ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

School of Mechanical, Chemical and Material Engineering

Project

On

# DESIGN & MANUFACTURING of MULTI-PURPOSE SIEVE MACHINE

*MSc Project submitted in partial fulfillment of the requirement for the award of the degree of Masters of Science*

*in*

*Manufacturing Engineering*

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**Adama,Ethiopia**

## DECLARATION

We hereby declare that the work which is being presented in this project entitle "Design &Manufacturing Multi-Purpose Sieves Machine", is our original work and has not been presented for a diploma / degree of any other institution/university and we have acknowledged and referenced all materials used in this project.

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**ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY**

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## ABBREVIATION AND ACRONYMS

| | |
|---|---|
| TVET | Technical Vocational and Educational Training |
| Rpm | Revolution Per Minute |
| Hp | Horse Power |
| Ppc | Portland cement Concert |
| WRMSDS | Work Related Musculoskeletal Disorder |
| OWAS | Ovaku Working Posture Analyzing System |
| LC | Load Constant |
| RWL | Recommended Weight Limit |
| PWL | Physical Work Capacity |
| MPWC | Maximum Physical Work Capacity |
| SME | Small Micro Enterprise |

# ABSTRACT

*Sand naturally occurring substance is one of the most important things in industrial world. Nowadays the industry need the sand sub stand that are already been process known as sand product. As we know the sand is a mixture of rocks and minerals. In order to utilize these resources for economic benefits technology has to be applied to screen the mixture found in it and make it ready for use. Therefore multipurpose sieve machine is designed and manufactured as technology for utilization of the abundant resource. In designing and manufacturing of this machine the recent scientific literature has been reviewed. Material selection and design analysis of critical machine part like shaft, pulley, screw conveyer, roller was carefully considered. Manufacturing of parts and assembling are performed. These are based on a systematic study of the sand sieving process and testing of multipurpose model of sieving machine. Total dimension of this machine is about 900mmx1127mm and weighs 84.65kg. It is driven by electric motor of 2hp as prime mover and uses pulley, belts and shaft as main motion transmission mechanism. It is easy to operate and produces about 1800kg/day. It costs only a cost 10,812 birr.*

*Key words:-Sand. Organic compost, screw conveyor, roller support and power transmission.*

# CHAPTER ONE

# INTRODUCTION

## 1.1 Background

Sand naturally occurring substance is one of the most important things in industrial world. Nowadays the industry need the sand sub stand that are already been process known as sand product. As we know the sand is a mixture of rocks and minerals. A mineral is a naturally occurring solid substance with an orderly internal structure and a chemical composition that ranges within narrow limits.

Rocks, which are classified as igneous, sedimentary, or metamorphic, depending on origin, are generally composed of several minerals. For example, granite contains quartz, feldspar, mica, and a few other minerals; most limestone consists of calcite, dolomite, and minor amounts of quartz, feldspar, and clay. Weathering and erosion of rocks produce particles of stone, gravel, sand, silt, and clay [1].

As know the way sand is been collected still used the conversional way such as sieving using hand or machine and human energy is needed to run the process. So to make the process more efficient new technology is needed to help increase the productivity so the human power can be reduce and also can cut the cost of the process. While Composting is the natural process of decomposition and recycling of organic material into humus rich soil amendment known as compost. For any business or institution producing food waste, this organic material can be easily decomposed into high quality compost.

Fruits, vegetables, dairy products, grains, bread, unbleached paper napkins, coffee filters, eggshells, meats, and newspaper can be composted. Thus Compost is well decomposed organic wastes like plant residues, animal dung, and urine earth from cattle shed. To make traditional compost, an alternate different type of shredded plant materials in 6- to 8-inch layers is done. Layering helps compost reach the correct nitrogen balance waste fodder etc. 2-inch layers of fine materials are used & processed through a machine shredder. Traditional composting includes soil as one of the layers. Water is added to the compost after every few layers of material. Livestock manure also can be added which supplies some nitrogen. The microbes that are naturally found on the plant waste ultimately because decomposition.

It has been realized that large quantity of agricultural wastes remains being unutilized because handling, storage and management related difficulties. The reasons are their low bulk density, large area/volume for storage. The farmers on the field burn most of these wastes after the harvesting of crops. Thus the agricultural waste burning phenomena is being repeated every year. In order to use these naturally occurring sand for construction and organic wastes for some economic benefits, so the necessary of such machine was felt to utilize all kinds of sand and agricultural waste after sieving, which could be economical and practicable.

Therefore, the machine was designed and developed considering the physical properties of natural sand for aggregate and agricultural wastes like different foreign particle which is not necessarily needed in compost, moisture content, and density, were determined[2].

These parameters were considered in designing the machine. The various assemblies such as stand, sieve trammel, motion transmit ion mechanism and reservation unit were designed. Finally the simple and portable machine is manufactured and tested and result and discussion will made real in this paper.

## 1.2 Statement of the Problem

The most commonly used sieve type in this country is basic sieve; which is made from very little material, can be made in a couple hours, and won't break the budget. Quite often, people start with this type of simple screen but these sieves have the following main problem:-

- The first is its size. Since it's quite small, it is able to process a small amount of material at a time.
- The second is its energy-consuming operation. Because it require a decent amount of arm strength and energy to lift and shake the sifter in order to screen the materials. So, this multipurpose sieving machine is believed to resolve the problems mentioned above.

## 1.3 Objectives of the Project

### 1.3. 1 General Objective of the Project

The general objective of the study is to design and manufacture multipurpose sieving machine which can solve the problem in sieving sand and organic compost in urban side of our country.

### 1.3.2 Specific Objectives of the project

The specific objectives of this project are:-

- Preparing working drawing;
- Selecting required material ;
- Selecting equipment's and machine's ;
- Manufacturing of each parts ;
- Assemble the parts ;
- Finishing the machine ;
- Test the manufactured prototype.

## 1.4 Scope and Target Group

The intension is to design and manufacture portable multi-purpose sieving machine which can perform screening of needed sand and fertile compost from unwanted one. This machine can be operated using electrical motors and it is capable of producing a continuous sieving with little electric power consumption. Target communities are SMEs, government and non-government institutes that works on construction as well as horticulture.

## 1.5 Significance of the study

This machine can contribute great achievement to both an individual, government and non-government institutes that works on horticulture. Some of the Beneficiaries form this machine are the following parties:-

- Micro and small enterprise works on horticulture ;
- TVET college;
- Agro-mechanization research institutes;
- Construction enterprise.

## 1.6 Organization of the Project

Chapter one describes a general introduction of the Thesis and the project. Chapter two reviews literatures about particles of sand sieve machine. Chapter three presents data collection and analysis. Chapter four presents machine parts design, the design analysis of the critical components of the machine and material selection. Chapter five covers manufacturing process of the machine and assembly of the components. Chapter six deals with Product cost analysis and operational and maintenance instructions of the machine. Chapter seven cover result and discussion. Chapter eight give a short recommendation and conclusions.

## 1.7 Working Principles and Feasibility of the Project

### 1.7.1 Technical Feasibility

The multipurpose sieve machine will be manufactured using simple machine .It is easily manufactured from locally available resource like used barrel and sieve. Multipurpose sieve machine is easy to repair and parts can also be replaced easily if it is necessary because they are available in the market .It is mechanically simple enough that any person operate it can able to service the machine in simple shop and tools. Taking into account the above mentioned reason we can say that this machine is simply technically feasible.

### 1.7.2 Operational Feasibility

Multipurpose sieve machine is built with simple mechanisms. Since it is built by simple mechanism any person with little experience in machine operation can simply operate it; because their no complicated part and mechanism which can make it difficult to operate. The machine only uses electric motors as prime power source and the power from the motor is transmitted to the main part of the machine through series arranged pulley connected via v-belt. For this reason we can conclude that the machine is operationally feasible.

### 1.7.3 Economic Feasibility

Since the materials and parts are available in the market in abundance, they can be purchased with a reasonable price.

In general the cost for manufacturing the machine is reasonable. Therefore any small scale enterprise can afford and use it for their-own purpose. Due to these reasons this machine is economically feasible.

### 1.7.4 Efficiency

It is much more efficient to sand sieving machine than to sieve sand by two men manual sieve. The machine requires less energy and man power and can produce large value of sand within a short period of time.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Introduction

Construction and Agriculture is the most important sectors it plays a vital role in Ethiopian economy. In order to further develop this sector technology has become one of the main components. Typically, dealing with the construction and agriculture sector can entail difficulties relating to a number of factors. Consequently, to overcome such problems, constructions interpose and farmers are being encouraged to adopt innovative technology that suits their construction and farming. Survey was carried out through observation, visit and reading of study etc.

As know the way sand and soil compost is been collected still used the conversional way such as sieving using hand and human energy is needed to run the process. So to make the process more efficient new technology is needed to help increase the productivity so the human power can be reduce and also can minimize the cost of the process. Sieving or screening of the materials or compost is normally accomplished to produce the fine, uniform texture desired for the final product, and to recover the bulking material for reuse in the composting process. Screening or sieving is not necessary with certain (fine) bulking agents [3].

Sieving can be accomplished either before or after curing. Composting is the age-old process of converting organic waste materials into a key ingredient of soil humus. While composting has often been driven by the need to recover organic materials to maintain soil health, more recently, composting has been seen as a way of reducing the problems associated with landfills, incinerators, and other waste disposal methods.

The Construction sand is one of the most accessible natural resources and a major basic raw material, is used mostly by the construction industry. The construction sand industry is a major contributor to and an indicator of the economic well-being of the Nation, producing a high volume of basic products with low unit value. In urban areas, the dense concentration of business, industry, and housing typically needs in large volume of sand and organic compost soil in a relatively small geographic area. This needs of sand and organic compost creates unique opportunities for recovery [3].

This paper presents the design considerations derived from a research and development effort to characterize the operation and performance of sieve or screen used in the processing of sand and solid waste sieving. The primary objective of the work was the definition and quantification of the parameters that govern and describe the sieving process as applied to the recovery of a high quality sand and compost from solid waste. Consequently the paper address the sand and solid waste material considered for as organic compost by design and manufacturing multi sieving machine.

