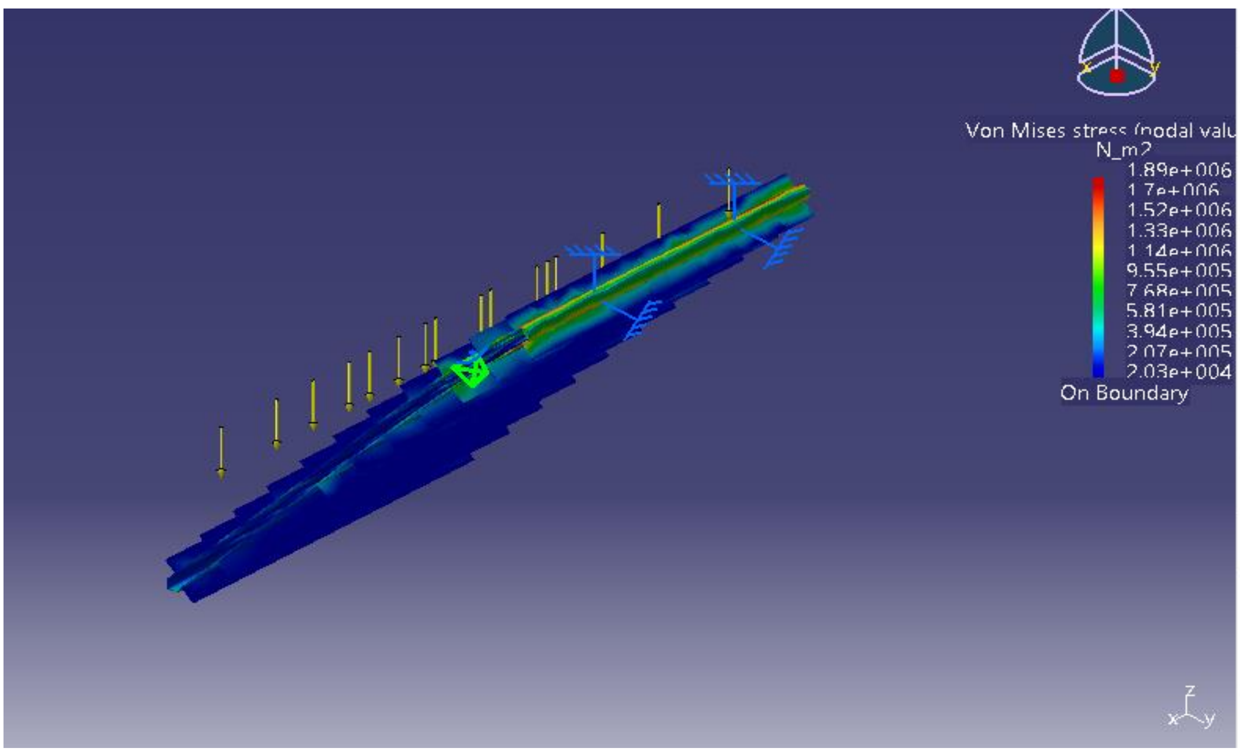


Fig 4.3: Distribution of von misses stress at 45 degree and 100N force

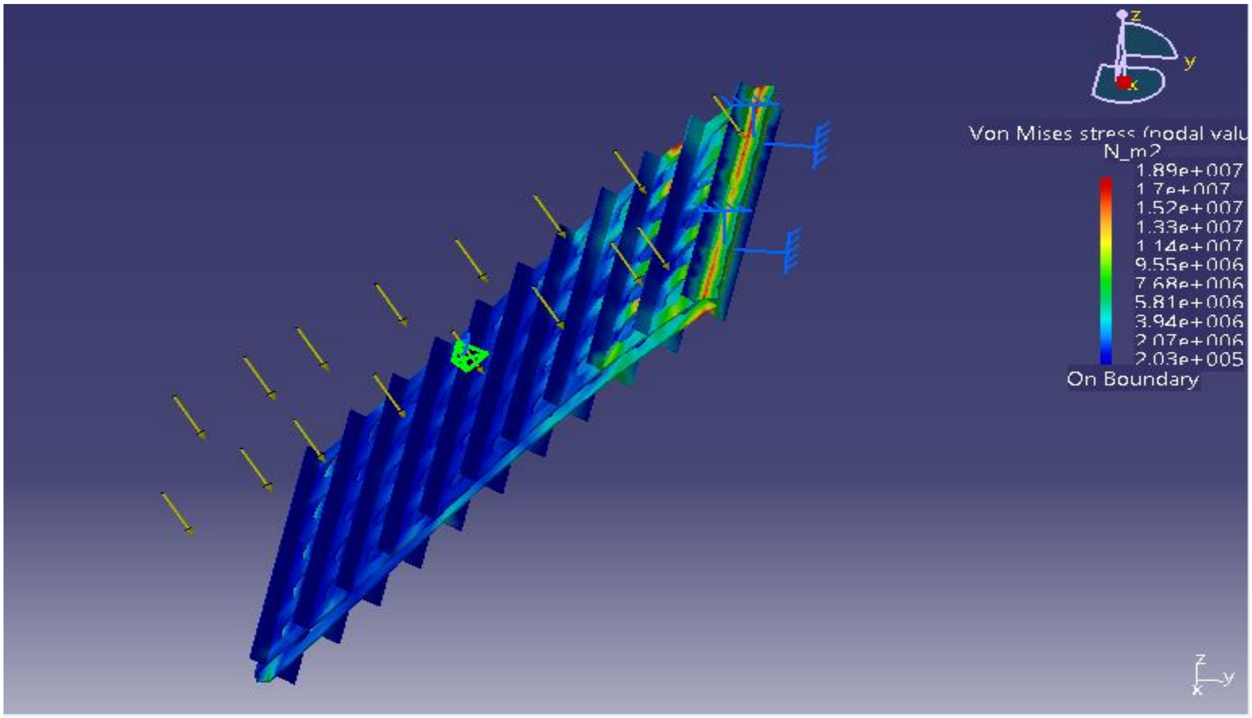


Fig 4.4: Distribution of von misses stress at 45 degree and 1000N force

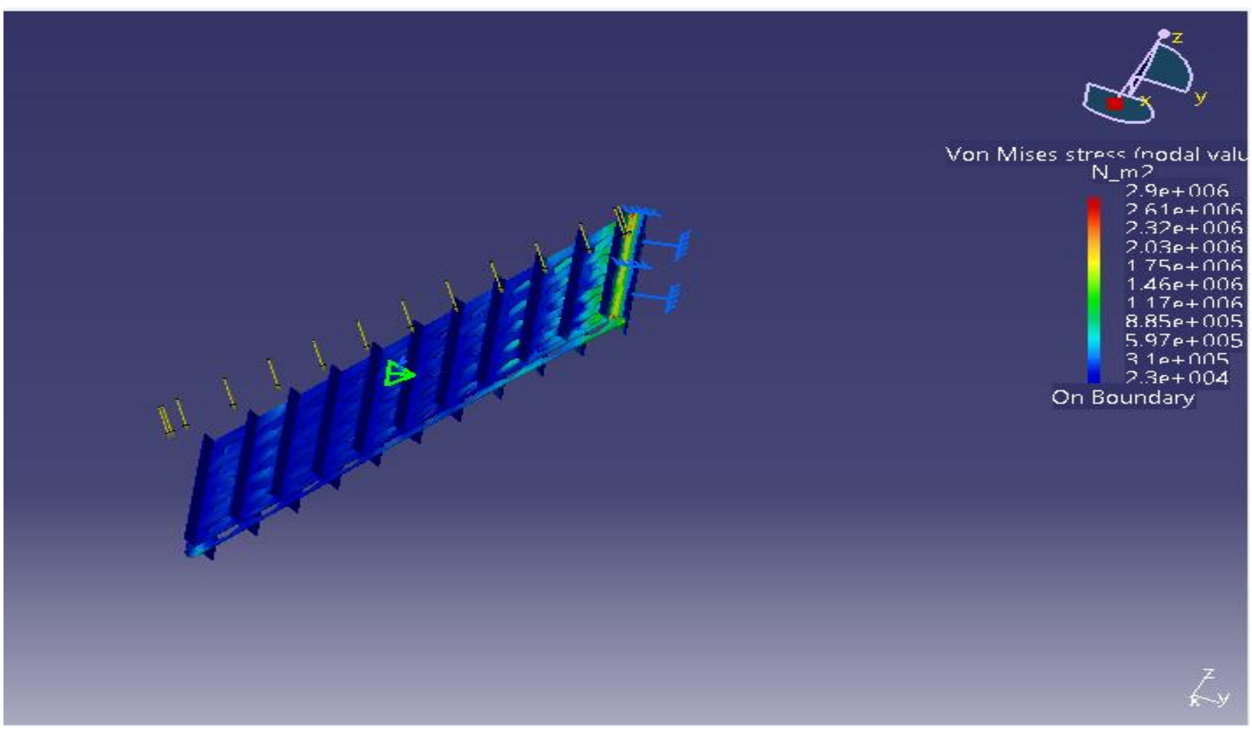


Fig 4.5: Distribution of von misses stress at 60 degree and 100N force