According to the research work carried out project on Methodology for Design & Fabrication of Portable Organic Waste Chopping Machine. Organic waste is fed uniformly through feeding drum and tray. Then the Shaft rotated at 1440 rpm through electric motor by means of pulleys makes the chopping drum to cut the waste by the effect of impact shear obtained from the shearing blades. The cut is also made inside the chopping house due to the effect of tensile, friction, and impact effect in chopping process. Then the cut pieces pass through the concave holes of the sieve & come out of the machine. The sieves of different sized holes can be used [4].

According to the paper on design and analysis of solar powered trammel screen experimental results reveal that compost losses as well as criterion costs were minimum while, separating and cleaning efficiencies were maximum under the following conditions: -Operate the trammel screen at a sieve speed of 25 rpm (1.18 m/min),The slope angle of the cylindrical sieve on the horizontal plane (Sieve inclination angle) should be lower than 15 degrees, the screen opening size should be of about 10 mm, Clean compost at a moisture content of about 25-30 %,Operate the trommel screen at an average feed rate of 4 kg/min[5].

According to the published a paper under the title "Eco –Design in the field of Spreading Technologies" in the Journal Green Technologies Conference IEEE to investigate environmental impacts of a centrifugal Spreader using organic compost and came to a conclusion that an Eco-innovative design should be proposed to allow the designers to identify & solve the environmental related problems [6].

Size Separation of Particulates in a trammel Screen System they designed a trammel screening system to successfully achieve the required tasks. The trammel screen system technology was practically applied to a moving granular bed filter and test of the separation of dust particulates from filter granules carried out. Relatively higher screening efficiency was obtained for undersized dust particulates when using a mass flow rate of filter granules of 360 g/min and trammel body rotational speed of 43 rpm. It was found that the screening efficiency tended to increase with the lower mass flow rate of filter granules and the corresponding rotational speed of trammel body due to the contracting motion. The testing of the trammel screen system with the moving granular bed filter showed that a higher dust concentration caused better screening efficiency, due to the Brazil nut effect. Undersized dust particulate collection became difficult when the inclination angle or rotational speed of the trommel body was either too high or too low. The result was that the screening efficiency of the trammel screen system was poor. These test results should provide industry with important design information for building a prototype of a moving granular bed filter or other filter system for hot tests[7].

A multi – purpose wet sieving machine has been developed. It was tested and found to be efficient in the processing of the mash of agricultural products such as maize, cassava and soybean for the production of food products such as “Ogi”, soymilk and starch .Generally, sieving capacity and performance coefficients decreased with increasing mash concentration. The highest performance coefficient was observed with maize, followed by wheat and lastly cassava. 12.23% is the optimum sieving concentration that would give best performance in terms of capacity and performance coefficients (PC). The equipment is easy to operate and maintain. It is highly recommended for every household in Nigeria and beyond where the desirable eating qualities of “Ogi” and starch diets are valued compared with the bad quality products from retail outlet [8].

The machine proposed in this project to have the best feature it works at 300 RPM, it simple because it weighs only 84.68kg which can easily be moved from place to place, it works with simple less cost single phase electric motor of 2Hp and have high production rate since it can sieves 100kg/hr.( which means 800kg/day ).Physically it is very attractive ergonomically it is very friendly to both human being and the large in environment as well[8].

## 2.2 Importance of Sand Sieving

- Sieve analyses reveal the size make up of aggregate particles from the largest to the smallest
- Used to screen a mixture of different minerals and foreign particles found in with sand

## 2.3 Factors Affecting Sieving

Sieving machine has been evaluated using parameters such as sieving efficiencies and losses associated sieving. Machine based factor such as sieve rotational speed, feeding rate, and sand based factor such like physical properties were considered to affect the performance of the machine.

### 2.3.1 Machine Factors

#### 2.3.1.1 Sieve Rotational Speed

The rotational speed of the machine is the most important factor to consider because it affects the out-put of the machine. This majorly affected by:-

- Frictional force of the sieve roller
- The accuracy of shaft
- The motor capacity to rotate it properly by supplying the required rpm.
- The amount of sand sieved at a time

#### 2.3.1.2. Feeding rate

Is mainly affected by:-

- The volume of the screw conveyor
- Types of material to be conveyed
- Pitch length of screw
- Rpm of the screw
- The out let capacity etc.

### 2.3.2 Sand Based Factors

#### 2.3.2.1 Physical Properties of Sand

The important characteristics of aggregates for concrete are listed in Table 2-1 and most are discussed in the following section: The majority of the tests and characteristics listed are referenced in ASTM C 33 (AASHTO M 6/M 80). ACI 221R-96 presents additional test methods and properties of concrete influenced by aggregate characteristics [1].

Table 2.1 Characteristics and Tests of Aggregate [1]

| Characteristic | Significance | Test designation* | Requirement or item reported |
|---|---|---|---|
| Resistance to abrasion and degradation | Index of aggregate quality wear resistance of floors and pavements | ASTM C 131 (AASHTO T 96)<br>ASTM C 535<br>ASTM C 779 | Maximum percentage Of weight loss.<br>Depth of wear and time |
| Resistance to freezi ng and thawing | Surface scaling, roug hness,loss of section, and aesthetics | ASTM C 666 (AASHTO T 161)<br>ASTM C 682<br>AASHTO T 103 | Maximum number of cycles or period of frost immunity; durability factor |
| Resistance to disint egration by sulfates | Soundness against weathering action | ASTM C 88 (AASHTO T 104) | Weight loss, particles exhibiting distress |
| Particle shape and surface texture | Workability of fresh Concrete | ASTM C 295<br>ASTM D 3398 | Maximum percentage of flat and elongated particles |
| Grading | Workability of fresh concrete; Economy | ASTM C 117 (AASHTO T 11)<br>ASTM C 136 (AASHTO T 27) | Minimum and maximum percentage passing standard sieves |
| Fine aggregate Degradation | Index of aggregate q uality;<br>Resistance to degrad ation during mixing | ASTM C 1137 | Change in grading |
| Un compacted void content of fine aggregate | Workability of fresh Concrete | ASTM C 1252 (AASHTO T 304) | Un compacted voids and specific gravity values |
| Bulk density(unit w eight) | Mix design calculati ons;<br>Classification | ASTM C 22 (AASHTO T 19) | Compact weight And lose weight |
| Relative density (specific gravity) | Mix design calculati ons | ASTM C 127 (AASHTO T 85)<br>ASTM C 128 (AASHTO T 84) | — |
| Absorption and | Control of concrete q | ASTM C 70 | — |

| | | | |
|---|---|---|---|
| Surface Moisture | uality<br>(water-cement ratio) | ASTM C 12(AASHTO T 85)<br>ASTM C 12 (AASHTO T 84)<br>ASTM C 56 (AASHTO T 255) | |
| Compressive and Flexural Strength | Acceptability of Fine aggregate failing other tests | ASTM C 39 (AASHTO T 22)<br>ASTM C 78 (AASHTO T 97) | Strength to exceed 95% of strength<br>achieved with<br>purified sand |
| Definitions of Constituents | Clear understanding and<br>Communication | ASTM C 125<br>ASTM C 294 | — |
| Aggregate Constituent | Determine amount of deleterious and orga nic<br>materials | ASTM C 40 (AASHTO T 21)<br>ASTM C 87 (AASHTO T 71)<br>ASTM C 11 (AASHTO T 11)<br>ASTM C 123 (AASHTO T 113)<br>ASTM C 14 (AASHTO T 112)<br>ASTM C 295 | Maximum percentage allowe d<br>of individual constituents |
| Resistance to alkali reactivity and volume change | Soundness against volume change | ASTM C 227<br>ASTM C 289<br>ASTM C 295<br>ASTM C 342<br>ASTM C 586<br>ASTM C 1260(AASHTO T 303)<br>ASTM C 1293 | Maximum length change, constituents an<br>mount<br>of silica, and alkalinity |

#### 2.3.2.2. Range of Particle Size

Grading is the particle-size distribution of an aggregate as determined by a sieve analysis (ASTM C 136 or AASHTOT 27). The range of particle sizes in aggregate is illustrated in Fig.2.1. The aggregate particle size is determined by using wire-mesh sieves with square openings. The seven standard ASTM C 33 (AASHTO M 6/M 80) sieves for fine aggregate have openings ranging from 150 µm to 9.5 mm (No. 100 sieve to 3⁄8 in.). The 13 standard sieves for coarse aggregate have openings ranging from 1.18 mm to 100 mm (0.046 in. to 4 in.).Tolerances for the dimensions of openings in sieves are listed in ASTM E 11 (AASHTO M 92).

Figure 2.1 Range Of Particle Sizes Found In Aggregate for Use in Concrete [1]

Size numbers (grading sizes) for coarse aggregates apply to the amounts of aggregate (by mass) in percentages that pass through an assortment of sieves.

For highway construction, ASTM D 448 (AASHTO M 43) lists the same 13 size numbers as in ASTM C 33(AASHTO M 6/ M80) plus an additional six more coarse aggregate size numbers [1]. Fine aggregate or sand has only one range of particle sizes for general construction and highway work. The grading and grading limits are usually expressed as the percentage of material passing each sieve [1].

#### 2.3.2.2.1 Reasons for Grading Limits

There are several reasons for specifying grading limits and nominal maximum aggregate size; they affect relative aggregate proportions as well as cement and water requirements, workability, pump ability, economy, porosity, shrinkage, and durability of concrete. Variations in grading can seriously affect the uniformity of concrete from batch to batch. Very fine sands are often uneconomical; very coarse sands and coarse aggregate can produce harsh, unworkable mixtures. In general, aggregates that do not have a large deficiency or excess of any size and give a smooth grading curve will produce the most satisfactory results.

Fig.2.2.Curves indicates the limits specified in ASTM C 33 for fine aggregate and for one commonly used size number (grading size) of coarse aggregate[1].