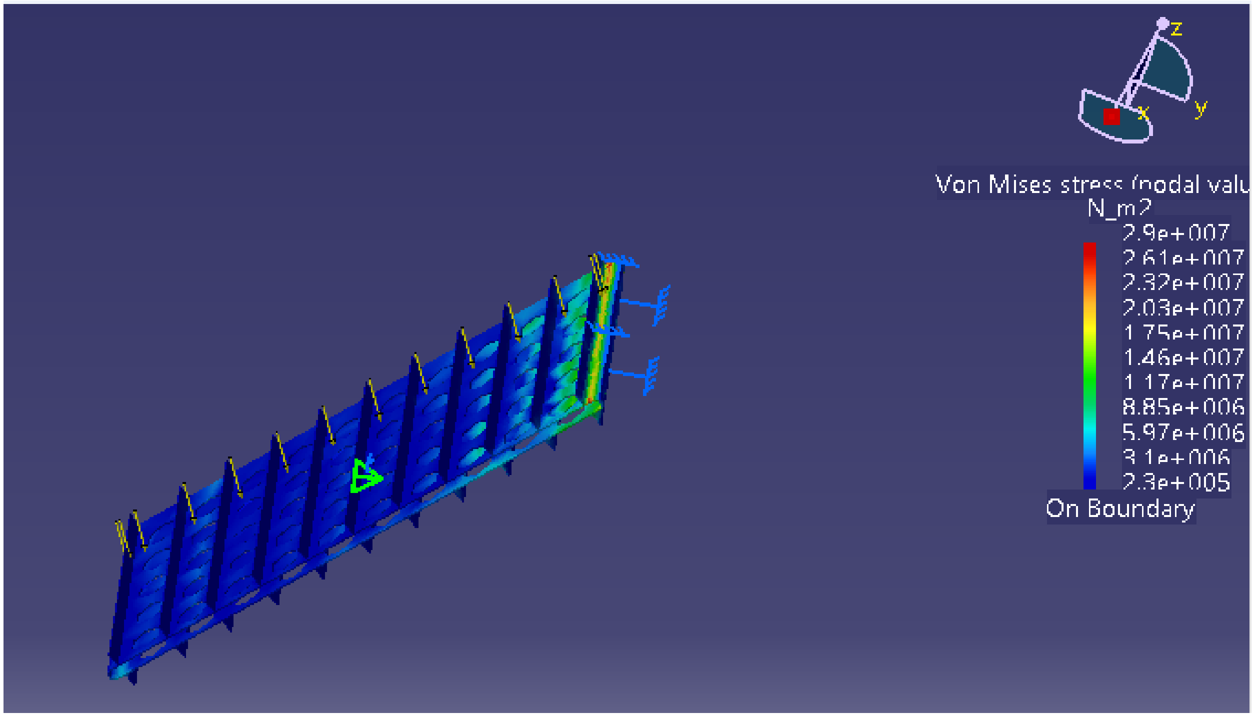


Fig 4.6: Distribution of von misses stress at 60 degree and 1000N force

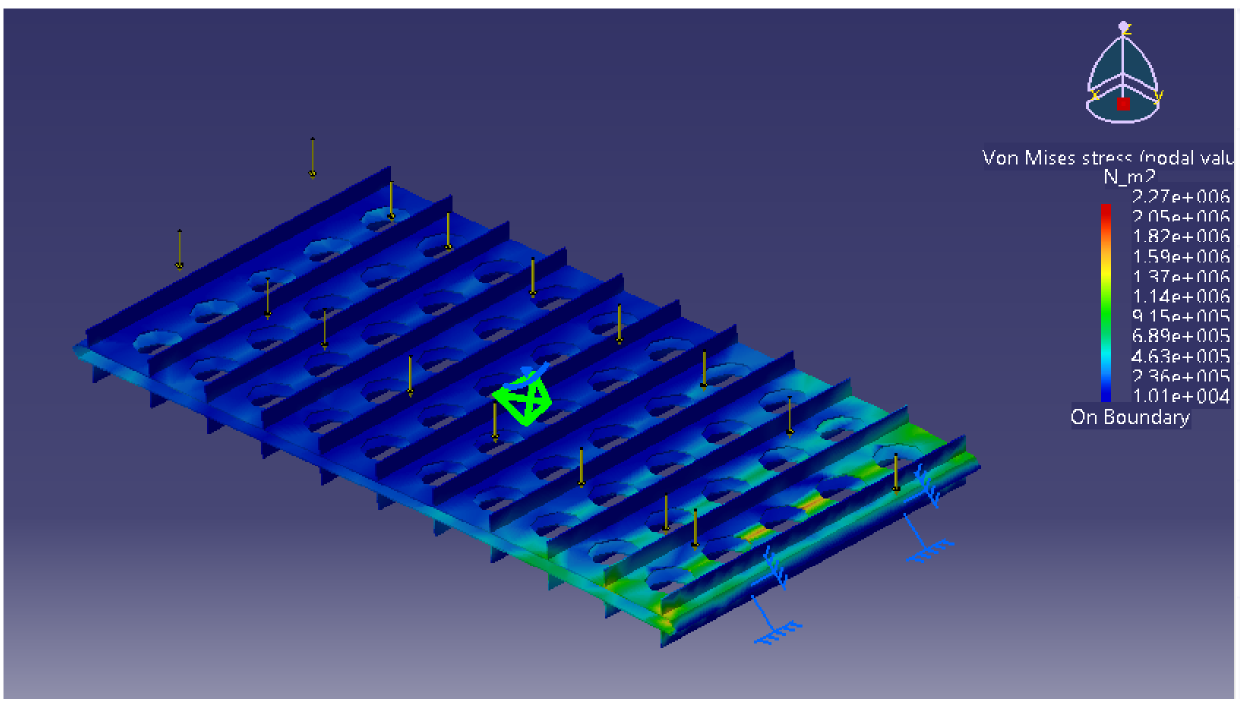


Fig 4.7: Distribution of von misses stress at 90 degree and 100N force

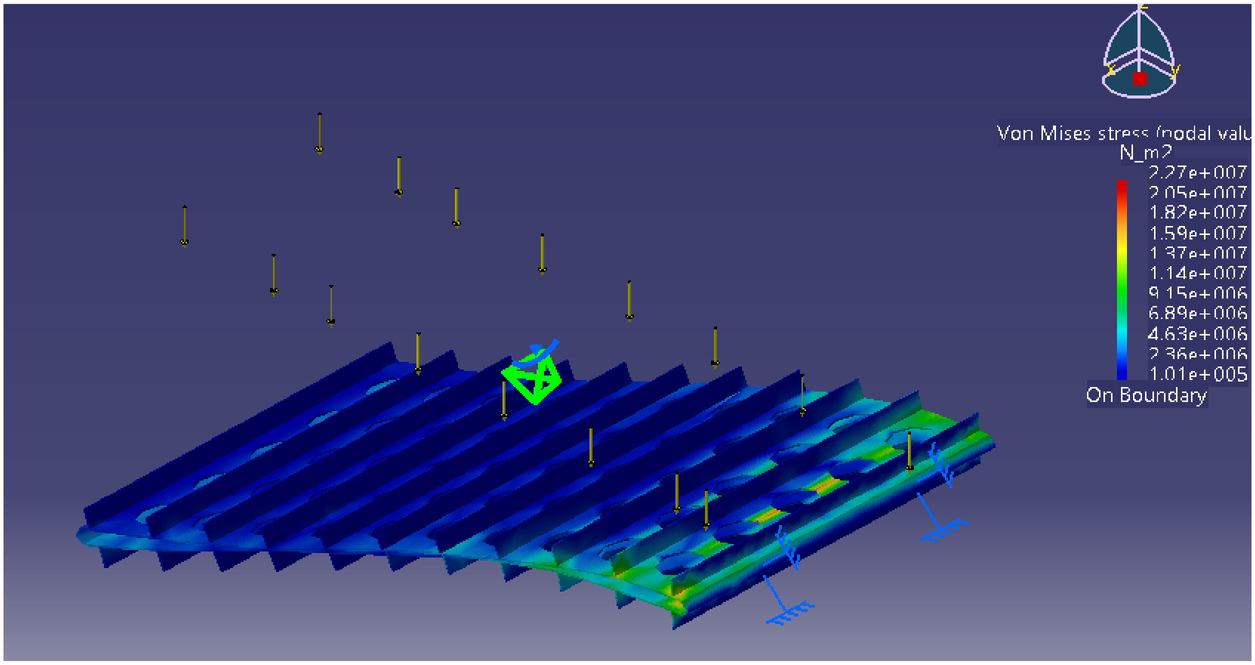


Fig 4.8: Distribution of von misses stress at 90 degree and 1000N force

In this case, a material is said to start yielding when the von Misses stress reaches a value known as yield strength. The von Misses stress is used to predict yielding of materials under complex loading from the results of uniaxial tensile tests.