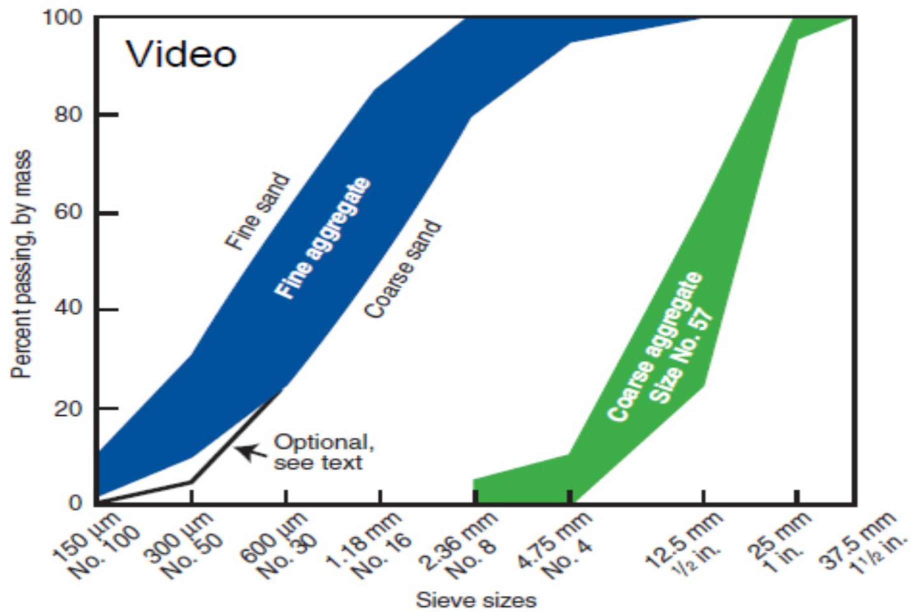



Figure 2.2 Curves Indicates the Limits Specified In ASTM C 33

## 2.4 Recommended Sieve Size and Passing Percentage

### 2.4.1 Fine-Aggregate

Fine-aggregate grading within the limits of ASTM C 33(AASHTO M 6) is generally satisfactory for most concretes. The ASTM C 33 (AASHTO M 6) limits with respect to sieve size are shown in Table 2.2.

Table 2.2 Fine Aggregate Grading Limits and Passing % by mass

| *Sieve size* | *Percent passing by mass* |
|---|---|
| 9.5 mm (3/6 in) | 100 |
| 4.75mm (No.4) | 95 to 100 |
| 2.36mm (No.8) | 80 to 100 |
| 1.18mm(No.16) | 50 to 85 |
| 600µm (No.30) | 25 to 60 |
| 300 µm (No.50) | 5 to 30 |
| 150 µm (No.100) | to 10 |

### 2.4.2 Coarse-Aggregate Grading

The coarse aggregate grading requirements of ASTM C 33(AASHTO M 80) permit a wide range in grading and a variety of grading sizes (see Table 2.3).

Table 2.3 Coarse Aggregate Grading Limits and Passing % by Mass[1]

| *Size number* | *Nominal size, sieves with square openings* | *Amounts finer than each laboratory sieve, mass percent passing* | | | | |
|---|---|---|---|---|---|---|
| | | 100 mm(4 in) | 90 mm (3 ½ in) | 75 mm (3 in) | 63 mm (2 ½ in | 50 mm (2 in) |
| 1 | 90 to 37.5 mm (31⁄2 to 11⁄2 in.) | 100 | 90 to 100 | | 25 to 60 | |
| 2 | 63 to 37.5 mm (21⁄2 to 11⁄2 in.) | | — | 100 | 90 to 100 | 35 to 70 |
| 3 | 50 to 25.0 mm (2 to 1 in.)` | | — | — | 100 | 90 to 100 |
| 357 | 50 to 4.75 mm | | — | — | 100 | 95 to 100 |
| 4 | 37.5 to 19.0 mm (11⁄2 to 3⁄4 in.) | — | — | — | — | 100 |
| 467 | 37.5 to 4.75 mm (11⁄2 in. to No. 4) | — | — | — | — | 100 |
| 5 | 25.0 to 12.5 mm (1 to 1⁄2 in.) | — | — | — | — | |
| 56 | 25.0 to 9.5 mm (1 to 3⁄8 in.) | | — | — | — | |
| 57 | 25.0 to 4.75 mm (1 in. to No. 4) | — | — | — | — | |
| 6 | 19.0 to 9.5 mm (3⁄4 to 3⁄8 in.) | | — | — | — | |
| 67 | 19.0 to 4.75 mm (3⁄4 in. to No. 4) | — | — | — | — | |
| 7 | 12.5 to 4.75 mm (1⁄2 in. to No. 4) | — | — | — | — | |

## 2.5 Density of sand

The density of aggregate particles used in mixture proportioning computations (not including voids between particles) is determined by multiplying the relative density (specific gravity) of the aggregate times the density of water. An approximate value of 1000 kg/m$^3$ (62.4 lb/ft$^3$) is often used for the density of water. Most natural aggregates have particle densities of between 2400 kg/m3 and 2900 kg/m$^3$ (150 and 181 lb./ft3)[1].

## 2.6 General Concept in Machine Design

Machine Design is the creation of new and better machines and improving the existing ones. A new or better machine is one which is more economical in the overall cost of production and operation. The process of design is a long and time consuming one. From the study of existing ideas, a new idea has to be conceived. The idea is then studied keeping in mind its commercial success and given shape and form in the form of drawings. In the preparation of these drawings, care must be taken of the Availability of resources in money, in men and in materials required for the successful completion of the new idea into an actual reality. In designing a machine component, it is Necessary to have a good knowledge of many subjects such As Mathematics, Engineering Mechanics, Strength of Materials, Theory of Machines, Workshop Processes and Engineering Drawing [9].

### 2.6.1 General Considerations in Machine Design

Following are the general considerations in designing a machine component:

Type of load and stresses caused by the load:-The load, on a machine component, may act in several ways due to which the internal stresses are set up. The various types of load and stresses are

1. Motion of the parts or kinematics of the machine:-The successful operation of any machine depends largely upon the simplest arrangement of the parts which will give the motion required. The motion of the parts may be:
   - Rectilinear motion which includes unidirectional and reciprocating motions.
   - Curvilinear motion which includes rotary, oscillatory and simple harmonic.
   - Constant velocity.
   - Constant or variable acceleration.
2. Selection of materials:-It is essential that a designer should have a thorough knowledge of the properties of the materials and their behavior under working conditions. Some of the important characteristics of materials are: strength, durability, flexibility, weight, resistance to heat and corrosion, ability to cast, welded or hardened, machinability, electrical conductivity, etc.

3. Form and size of the parts:-The form and size are based on judgments. The smallest practicable cross-section may be used, but it may be checked that the stresses induced in the designed cross-section are reasonably safe. In order to design any machine part for

form and size, it is necessary to know the forces which the part must sustain. It is also important to anticipate any suddenly applied or impact load which may cause failure.

4. Frictional resistance and lubrication: - There is always a loss of power due to frictional resistance and it should be noted that the friction of starting is higher than that of running friction. It is, therefore, essential that a careful attention must be given to the matter of lubrication of all surfaces which move in contact with others, whether in rotating, sliding, or rolling bearings.

5. Use of standard parts:-The use of standard parts is closely related to cost, because the cost of standard or stock parts is only a fraction of the cost of similar parts made to order. The standard or stock parts should be used whenever possible; Parts for which patterns are already in existence such as gears, pulleys and bearings and parts which may be selected from regular shop stock such as screws, nuts and pins. Bolts and studs should be as few as possible to avoid the delay caused by changing design considerations play important role in the successful production of machines. Drills, reamers and taps and also to decrease the number of wrenches required.

6. Safety of operation:-Some machines are dangerous to operate, especially those which are speeded up to insure production at a maximum rate. Therefore, any moving part of a machine which is within the zone of a worker is considered an accident hazard and may be the cause of an injury. It is, therefore, necessary that a designer should always provide safety devices for the safety of the operator. The safety appliances should in no way interfere with operation of the machine.

7. Workshop facilities:- A design engineer should be familiar with the limitations of his employer’s workshop, in order to avoid the necessity of having work done in some other workshop.it is sometimes necessary to plan and supervise the workshop operations and to draft methods for casting, handling and machining special parts.

8. Number of machines to be manufactured:-The number of articles or machines to be manufactured affects the design in a number of ways. The engineering and shop costs which are called fixed charges or overhead expenses are distributed over the number of articles to be manufactured. If only a few articles are to be made, extra expenses are not

justified unless the machine is large or of some special design. An order calling for small number of the product will not permit any undue expense in the workshop processes, so that the designer should restrict his specification to standard parts as much as possible.

9. Cost of construction:-The cost of construction of an article is the most important consideration involved in design. In some cases, it is quite possible that the high cost of an article may immediately bar it from further considerations. If an article has been invented and tests of handmade samples have shown that it has commercial value, it is then possible to justify the expenditure of a considerable sum of money in the design and development of automatic machines to produce the article, especially if it can be sold in large numbers. The aim of design engineer under all conditions should be to reduce the manufacturing cost to the minimum.

10. Assembling:-Every machine or structure must be assembled as a unit before it can function. Large units must often be assembled in the shop, tested and then taken to be transported to their place of service. The final location of any machine is important and the Design engineer must anticipate the exact location and the local facilities for erection [9].

### 2.6.2 The 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 fig.2.3. General procedure in machine design. 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. The flow chart for the general procedure in machine design is shown in fig 3. Exact location and the local facilities [9].

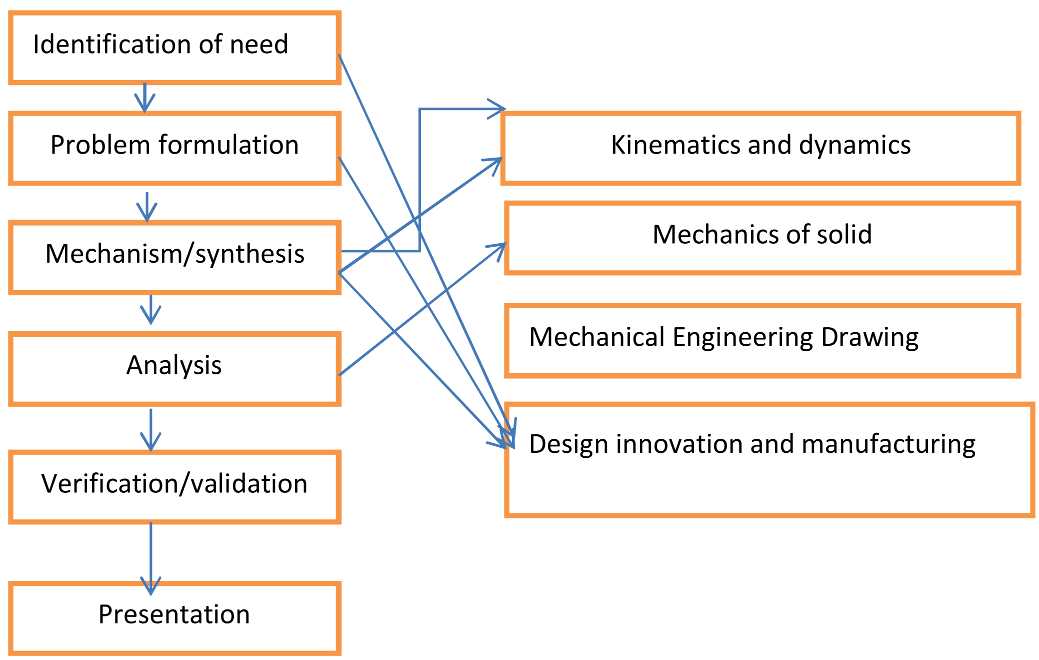



Figure 2.3 General procedure in machine design [9]

### 2.6.3 General Concept in Material Selection

#### 2.6.3.1 Introduction to Material Selection

The Material and processes selection are integral parts of the design of any machine component. Strength and rigidity are traditionally key factors considered in the selection of a material. Equally important are the relative reliability and durability of the part when made from alternative materials. When the component is expected to operate at extreme temperatures, this must be considered carefully when selecting the material.

In recent years, choices of materials have been increasingly influenced by recyclability, energy requirements, and environmental pollution. Cost and availability are also vitally important. The cost to be considered is the total cost of the fabricated part, including labor and overhead as well as the material itself. The relative cost and availability of various materials vary with time, with the result that the engineer is frequently called upon to evaluate alternative materials in light of changing market conditions. In summary, the best material for a particular application is the one that provides the best value, defined as the ratio between overall performance and total cost .Material selection is a step in the process of designing any physical object. In the context of product design, the main goal of material selection is to minimize cost while meeting product performance goals. Systematic selection of the best material for a given application begins with properties and costs of candidate materials. Clearly material selection is not a trivial process. The impediments to getting it right are:-

- Lack of broad knowledge of various materials
- Materials Data Accuracy Problems
- A lack of clear goals (e.g. no product design specification).

The design engineer is to select materials under two main conditions:-

- For new parts or components in combination with other new parts.
- Materials to replace existing parts or components where the current performance is inadequate.

In either case the designer must follow a problem solving process such as:-

- Determine the material requirements;
- Screen Possible candidate materials;
- Selection of a range of possible candidate materials;
- Develop design solution(s) based on the confirmed capabilities of the materials [10].

#### 2.6.3.2 Quantitative Methods of Materials Selection

It is estimated that there are more than 40,000 currently useful metallic alloys and probably close to that number of nonmetallic engineering materials like plastics, ceramics and glasses, composite materials, and semiconductors. This large number of materials and the many manufacturing processes available to the engineer, coupled with the complex relationships between the different selection parameters, often make the selection of a material for a given component a difficult task. If the selection process is carried out haphazardly, there will be the risk of overlooking a possible attractive alternative material. This risk can be reduced by adopting a systematic material selection procedure. A variety of quantitative selection procedures have been developed to analyze the large amount of data involved in the selection process so that a systematic evaluation can be made. Several of the quantitative procedures can be adapted to use computers in selection from a data bank of materials and processes. Experience has shown that it is desirable to adopt the holistic decision-making approach of concurrent engineering in product development in most industries. With concurrent engineering, materials and manufacturing processes are considered in the early stages of design and are more precisely defined as the design progresses from the concept to the embodiment and finally the detail stages. Figure 2.4 defines the different stages of design and shows the related activities of the material and manufacturing process selection [10].

| Stages of design | stages of material selection |
|---|---|

**Preliminary and Conceptual Design**

- Translate marketing ideas into industrial design leading to broad description of the product: What is it? What does it do? How does it do it? How much should it be?
- Decompose the product into subassemblies and identify the different parts of each Subassembly.
- Specifying the main function of each part and identify their critical requirements.

**Initial Screening**

- Use the critical requirements of each part to define the performance requirements of the material. Start with all materials available and narrow down the choices on the basis of the rigid properties.

**Configuration (Embodiment) Design**

- Develop a qualitative sketch of each part giving only the order of magnitude of the main dimensions but showing the main features – walls, bosses, ribs, holes, grooves, etc.

Comparing and Ranking Alternative Solutions

- Use soft material requirements to further narrow the field of possible materials to a few promising candidates.

**Detail (Parametric ) Design**

- Determine the dimensions of the parts based on a specific material and a manufacturing process taking into account the design limitations, the manufacturing process, weight concerns, space limitations, etc. The cost must now be considered in detail.
- Generation of an alternative detail design, which requires selecting a design based on alternative materials and evaluation against requirements.

**Selection of Optimum Solution**

- Use the promising materials and matching manufacturing processes to make detail designs.
- Compare alternative combinations taking into account the elements of cost.
- Select optimum combination of design-material-manufacturing process

Figure 2.4 Stages of design and the related stages of materials selection [10]

### A. Initial Screening of Materials

In the first stages of development of a new product, such questions as the following are posed: What is it? What does it do? How does it do it? After answering these questions it is possible to specify the performance requirements of the different parts involved in the design and to broadly outline the main materials performance and processing requirements.

This is then followed by the initial screening of materials whereby certain classes of materials and manufacturing processes may be eliminated and others chosen as likely candidates.

I. Analysis of Material Performance Requirements

The material performance requirements can be divided into five broad categories:

- Functional Requirements;
- Process Ability Requirements;
- Cost;
- Reliability;
- Resistance to Service Conditions.

1. Functional Requirements

Functional requirements are directly related to the required characteristics of the part or the product. For example, if the part carries a uniaxial tensile load, the yield strength of a candidate material can be directly related to the load-carrying capacity of the product. However, some characteristics of the part or product may not have simple correspondence with measurable material properties, as in the case of thermal shock resistance, wear resistance, reliability, etc. Under these conditions, the evaluation process can be quite complex and may depend upon predictions based on simulated service tests or upon the most closely related mechanical, physical, or chemical properties. For example, thermal shock resistance can be related to the thermal expansion coefficient, thermal conductivity, modulus of elasticity, ductility, and tensile strength. On the other hand, resistance to stress–corrosion cracking can be related to tensile strength and electrochemical potential.

2. Process Ability Requirements

The process-ability of a material is a measure of its ability to be worked and shaped into a finished part. With reference to a specific manufacturing method, process ability can be defined as cast ability, weld ability, machinability, etc. Ductility and hardenability can be relevant to process ability if the material is to be deformed or hardened by heat treatment, respectively.

The closeness of the stock form to the required product form can be taken as a measure of process ability in some cases. It is important to remember that processing operations will almost always affect the material properties so that process ability considerations are closely related to functional requirements.

3. Cost

Cost is usually an important factor in evaluating materials, because in many applications there is a cost limit for a given component. When the cost limit is exceeded, the design may have to be changed to allow for the use of a less expensive material or process. In some cases, a relatively more expensive material may eventually yield a less expensive component than a low-priced material that is more expensive to process.

4. Reliability Requirements

Reliability of a material can be defined as the probability that it will perform the intended function for the expected life without failure. Material reliability is difficult to measure, because it is not only dependent upon the material's inherent properties, but it is also greatly affected by its production and processing history. Generally, new and nonstandard materials will tend to have lower reliability than established, standard materials.

Despite difficulties of evaluating reliability, it is often an important selection factor that must be taken into account. Failure analysis techniques are usually used to predict the different ways in which a product can fail and can be considered as a systematic approach to reliability evaluation. The causes of failure of a part in service can usually be traced back to defects in materials and processing, faulty design, unexpected service conditions, or misuse of the product.

5. Resistance to Service Conditions

The environment in which the product or part will operate plays an important role in determining the material performance requirements. Corrosive environments, as well as high or low temperatures, can adversely affect the performance of most materials in service. Whenever more than one material is involved in an application, compatibility becomes a selection consideration. In a thermal environment, for example, the coefficients of thermal expansion of all the materials involved may have to be similar in order to avoid thermal stresses. In wet environments, materials that will be in electrical contact should be chosen carefully to avoid galvanic corrosion. In applications where relative movement exists between different parts, wear resistance of the materials involved should be considered. The design should provide access for lubrication; otherwise self-lubricating materials have to be used[10].

#### 2.6.3.2.1 Quantitative Methods for Initial Screening

Having specified the performance requirements of the different parts, the required material properties can be established for each of them. These properties may be quantitative or qualitative, essential or desirable. The performance requirements are that it should transmit the power efficiently without failing during the expected life of the engine. The essential material properties are tensile and fatigue strengths, while the desirable properties that should be maximized are processability, weight, reliability, and resistance to service conditions. All these properties should be achieved at a reasonable cost.

The selection process involves the search for the material or materials that would best meet those requirements. In some cases none of the available materials can meet the requirements or the possible materials are too expensive or environmentally unsafe. In such cases, alternatives must be made possible through redesign, compromise of requirements, or development of new materials.

Generally, the starting point for materials selection is the entire range of engineering materials. At this stage, creativity is essential in order to open up channels in different directions, not let traditional thinking interfere with the exploration of ideas, and ensure that potential materials are not overlooked. A steel may be the best material for one design concept while a plastic is best for a different concept, even though the two designs provide the same function.

After all the alternatives have been suggested, the ideas that are obviously unsuitable are eliminated and attention is concentrated on those that look practical. Quantitative methods can be used for initial screening in order to narrow down the choices to a manageable number for subsequent detailed evaluation. Following are some of the quantitative methods for initial screening of materials.

a. Limits on Material Properties

Initial screening of materials can be achieved by first classifying their performance requirements into two main categories1:

- Rigid, or go–no go, requirements
- Soft, or relative, requirements

b. Cost-per-Unit-Property Method

The cost-per-unit-property method is suitable for initial screening in applications where one property stands out as the most critical service requirement. As an example, consider the case of a bar of a given length L to support a tensile force F. The cross-sectional area A of the bar is given by

$$A = \frac{F}{S} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.1)$$

where S is the working stress of the material, which is related to its yield strength divided by an appropriate factor of safety.