4.1.2 Translation Displacement

Enforced Displacements are loads applied to support geometries, resulting for the subsequent analysis in assigning non-zero values to displacements in previously restrained directions. In the translation displacement loads are applied to support geometry, result for non-zero values for any other degree of freedom will be ignored by the program. The translation displacement in forced displacement is loads applied to support geometries, resulting for the subsequent analysis in assigning non-zero value to displacement.

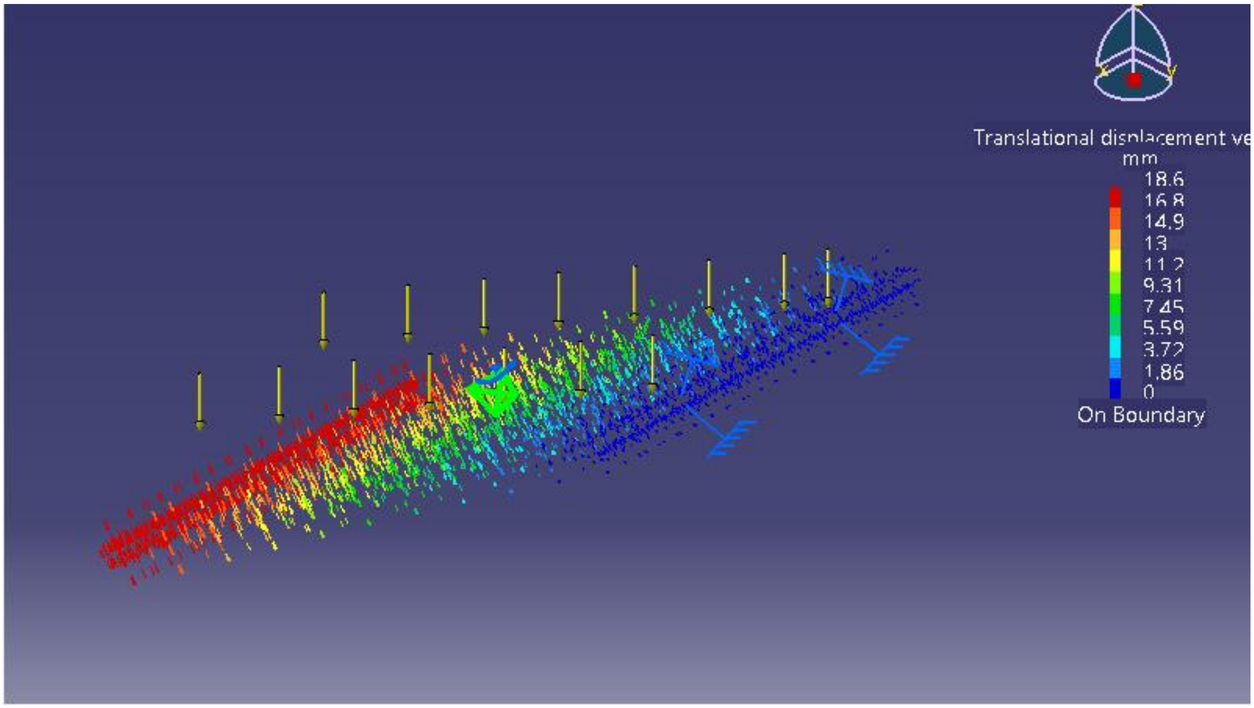


Fig4.9: translation displacement at 30 degree and 100N force

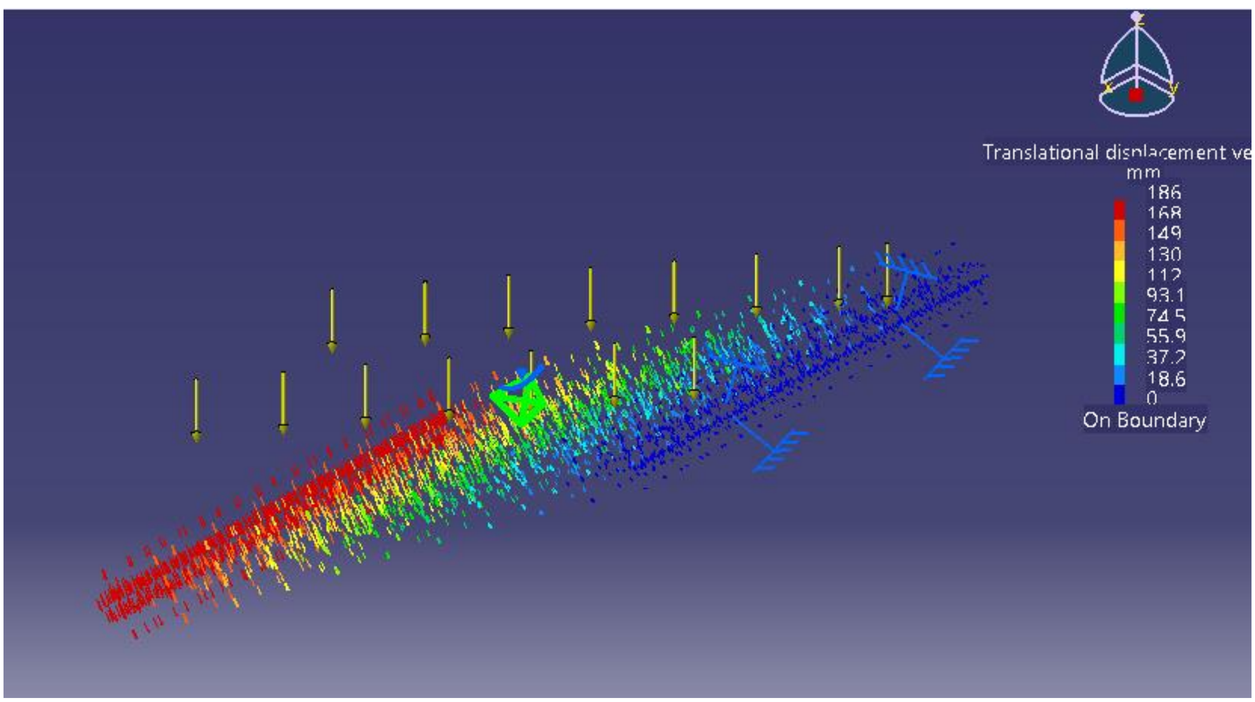


Fig4.10: translation displacement at 30 degree and 1000N force

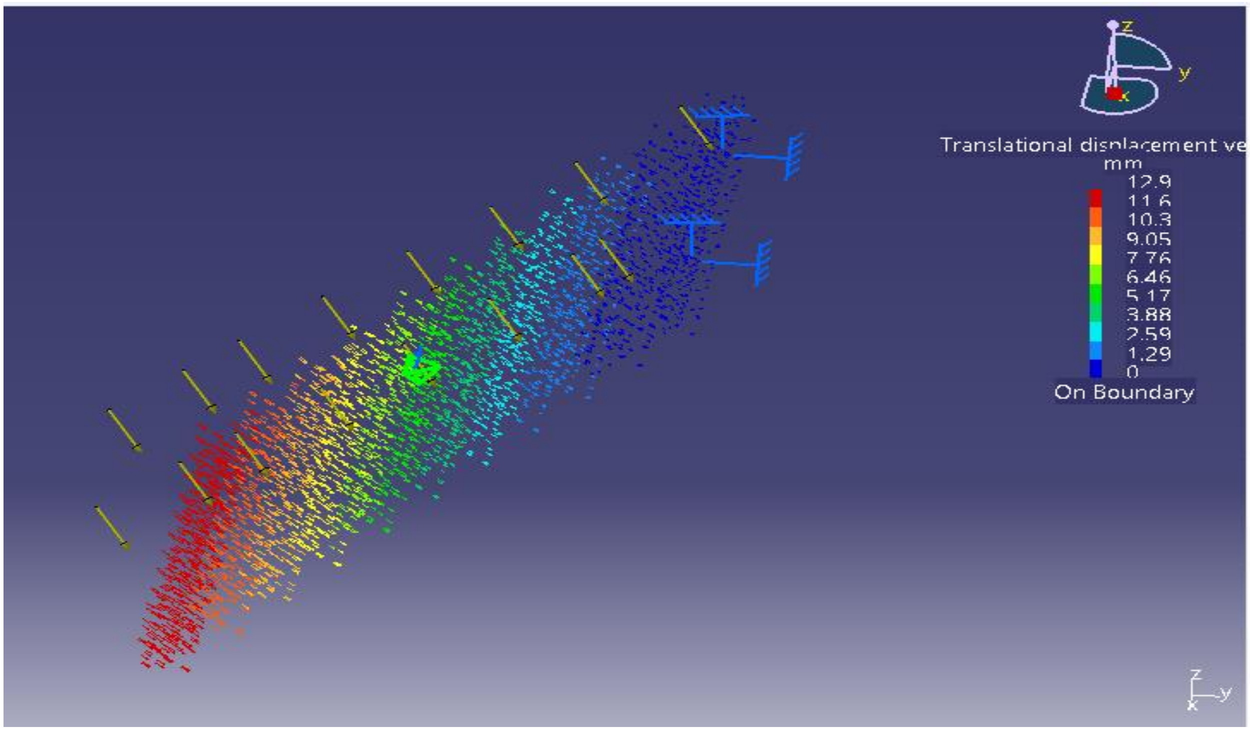


Fig4.11: translation displacement at 45 degree and 100N force