The cost of the bar (C') is given by

$$C' = C\rho AL = \frac{C\rho FL}{S} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (2.2)$$

Where C =cost of material per unit mass

ρ density of material

Since F and L are constant for all materials, comparison can be based on the cost of unit strength, which is the quantity

$$\frac{C\rho}{S} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2.3)$$

Materials with lower cost per unit strength are preferable. If an upper limit is set for the quantity $C\rho/S$, then materials satisfying this condition can be identified and used as possible candidates for more detailed analysis in the next stage of selection.

c. Weighted-Properties Method

In the weighted-properties method each material requirement, or property, is assigned a certain weight, depending on its importance to the performance of the part in service. A weighted-property value is obtained by multiplying the numerical value of the property by the weighting factor (α). The individual weighted-property values of each material are then summed to give a comparative materials performance index (γ). Materials with the higher performance index (γ) are considered more suitable for the application.

i. Digital Logic Method

In the cases where numerous material properties are specified and the relative importance of each property is not clear, determinations of the weighting factor(α) can be largely intuitive, which reduces the reliability of selection. The digital logic approach can be used as a systematic tool to determine α.In these procedure evaluations are arranged such that only two properties are considered at a time. Every possible combination of properties or goals is compared and no shades of choice are required, only a yes or no decision for each evaluation.

To determine the relative importance of each property or goal, a table is constructed, the properties or goals are listed in the left-hand column, and comparisons are made in the columns to the right of the table.

In comparing two properties or goals, the more important goal is given the number 1 and the less important is given as 0. The total number of possible decisions is

$$N = \frac{n(n-1)}{2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (2.4)$$

Where n is the number of properties or goals under consideration. A relative emphasis coefficient or weighting factor α for each goal is obtained by dividing the number of positive decisions for each goal (m) into the total number of possible decisions (N). In this case$\sum \alpha = 1$.

To increase the accuracy of decisions based on the digital logic approach, the yes–no evaluations can be modified by allocating gradation marks ranging from 0 (no difference in importance) to 3 (large difference in importance). In this case, the total gradation marks for each selection criterion are reached by adding up the individual gradation marks. The weighting factors are then found by dividing these total gradation marks by their grand total [11].

## 2.7 Ergonomics Consideration in Machine

### 2.7.1 Introduction

Successful application of industrial ergonomics requires an understanding of human capacity, workplace design, musculoskeletal disorders, and occupational risk factors. Such information may not be readily available to non-specialists charged with the responsibility of initiating ergonomic intervention in the workplace. When attempting to ergonomically analyze, evaluate, and redesign the workplace, the most valuable tool at an engineer's disposal is access to information. Ergonomics information in particular can provide the engineer with appropriate procedures for identifying potential hazards, quantifying specific risk factors, and developing feasible solutions for those jobs associated with work-related musculoskeletal disorders (WRMSDs). This information can also yield design specifications that maximize human comfort or performance. The various resources for ergonomics information can fall into one of the three categories: print, human/institutional, and electronic[10].

### 2.7.2 Ergonomics Background

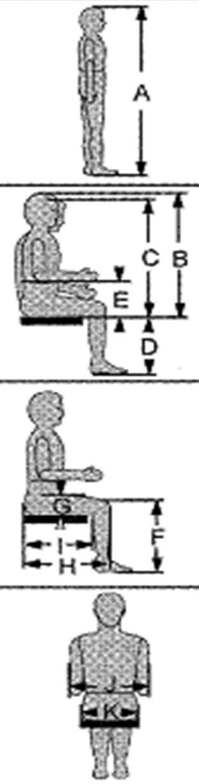
Definition: Ergonomics is an applied science concerned with the characteristics of people that need to be considered in designing and arranging things that they use in order that those things may be used most easily, effectively, and safely--called also human engineering, human factors engineering.

#### 2.7.2.1 The Science of Ergonomics

Ergonomics is a multidisciplinary science comprised of engineering, mathematics, anatomy, physiology, anthropometry, psychology, and biomechanics. Ergonomics allows an engineer to understand the human element when considering the design of a job, tool, or equipment. Without the understanding of the employee characteristics, the engineer is unable to meet the physical requirements (e.g., reaches, clearances, cycle times) that would be appropriate for productivity while maintaining the health and safety of the working population. When the employee population is not considered in the job design, issues such as equipment selection and design, work flow, and material flow may impact the bottom line of any company. Musculoskeletal Stress and Injury Lack of attention to ergonomics may lead to injury and illness of the worker. There are stress or risk factors associated with most jobs. The risk factors can produce workplace musculoskeletal disorders (WMSDs), which are subtle and costly injuries and illnesses that can occur in any body part and happen over time. The science of measurement and the art of application that establishes the physical geometry, mass properties, and strength capabilities of the human body. The mechanical bases of biological especially muscular activity; mechanical engineering of the human body. Same as MSDs, overuse syndrome, repetitive strain injuries, repetitive motion injuries[10].

#### 2.7.2.2 Tools for Ergonomic Improvement

There are a variety of tools available to the engineer to assist in the design of work methods, workstations, tools, and equipment that will meet the needs of the changing work environment. For example, the science of anthropometry allows the engineer to design with specifications that meet the needs of our changing industrial working population. The science is an outgrowth of physical anthropology. It was conceived more than 200 years ago and used in an attempt to distinguish among races and ethnic groups of humans to aid in medical diagnoses. More recently, it has become useful in industrial settings and is identified with the development of engineering design requirements and the evaluation of modern vehicles, work sites, equipment, and clothing. Figure 2.3 illustrates some common anthropometric measures that are used in design [11].



| BODY DIMENSION | US MALE (%-ile) | | | US FEMALE (%-ile) | | |
|---|---|---|---|---|---|---|
| | 5th | 50th | 95th | 5th | 50th | 95th |
| A. Standing height | 63.6 | 68.3 | 72.8 | 59.0 | 62.9 | 67.1 |
| B. Sitting height, erect | 33.2 | 35.7 | 38.0 | 30.9 | 33.4 | 35.7 |
| C. Sitting height, normal | 31.6 | 34.1 | 36.6 | 29.6 | 32.3 | 35.7 |
| D. Popliteal height | 15.5 | 17.3 | 19.3 | 14.0 | 15.7 | 17.5 |
| E. Elbow rest height | 7.4 | 9.5 | 11.6 | 7.1 | 9.2 | 11.0 |
| F. Knee height | 19.3 | 21.4 | 23.4 | 17.9 | 19.6 | 21.5 |
| G. Thigh clearance height | 4.3 | 5.7 | 6.9 | 4.1 | 5.4 | 6.9 |
| H. Buttock-knee length | 21.3 | 23.3 | 25.2 | 20.4 | 22.4 | 24.6 |
| I. Buttock-popliteal length | 17.3 | 19.5 | 21.6 | 17.0 | 18.9 | 21.0 |
| J. Elbow to elbow breadth | 13.7 | 16.5 | 19.9 | 12.3 | 15.1 | 19.3 |
| K. Seat breadth | 12.2 | 14.0 | 15.9 | 12.3 | 14.3 | 17.1 |
| L. Weight | 126 lb | 166 lb | 217 lb | 104 lb | 137 lb | 199 lb |

Figure 2.5 Body Dimensions of Male and Female Population of the United States

Industrial Engineering Ergonomics Toolbox: The following is a list of some major and most widely used tools industrial engineers should consider for their ergonomics toolbox.

- Posture data collection--a must for every analysis;
- Anthropometric data analysis ;
- Upper limb checklist (e.g., RULA) ;
- Load limits for lifting (e.g., the NIOSH equation) ;
- Lumbar spine forces and strength demands analysis (e.g., University of Michigan's 2D, 3D analysis and University of Waterloo's WATBAK;
- Push/pull/carry analysis (e.g., Snook and Ciriello, and Mital ;
- Force, posture, repetition, grip, and vibration ergonomic analysis (e.g., Ergo MOST) ;
- Metabolic energy cost analysis (e.g., University of Michigan's Energy-Expenditure) ;
- Ergonomic line balance ;

- Other tools ;
- Recovery time for repetitive work;
- Borg RC-10 ;
- Ovako Working Posture Analyzing System (OWAS).

According to NIOSH Revised 1991 Lifting Equation (Dynamic Lifts).The lifting equation was designed to estimate physical stress of two-handed manual lifting tasks A lifting task is defined as grasping an object with two hands and lifting it vertically through space without any assistance. The NIOSH equation calculates the recommended weight limit (RWL). If the RWL is equal to or greater than the actual weight of the part being lifted, then the task is an acceptable ergonomic risk. Since load constant (LC) = constant 23.1 kg (51 lb), the maximum weight a person can lift is 23.1 kg (51lb) under optimal condition. While lifting object is object weight per RWL [11].

### 2.7.3 Manufacturing Ergonomics

Ergonomics can be defined as the study of work. Chaffin, and Andersson further define ergonomics as fitting the work to the person. The primary goal of ergonomics is "improving worker performance and safety through the study and development of general principles that ,govern the interaction of humans and their working environment." Rohmert states that ergonomics "deals with the analysis of problems of people in their real-life situations." Further, he urges that ergonomists “design these relations, conditions and real-life situations with the aim of harmonizing people's demands and capacities, claims and actualities, longings and constraints." Ergonomics is concerned with the problems and processes involved in designing systems and processes for effective human use, and in creating environments that are suitable for human living and work[11].

#### 2.7.3.2 Manufacturing Ergonomics of Risk and Control

In many cases, ergonomic analysis looks at how the physical design of a particular workstation may affect human performance. In the area of biomechanics, ergonomic analysis often deals with three distinct types of work or activities:

- Work Involving Manual Handling Of Objects;
- Work Involving Assembly and/or Disassembly; And
- Work Involving Machine operation.

The human body can be thought of as a sophisticated mechanical system. The bones pro- vide a framework to support the various loads on the body. The muscles provide the power to move the frame about the joints through muscle contraction. Tendons attach bone to muscle and convert the muscle contraction to mechanical energy. As muscles contract, the tendons pull the bone around the axis of the joint like a pulley.

The three main generic occupational risk factors associated with ergonomic stress are force, frequency, and stressful postures. Independently, each factor can lead to ergonomic stress if it exceeds human capability limits. However, combinations of these factors may lead to physical harm even if the independent levels of each risk factor are at or below their individual human capability limits.

- Force can be defined as the amount of work that the muscles, tendons, joints, and adjacent tissues must do in order to perform a particular action. The force exerted often depends on a variety of factors, including posture, weight, and friction.
- Frequency, often referred to as repetitiveness, is a measure of the time required in specific postures. Depending on the amount of force or the type of posture, repetitiveness can be harmful if repeated many times or if held for sustained periods of time.
- Stressful postures, when sustained or used repeatedly, can be harmful to the musculoskeletal structure, especially when force is exerted. There are many stressful postures, usually described by body part.

#### **2.7.3.3** Activities Involving Manual Handling of Objects

Physical work capacity (PWC): is a measure of the recommended energy expenditure rate for a specific duration of time and is dependent on maximum physical work capacity /MPWC. As just noted, maximum physical work capacity MPWC is dependent on physical fitness. In the absence of information of the physical fitness of a specific individual or population maximum physical work capacity/MPWC can be estimated as function of age.

1. Estimating Job Energy Expenditure Rate Requirements: Four methods are commonly used to determine the metabolic requirements of specific jobs:
    - Actual measurement of oxygen consumption of a worker while performing the job
    - Macro studies (table values and job classifications)
    - Predictive macrostudics (job attribute energy summation)
    - Predictive microstudies (elemental work-task energy summation)
2. Simple Measures of Spinal Loading:- Two concepts must be understood to appreciate the impact of the work environment on the cause and prevention of low back problems in industry. These are moment and compressive force.

Moment: - A moment is defined as the quantity necessary to cause or resist the rotation of a body. This can be thought of as the effect of a force acting over a distance, or (force x instance) [11].

# CHAPTERTHREE

# MATERIAL AND METHODS

## 3.1 Material

The material required in preparation of this project is:-

1. Stationery
   - Paper A4
   - Pen
   - Computer
   - CATIA software
   - RW CD

Table 3.1 Raw material

| No | Material Description | Specification and Size Required | Unit | Qty |
|---|---|---|---|---|
| 1 | Mild steel sheet metal | 1mm thick | Pcs | 02 |
| 2 | Square pipe | 40x40x1.5mm | Pcs | 03 |
| 3 | Barrel | Ø570x900mm | Pcs | 01 |
| 4 | Square pipe | 50x50x2mm | Pcs | 01 |
| 5 | Round pipe | Ø30x1000mm | Psc | 01 |
| 6 | Mild steel plate | 80x75x4 mm | Pcs | 06 |
| 7 | Angle iron | 25x25x3mm | Pcs | 01 |
| 8 | Round bar | Ø30x500mm | Pcs | 01 |
| 9 | Round bar | Ø10x480mm | Pcs | 01 |
| 9 | Round bar | Ø50x560mm | Pcs | 01 |
| 10 | Aluminum ingot | Ø80x500mm | Pcs | 01 |
| 11 | Aluminum ingot | Ø150x500mm | Pcs | 01 |
| 12 | Sieve for fine | No. 4 | M | 2m |
| 13 | Sieve medium | No. 8 | M | 2m |
| 15 | Fly wheel | Φ300mmx40mm | Pcs | 01 |

## 3.2 (Methods) Research Methodology

In making the thesis work successful, focusing on the need assessment of the project, developers are using exploratory research method. Exploratory research might involve a literature search or conducting focus group discussion. The exploration of new phenomena can help our need for better understanding and test the feasibility of a more extensive study, or determine the best methods to be used in a subsequent study. For these reasons, exploratory research is broad in focus and provides definite answers to specific research issues. The objective of exploratory research is to identify key issues and key variables.

The following methods were used to achieve the thesis objectives:-

A. Literature survey on the subject matter: the sources used at most are books, journals, and websites.
B. Consultations and informal discussions: Consultations were detained with the study team advisor, and informal discussions were conducted with those who have any expertise knowledge and skill regardless of sand sieving machine.
C. Design of critical components of the machine: - In designing of the Critical components of the machine, Critical machine components identified, rough sketch is drawn using free hand and finally drawing of the component and assembly is developed by CATIA software.
D. Material selection:-In order to select the proper material for machine
    - 1$^{st}$ functional requirement of the components is identified
    - 2$^{nd}$ material properties that meet functional requirements of the components is listed
    - Finally the material that meets expected properties
E. Manufacturing of the components:- In manufacturing of each component steps like measuring, cutting and joining according to the specified dimension has been performed using measuring tool, cutting and joining machinery available in the work shop.
F. Assembly of the components: All components of the machine are assembled step by step according to the assembling procedure.
G. Testing the performance of the machine: In testing of the machine the following steps has been used:-

- Field of testing is selected,
- Natural sand is prepared.
- Electric power supplied to the machine
- Sand is filled to the screw conveyor
- Finally the functionality of the machine is evaluated.

## 3.3 Sample and Sampling Technique

What is sampling? Sampling involves the selection of a number of study units from a defined study population. The population is too large to consider and collect information from all its members. Instead we select a sample of individuals hoping that the sample is representative of the population. When taking a sample, we will be confronted with the following questions:

A. What is the group of people from which we want to draw a sample?
B. How many people do we need in our sample?
C. How will these people be selected?

Target population (reference population): Is that population about which an investigator wishes to draw a conclusion.

- Study population (population sampled):-Population from which the sample actually was drawn and about which a conclusion can be made.
- Sampling unit:- The unit of selection in the sampling process
- Study unit:- The unit on which the observations will be collected
- Sample design:-The scheme for selecting the sampling units from the study population.
- Sampling frame:-The list of units from which the sample is to be selected.
- Sampling methods:- An important issue influencing the choice of the most appropriate sampling method is whether a sampling frame is available, that is, a listing of all the units that compose the study population.

### 3.3.1 Sampling Technique

a) Non-probability sampling method

- Convenience sampling: - is a method in which for convenience sake the study units that happen to be available at the time of data collection are selected.
- Quota sampling:- is a method that insures that a certain number of sample units from different categories with specific characteristics appear in the sample so that all these characteristics are represented
- Purposeful sampling strategies for qualitative studies

b) Probability sampling methods: They involve random selection procedures to ensure that each unit of the sample is chosen on the basis of chance. All units of the study population should have an equal or at least a known chance of being included in the sample.

- Simple Random Sampling (SRS):- This is the most basic scheme of random sampling
- Systematic Sampling: - Individuals are chosen at regular intervals (for example, every 5th, 10th, etc.) from the sampling frame.
- Stratified sampling: - If it is important that the sample includes representative groups of study units with specific characteristics (for example, residents from urban and rural areas), then the sampling frame must be divided into groups, or strata, according to these characteristics. Random or systematic samples of a predetermined size will then have to be obtained from each group (stratum) (Research method for construction 3rd edition).

### 3.3.2 Sample Selection

Sampling involves selecting relatively small number of elements from the large defined group of elements and expecting that the information gathered from small group allow generalization to be made about the larger group of population. (Research method for construction 3rd edition)

The sampling units are the defined target population elements available for selection during the sampling process. In this research, Adama Town construction enterprise workers are selected purposely as the total population since the result can be considered for the whole construction workers in the country using sample random sampling technique.

A total of 12 numbers of workers are randomly selected from the population of 22 number of construction workers including SMEs at Adama Town that are currently working in the field of construction of building.

The reason why Adama Town is selected for this study is because the town is near to the university and due to limited budget; the researchers couldn't include other places. The sampling is selected by using systematic random sampling method. The sample ratio can give sufficient information because it is taken 54.5% out of total population.

## 3.4. Data Collection Tools

We use three data gathering techniques to understand current problems of sand sieving and need of this machine; collect data by interviewing, direct observation, document analysis. The documents which are analyzed for the project are internet, and many types of reports and researches about sand sieve machine. After the quantitative and qualitative data are gathered from those sources, sand sieve machine is designed and manufactured as a solution to facilitate and avoid exhausting and time consuming of sand sieving activities

### 3.4.1 Interview's

The interview includes workers of different private sectors and small micro enterprise. Structured interviews (face to face) conducted with different construction sand sieving workers. Most of the interview questions conducted is closed type of questioners. This helped us to crosscheck the response given by the interviewees.

The main objectives of conducting interviews are to get accurate and relevant information from the beneficiary themselves easily.

### 3.4.2 Direct observation

We have also used this method for collecting the required data and information from different documents. We have observed the current sand sieving methods in construction works and the problem they are facing know.

### 3.4.3 Data Analysis and Interpretation

The collected data through the means of interviews, direct observation of documents are analyzed & interpreted. It is believed that the current situation of the sand sieving methods has exactly reflected the problems in these interviews. The findings indicate that, there is a need of sand sieving machine.

Table 3.2 Analyzing Of Interview Questioner

| *No* | *Question raised* | *Comment* |
|---|---|---|
| 1 | What is your current role in this site? | Most our respond where daily laborer in working in adama town of different construction enterprise |
| 2 | Do you have sand sieve machine sand? | |
| 3 | If your answer is yes for question 2 what type sand sieve machine is it? | |
| 4 | What is the problem with this machine? | |
| 5 | What are the sieve sizes you use frequently? | |

Most our respond where daily laborer in working in Adama town of different construction enterprise. Out of 12 individual 100 % responded that there is no sand sieving machine they use manual sand sieving which is made of wooden rectangular box inside with mish fix. Us to the respondent this type of sieving is time consuming and needs high labor force. The analysis the interview indicates that there is high demand in sand sieving machine. According to the respondent the most commonly used mish size in construction site is only two type that No.4 and No.8 which used for Fino and shinbera gerfe.

### 3.5 Tools, Equipment's and Machinery

The following are lists of tools, equipment's and machinery used in accomplishing of this project:-

A. Tools and Equipment's
   1. Open end wrench No.18-19
   2. Open end wrench No. 20-22
   3. Open end wrench No. 22-24
   4. Adjustable wrench

5. Rubber Mallet
6. Ball peen hammer 1.5kg
7. Engineering level
8. Steel rule
9. Rubber hammer or mallet
10. Vanier caliper
11. Scriber
12. Tape rule
13. Try-square
14. Hack saw
15. Face shield
16. Chipping hammer
17. File card
18. Leather gloves

B. Machinery

1. Power hack saw
2. Lathe machine
3. Milling machine
4. Arc welding machine
5. Oxy-fuel cutting
6. Portable Drilling machine
7. Electric furnace
8. Portable hand grinder
9. Pedestal drilling machine

# CHAPTER FOUR

# MATERIAL SELECTION AND CRITICAL MACHINE PARTS DESIGN

## 4.2. Material selection for critical parts (components)

The criteria for selection of the materials for the critical components of the machine is based on the availability of the materials, suitability of the material for the working condition in service, the cost of the materials, the type of force that apply on them, the work they are expected to perform, the environmental condition, their useful physical and mechanical properties.