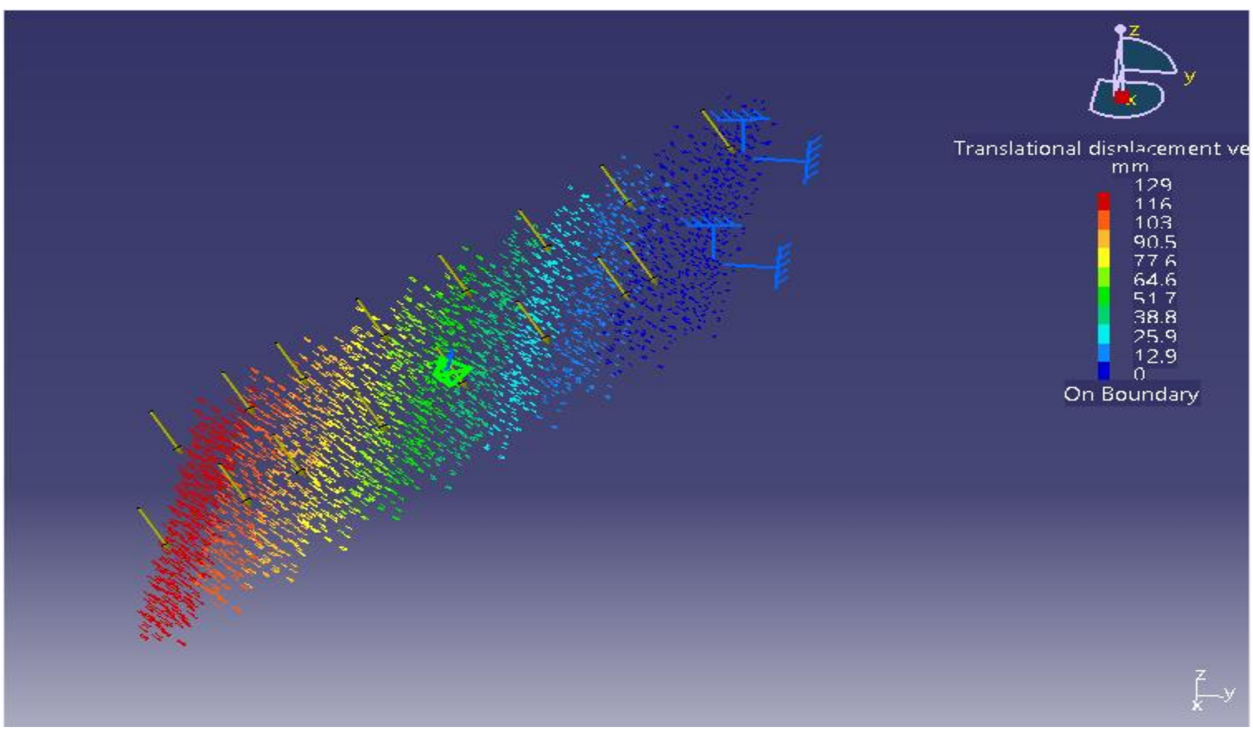


Fig4.12: translation displacement at 45 degree and 1000N force

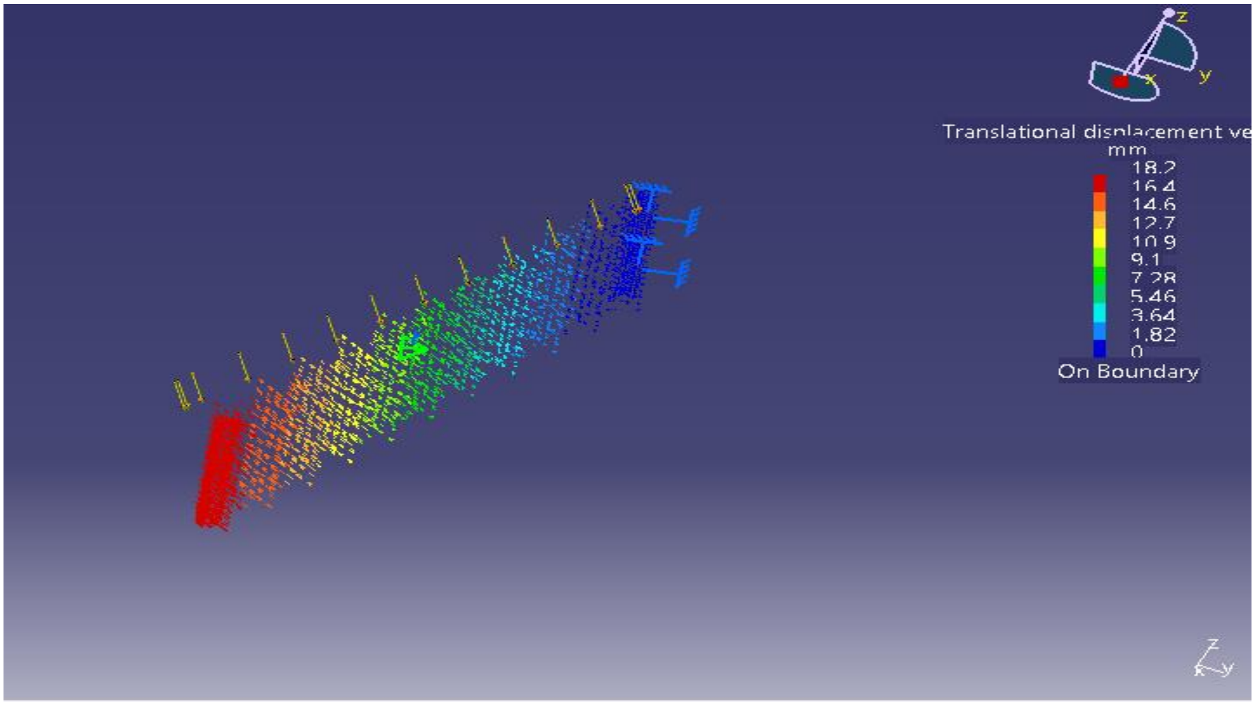


Fig4.13: translation displacement at 60 degree and 100N force

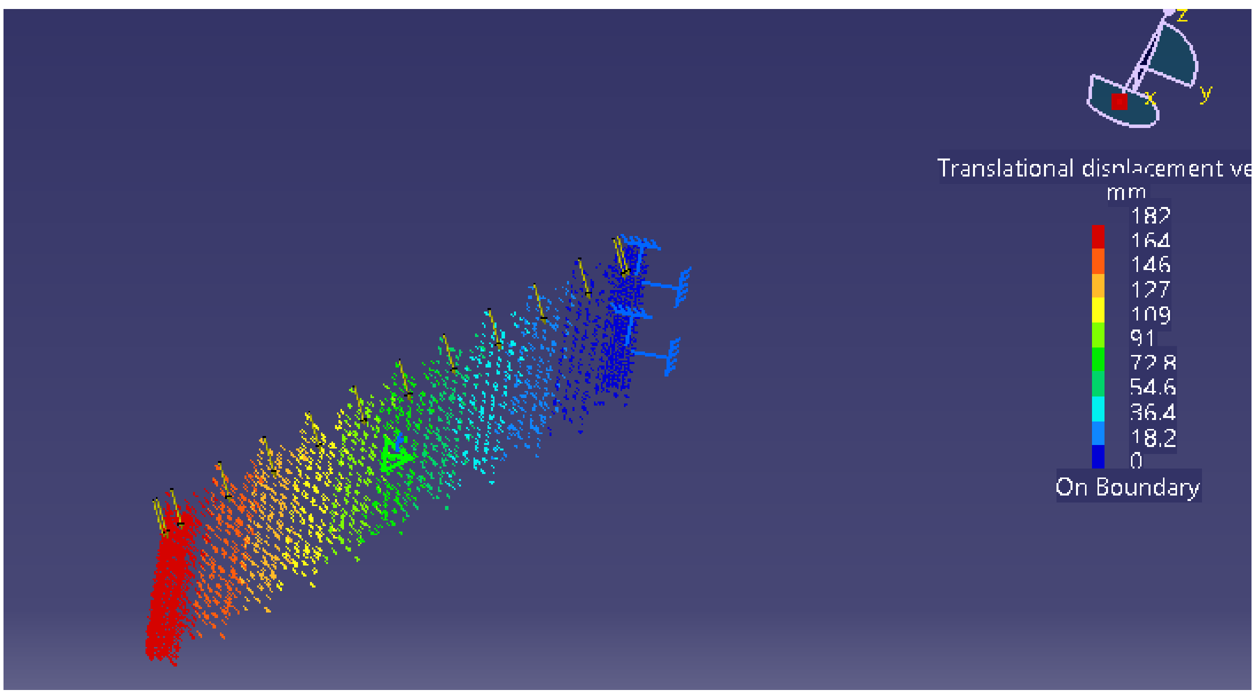


Fig4.14: translation displacement at 60 degree and 1000N force

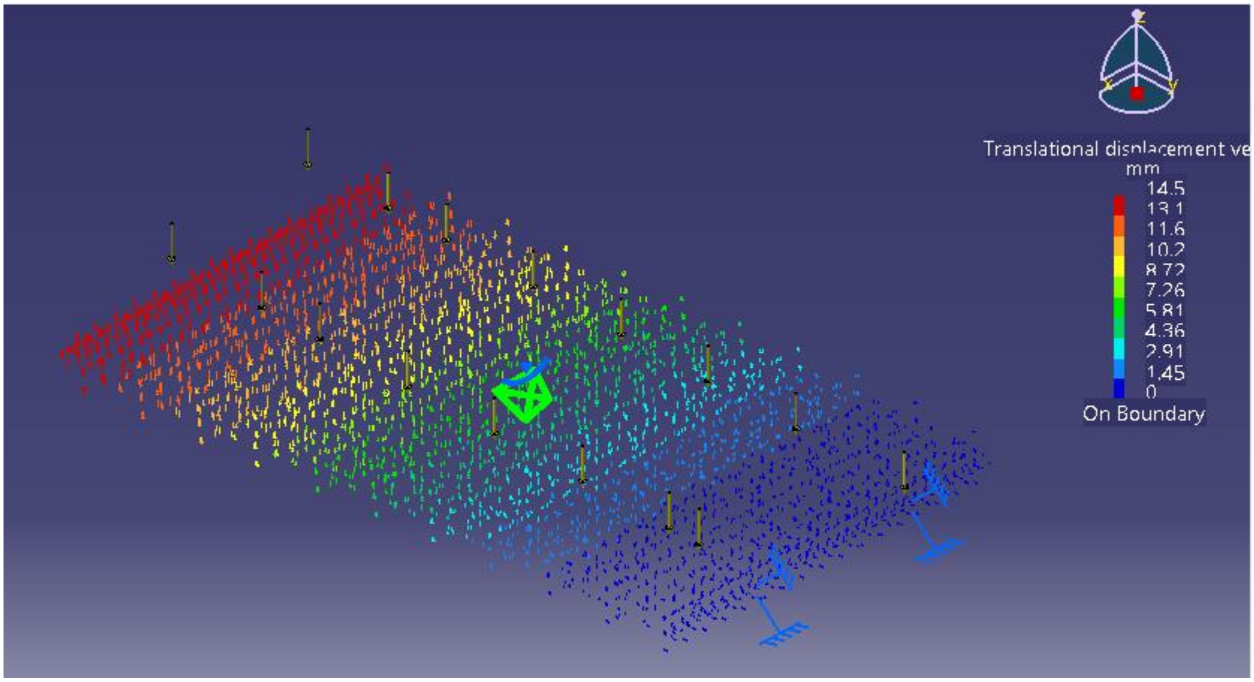


Fig4.15: translation displacement at 90 degree and 100N force

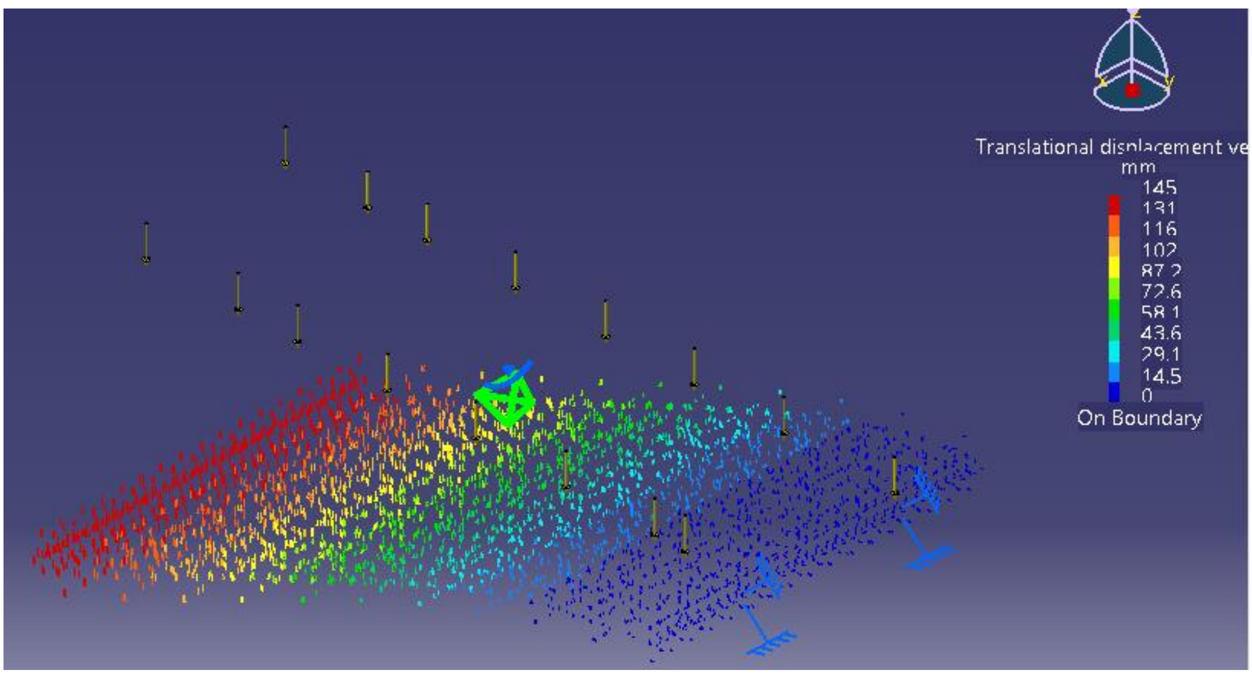


Fig4.16: translation displacement at 90 degree and 1000N force

4.2 Discussions

CAD model of the belt conveyor system is generated and analysis using CATIA V5R19 and 100 up to 1000 N amount of force is applied along the upper belt surface. Based on the above results, the materials were analyzed by two parameters such as applied load and angle of the structural material. The followings are the discussion from the result obtained:

- ✓ From the FEA result, when increasing the angle and applied force on the belt conveyor, the solid waste will be slide from the conveyor and the material will deform.
- ✓ From the above result, we had better take the 100N applied force, and depending on geometrical structure of the boat 45, degree angle of the conveyor belt is safe. Because when we increase the angle and the load of the material it will be deformed and the solid waste will also slip**.**
- ✓ From the FEA output, the maximum design strength is 1.89e+006 N-$\boldsymbol{m^2}$from the material property where the ultimate tensile strength of the material is 527 Mpa, then the material is safe.
- ✓ A conveyor belt undergoes constant load changes, which then cause the belt to stretch. The belt elongation is on one hand determined by the elastic characteristics of the nylon NN 66carcass and on the other hand by the permanent elongation of the nylon N66 carcass.
- ✓ The value of equivalent (Von-Misses) stress that obtained from the analysis is far less than the material yield stress which means the ratio between ultimate tensile stress and working stress is the factor of safety, so this design is safe.
- ✓ The Figure 4.17 below shows that when the translational displacement increases, Von Misses stress also increase.
- ✓ The stress concentration is high at 1.89e+006 N-$\boldsymbol{m^2}$ and translational displacement 12.9mm.

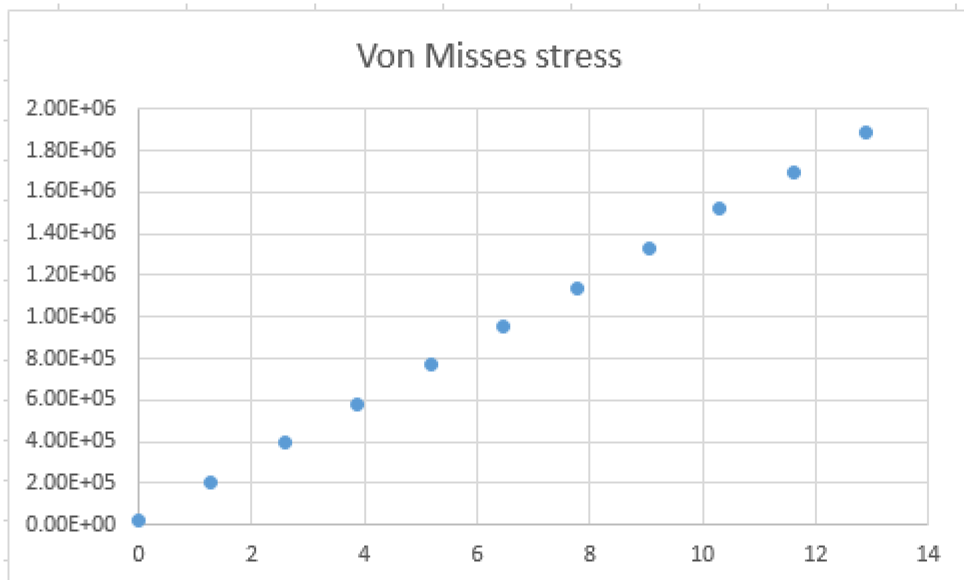


Fig4.17: Von Misses Stress at 45 degree and 100N force

CHAPTER FIVE

5. Conclusion recommendation and future work

5.1 Conclusion

The finite element analysis (FEA) is a powerful computational tool for analyzing complicated structures like conveyors. It can also reduce prototype parts,' producing the number of physical tests to shorten the development cycle and to reduce the development investment; i.e., it saves much time, effort and costs.

In order to achieve the goal of this study, different tasks were carried out and the following conclusions are drawn.

- ✓ This thesis has focused on modelling, analysis of solid waste collector belt conveyor with emphasis on lightweight, flexibility, on portability and simple availability of the material and as well as on low initial, operational and maintenance cost. This project is use full for the small scale works.
- ✓ The major components and parameters such as belt capacity, belt length, belt width, power, motor speed, as well as angle of the conveyor and, applied force were selected successfully by considering application area and, purpose of the Nylon NN66 material. The CATIA V5R19 was used to get the modelling of the belt conveyor for appropriate analyses of the material.
- ✓ Comparing this thesis with r.s. Rajesh Kumar and his friends work "On Design and Analysis of Belt Conveyor for Finishing House Pulper "the material used for the conveyor belt is PVC (poly vinyl chloride) which has high hardness and mechanical properties. These types of conveyor materials are widely used for industries. And the material are less good for water, it is more expensive and not easily available than material used for this thesis.
- ✓ And material has to be safer because this conveyor belt must resist the cold effect and any changing weather condition in the water and chemicals released from the industries.

5.2 Recommendation

- Mostly this project is only used to collect the most commonly found solid waste on shallow water bodies, excluding algae with deep roots, heavy woods and heavy solid wastes.
- Additional parts of conveyor like shaft, fasteners, bearing, chained needs a detailed design based on the working environment, belt width and other conditions to do the designed belt conveyor for its intended task of collecting solid waste efficiently.

5.3 Future work

In future this project can be improved to sort more categories of waste. In this thesis we used advanced conveyor system, conveyor material and geared motor as a power source for increasing the efficiency of collection of garbage. So this work is restricted to specified cases, however this paper can be extended to other situation listed below.

- ✓ Belt manufacturing process.
- ✓ To modify and design all parts of the boat according to waste collecting capacity is increase.
- ✓ To modify input source of power by solar panel for providing power to the boat instead of geared motor operation to minimize the cost.
- ✓ This project applies only for stagnant water, however, by doing some modification in its size and capacity; it can use in big lakes and rivers.

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