The best material is one which services the desired objectives at the minimum cost and the following factors should be consider while selecting material.

- Availability of the material in the form and shape desired;
- Total cost of the material including initial and future cost;
- Material properties as they relate to service performance requirements;
- Suitability of material for working condition in service;
- Substitutability of the materials; and
- The processing of the material into a finished part.

Generally material selection factors are service performance (specifications), availability, economics (total cost), material properties, manufacturing processes, formability and join ability and finishing and coatings.

Selecting the right material for the machine which can fulfill the functional requirement for the shaft is very important. To select the suitable material the digital logic methods was followed. The steps for digital logic methods are:-

- Set the functional requirements for the part under consideration. This are used to set rating factor.
- Rank the rating factors (properties) then determine the weight factors using equation below;

$$N = \frac{n(n-1)}{2} \quad (4.1)$$

Where N= Is Total Number of Decision

n= number of rating factors

- Write the most suitable candidate materials and list properties.
- Normalize the outcomes of the parts.
- Value outcomes and overall satisfaction of parts.

Depending on the above criteria the following materials are selected for the basic components for multipurpose sieve machine. The most critical machine elements that need design analysis in the manufacturing multipurpose sieve machine are Screw conveyor, shaft, pulley, belt, barrel hoper out let and bearing.

### 4.2.1 Material Selection for Sieve and Screw Shaft

A shaft is a rotating machine element which is used to transmit power from one place to another. The power is delivered to the shaft by some tangential force and the resultant torque (or twisting moment) set up within the shaft permits the power to be transferred to various machines linked up to the shaft.

In order to transfer the power from one shaft to another, the various members such as pulleys, gears etc., are mounted on it. These members along with the forces exerted upon them causes the shaft to bending. When a shaft of high strength is required, then alloy steel such as nickel, nickel-chromium or chrome-vanadium steel is used.

If strength considerations turn out to dominate over deflection, then a higher strength material should be tried, allowing the shaft sizes to be reduced until excess deflection becomes an issue. If concentricity is important, it may be necessary to rough machine, then heat treat to remove residual stresses and increase the strength, and then finish machine to the final dimensions by the process called “cylindrical grinding”.

Generally, the shaft materials should have the following properties:

1) Material should have better yield strength and tensile strength;
2) Low notch sensitivity factor;
3) Material should be tough enough, machine able and light in weight;
4) Wear resistant and good heat treatment properties;
5) To less prone to environmental effects.

To achieve the required functional requirement of shaft materials, the Number of properties to be evaluated is density, modules of elasticity, toughness, tensile strength, and yield strength.

The total number of decision is calculated using equation (4.1)

$$N = \frac{n(n-1)}{2}$$

Where N= Is Total Number of Decision

n= number of rating factors

$$N = \frac{5(5-1)}{2}=10$$

$$Weight\ factor\ (Wf) = \frac{positive\ decision}{Total\ No.decisions} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(4.2.)$$

$$Performance\ index\ (\mu) = (normalized\ value)(weight\ factor) \ldots\ldots\ldots\ldots\ldots..(4.3)$$

Table 4.1 Application of Digital Logic with Different Decisions Number

| *Property* | *Decision No.* | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Density | 1 | 0 | 1 | 1 | | | | | | |
| Modules of elasticity | 0 | | | 1 | 0 | 1 | 1 | | | |
| Toughness | | 0 | 0 | 0 | 0 | 1 | 0 | 1 | | |
| Tensile strength | | | | | | | 0 | 0 | 1 | |
| Yield strength | | | | | | | 0 | | 0 | 1 |

Table 4. 2 Weight Factors For Shaft

| *Property* | *Positive decision* | *Weight factors* |
|---|---|---|
| Density | 3 | 0.3 |
| Modules of elasticity | 3 | 0.3 |
| Toughness | 2 | 0.2 |
| Tensile strength | 1 | 0.1 |
| Yield strength | 1 | 0.1 |
| | 10 | 1.0 |

Table 4. 3 Selected Shaft Material Properties

| *Material* | *Density kg/m3* | *Modules of elasticity(Mpa)* | *Toughness (Mpa)* | *Ultimate tensile strength(Mpa)* | *Yield strength(Mpa)* |
|---|---|---|---|---|---|
| SAE1020 | 7680 | 207 | 25 | 380 | 207 |
| SAE1010 | 7680 | 207 | 28 | 325 | 180 |
| SAE1045 | 7680 | 207 | 8 | 825 | 614 |
| SAE1040 | 7680 | 207 | 33 | 621 | 414 |

Table 4. 4 Normalized Outcomes for Shaft

| *Material* | *Density kg/m3* | *Modules of elasticity(Mpa)* | *Toughness (Mpa)* | *Ultimate tensile strength(Mpa)* | *Yield strength(Mpa)* |
|---|---|---|---|---|---|
| SAE 1020 | 100 | 100 | 75.75 | 46 | 33.7 |
| SAE 1010 | 100 | 100 | 84.85 | 39.4 | 29.3 |
| SAE 1045 | 100 | 100 | 24 | 100 | 100 |
| SAE 1040 | 100 | 100 | 100 | 75.3 | 67.4 |

Table 4.5 Shows Performance Index (Value Out Comes)

| *Material* | *Density (0.3)* | *Modules of Elasticity(0.3)* | *Toughness (0.2)* | *Ultimate Tensile strength (0.1)* | *Yield Strength (0.1)* |
|---|---|---|---|---|---|
| SAE 1020 | 30 | 30 | 15 | 4.59 | 3.37 |
| SAE 1010 | 30 | 30 | 17 | 3.925 | 2.93 |
| SAE 1045 | 30 | 30 | 4.8 | 10 | 10 |
| SAE 1040 | 30 | 30 | 20 | 7.5 | 6.74 |

Table 4.6 Overall Satisfactions

| | |
|---|---|
| *Annelid SAE 1020* | *82.96* |
| SAE 1010 | 83.855 |
| W-1000 of SAE 1045 | 84.8 |
| SAE 1040 | 94.24 |
| Annelid SAE 1020 | 82.96 |

The result shows that on the bases of allocated weighting factor SAE 1040 gives the highest overall satisfaction among these materials. Therefore, this material is preferable for the production shaft (suitable material selected for the shaft is SAE 1040 for designing) and the required safety factor are 5. The yield strength for steel SAE 1040 is 414Mpa and the ultimate tensile strength is 621 Mpa[12].

### 4.2.2 Material Selection for Frame

The frame works as main a body in the multipurpose sieve machine on which all other parts are mounted (attached). The frame is made up of mild steel square pipe (40 × 40 × 1.5 mm) welded together to provide the desired strength and rigidity

### 4.2.3 Material Selection for Pulley

#### 4.2.3.1 Material Selection for Pulley

I. Functional requirement for pulley

The main function of pulley is to transmit power from the prime mover to the driven shaft through belt.

II. Material requirement for pulley

1) The material should possess optimal tensile strength;
2) The material should have adequate value of yield strength;
3) Density of the material should meet value of safe operation ;
4) It possesses moderate specific heat capacity;
5) Coefficient of linear expansion of the material should lie at range of minimal value;
6) Wear resistance.

The total number of decision is calculated using equation (4.1)

$$N = \frac{n(n-1)}{2}$$

$$N = \frac{6(6-1)}{2} = 15$$

Table 4.7 Weighting factors for pulley

| *Properties* | *Number of decision* | | | | | | | | | | | | | | | Weighting factor |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | |
| Tensile strength | 0 | | | 0 | | 1 | | 1 | | | | 0 | | | | 2/10 = 0.2 |
| Yield strength | | 0 | | | 0 | | | | 0 | 1 | | 0 | | | | 1/10 = 0.1 |
| Density | 1 | 1 | 1 | | | | 0 | | | | | 0 | | | | 3/10 = 0.3 |
| Specific heat capacity | | | 0 | | 1 | 0 | | 0 | | | | | | | | 1/10 = 0.1 |
| Coefficient of linear expansion | | | | 1 | | | 1 | | 1 | 0 | | 0 | | | 0 | 3/10 = 0.3 |
| Wear resistance | | | | | | | | | | | 1 | 0 | 1 | 0 | 1 | 3/10 = 0.3 |

Table 4.8 Properties of Candidate Material for Pulley

| Materials | Tensile strength | Yield strength | Density | Specific heat capacity | Coefficient of Linear expansion |
|---|---|---|---|---|---|
| AISI1010 | 370 | 300 | 7.85 | 0.47 | 12.20 |
| AISI1035 | 550 | 460 | 7.85 | 0.48 | 11.50 |
| ASTM 20 | 152 | 152 | 7.20 | 0.34 | 11.00 |
| ASTM 25 | 197 | 197 | 7.35 | 0.46 | 10.00 |

Table 4.9 Normalized outcome value

| Materials | Tensile strength | Yield strength | Density | Specific heat Capacity | Coefficient of Linear expansion |
|---|---|---|---|---|---|
| AISI1010 | 67 | 65 | 100 | 72 | 82 |
| AISI1035 | 100 | 100 | 100 | 71 | 87 |
| ASTM 20 | 27 | 33 | 92 | 100 | 91 |
| ASTM 25 | 32 | 39 | 95 | 74 | 100 |

Table 4.10 Shows performance index (outcome Value)

| Materials | Tensile strength x 0.2 | Yield strength X 0.1 | Density x0.3 | Specific heat capacityx 0.2 | Coefficient of linear expansion x0.3 | Performance index | Rank |
|---|---|---|---|---|---|---|---|
| AISI1010 | 13.45 | 6.5 | 30 | 7.2 | 24.6 | 81.75 | 2 |
| AISI1035 | 20 | 10 | 30 | 7.1 | 26.1 | 93.20 | 1 |
| ASTM 20 | 5.4 | 3.3 | 27.6 | 10 | 27.3 | 73.6 | 4 |
| ASTM 25 | 6.4 | 3.9 | 28.5 | 7.4 | 30 | 76.2 | 3 |

Therefore, from the above candidate materials Carbon steel re-sulfurized (AISI1035) is a best suitable for the pulley material which is relatively less weight [13]

### 4.2.4 Material Selection for Bearing

#### 4.2.4.1 Functional Requirement

A bearing is a machine element which supports other moving machine components (known as Journal, i.e., the portion of the shaft resting on the sleeve). It permits a relative and smooth motion between the contact surfaces of the members, while carrying the load.

Since there is a relative motion between the bearing and the moving element, a certain amount of power must be absorbed in overcoming friction, and if the surface actually touches, there will be a rapid wear.

#### 4.2.4.2 Material Requirement

The various considerations in the selection of bearings to satisfy the functional requirement, the bearing should have:

- Direction of load relative to bearing axis;
- Intensity of loads. Ball bearings can sustain considerable loads;
- Speed of rotation;
- Thermal stability;
- Shaft stiffness. Rigid bearings are used for stiff well designed shafts;
- Class of accuracy of the machine

Table 4. 11 Principal Dimension for Radial Ball Bearings (From Text Book of A Machine Design R.S KHURMI AND J.K.GUPTA 2005)

| *Bearing Basic* | *Bore (mm)* | *OD (mm)* | *W(mm* |
|---|---|---|---|
| L03 | 17 | 35 | 10 |
| 203 | 17 | 40 | 12 |
| 303 | 17 | 47 | 14 |
| L04 | 20 | 42 | 12 |
| 204 | 20 | 47 | 14 |
| 304 | 20 | 52 | 15 |
| L05 | 25 | 47 | 12 |
| 205 | 25 | 52 | 15 |
| 305 | 25 | 62 | 17 |
| L06 | 30 | 55 | 13 |
| 206 | 30 | 62 | 16 |
| 306 | 30 | 72 | 19 |

Already, from the design analysis the shaft diameter obtained is 30mm. therefore based on the diameter of shaft and the properties of bearing mentioned above, ball bearing with Bearing Basic Number L06, from the above table is selected for this project [12].

### 4.2.5 Material Selection for Keys

#### 4.2.5.1 Functional Requirement

A key is a piece of metal inserted between shaft and hub or boss of the pulleys to connect these parts in order to prevent relative motion between them. It is always inserted parallel to the axis of the shaft. Keys are used as temporary fasteners and are subjected to considerable crushing and shear stresses. The most widely used method of torque transfer is by the use of keys.

#### 4.2.5.2 Material Requirement

The material for the key should be selected based on the following criteria

- The key should be tough enough
- It should be resistance to wear
- Having sufficient high strength.
- Has high fatigue strength

Therefore by considering the above functional requirement Carbon steel SAE 1040 selected for shaft is used for the key since it can satisfy the requirement.

## 4.3 Design Analysis

### 4.3.1 Introduction to Design Concept

Machine Design is the creation of new and better machines and improving the existing ones. A new or better machine is one which is more economical in the overall cost of production and operation. The process of design is a long and time consuming one. From the study of existing ideas, a new idea has to be conceived. The idea is then studied keeping in mind its commercial success and given shape and form in the form of drawings. In the preparation of these drawings, care must be taken of the Availability of resources in money, in men and in materials required for the successful completion of the new idea into an actual reality. In designing a machine component, it is Necessary to have a good knowledge of many subjects such As Mathematics, Engineering Mechanics, Strength of Materials, Theory of Machines, Workshop Processes and Engineering Drawing [9].

### 4.3.2 Design analysis of Critical Part of the Machine

The sand sieving machine was designed for separating sand of different size. In order to meet the sieving requirements, different parameters such as determination sieve, determination of sieve rotational speed, screw conveyor design .pulley diameters, shaft diameter, belt length, center distance between pulleys etc. were decided by applying theories, principles and practices of machine design. Accordingly, the following speed have been selected; Maximum sieve speed 300 rpm, screw conveyor speed 150rpm which most commonly recommend speed for light weight machinery.

#### 4.3.2.1 Selection of Pulleys and Belts

The machine required four pulleys; one pulley mounted on the electric motor shaft as prime drive, two pulleys mounted on sieve shaft and the fourth pulley is mounted on the screw conveyor shaft. One belt was used to transmit power from the motor to the sieve shaft and the second belts are used to transmit power from the sieve shaft to the screw conveyor shaft. The driving pulley was mounted on the motor and the driven pulleys were mounted on sieve shaft and on the screw conveyor shaft. Due to its availability, low cost and light in weight aluminum pulley were selected. The power, from the motor shaft to sieve shaft and screw shaft, running at different angular speeds, was transmitted through V-belts. Since the selected motor was 2hp, having range from 0.7 to 3.5 KW, type A V-belt was selected and used. The diameter of driven pulleys, center distance, belt length and belt speeds were calculated as follows.

##### 4.3.2.1.1 Design and selection of pulley

The diameter of the driving pulley was selected based on the prime mover (electric motor) power rating while that of the driven drive was determined.

The diameter of driving pulley, d1 was chosen as equal to pitch diameter of 75mm for power ranging from 0.7of 3.5kW from the dimension of standard v-belts according to IS: 2494 - 1974 [14].

Diameter of pulley is calculated using equation of ratio written below.

$$\frac{d1}{d2} = \frac{N2}{N1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.4)$$

Where d1= is diameter of motor pulley

d2= is diameter of sieve pulley

N1= is speed of the motor

N2= is speed of the sieve

So diameter of motor pulley (d1) = 75mm,

N1 1200rpm which speed of motor

N2 is speed of pulley on shaft of sieve which is expected to be 300rpm

Therefore, the diameter of the driven pulley d2 is given by

$$d_2 = \frac{d1N1}{N2} \text{-------------------------------------} (4.5)$$

Substituting the value in the above an equation

$$d2 = \frac{d1N1}{N2} = \frac{75mmx1200rpm}{300rpm} = 300mm$$

To find the third diameter of pulley this is used to transmit motion from the sieve shaft to screw conveyer pulley can be determined by the following equation. Since the expected rpm on the screw conveyor is 150rpm, in order to obtain this rpm the diameter of pulley on that used to transmit motion from sieve shaft to screw conveyor should be 75mm (d3) and

$$N3 = \frac{d2N2}{d3} = \frac{300mmx300rpm}{75mm} = 1200rpm$$

The forth pulley diameter of the screw conveyor shaft is also determined as follow

$$d4 = \frac{d3N3}{N4} = \frac{75mmx1200rpm}{150rpm} = 600mm$$

#### 4.3.2.1.2 Design and Selection of Belts

A V-belt is mostly used in factories and workshops where a great amount of power is to be transmitted from one pulley to another when the two pulleys are very near to each other.

The V-belts are made of fabric and cords molded in rubber and covered with fabric and rubber as shown in Fig. 4.1. These belts are molded to a trapezoidal shape and are made endless. These are particularly suitable for short drives. The included angle for the V-belt is usually from 30° to 40°. The power is transmitted by the wedging action between the belt and the V-groove in the pulley or sheave. A clearance must be provided at the bottom of the groove as shown in Fig. 20.1 (b), in order to prevent touching of the bottom as it becomes narrower from wear. The V-belt drive may be inclined at any angle with tight side either at top or bottom. In order to increase the power output, several V-belts may be operated side by side. It may be noted that in multiple V-belt drive, all the belts should stretch at the same rate so that the load is equally divided between them. When one of the set of belts breaks, the entire set should be replaced at the same time. If only one belt is replaced, the new unworn and unscratched belt will be more tightly stretched and will move with different velocity [9].

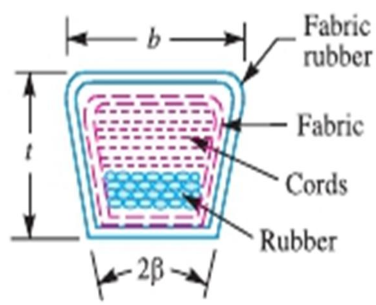



Figure 4.1 The Cross Section of V-Belt

V-belts are selected for the following reason:-

- It’s drive gives compactness due to small distance between centers of pulleys;
- It’s drive is positive because the slip between belt and pulley groove is negligible
- It provides longer life 3 to 5 years
- It can  easily installed and removed
- It have the ability to cushion the shock when the machine are started

- The high velocity ratio may be obtained
- The V-belt may be operated in either direction

A. First belt design analysis

V – Belt design was used. In the design of the belt, the center distance and the pitch length were determined after which the tight and slack tensions were determined.

A tentative minimum center distance was determined from equation below.

$$C = (1.5 \rightarrow 2)(d1 + d2) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (4.6)$$

Using the above equation the tentative minimum center distance for the first belt will be calculated as follow.

$$C = (2)(d1 + d2) = 2(75mm + 300mm) = 750mm$$

Take tentative C = 750mm

The pitch length of the belt, Lp was determined from equation

$$Lp = 2C + 1.57(d2 + d1) + \frac{(d2 - d1)2}{4C} \ldots\ldots (4.7)$$

Where Lp = length of belt (pitch length),

C = center distance.

$$2x750 + 1.57(300mm + 75mm) + \frac{(300mm - 75mm)2}{4x750} = 2089.05mm$$

Lp = 2089.05mm

From the standard pitch length of V-belt according to IS: 2494 - 1974, the standard pitch length of belt adopted is Lp = 2093mm.

By substituting the actual standard pitch length to the equation (4.7) the actual center distance will be:--

$$2093mm = 2C + 1.57(300mm + 75mm) + \frac{(300mm - 75mm)2}{4C}$$

C = 752mm.

The tension in the belt was determined based on the following procedure.

$$sin\alpha = \frac{d2 - d1}{2C} \ldots\ldots\ldots\ldots\ldots\ldots\ldots. (4.8)$$

$$sin\alpha = \frac{300mm - 75mm}{2x752} = 0.1496$$

Where $\alpha$ = Angle between the vertical axis and a line joining inside point of contact of belt with pulley to the Centre of the pulley.

$$\alpha = 8.57°$$

$$\theta = \frac{(180 - 2\alpha)\pi}{180} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (4.9).$$

$$\theta = \frac{(180 - 2x8.57)3.14}{180} = 2.84$$

Where $\theta$ = Angle of contact (wrap) at the smaller pulley (in this case, driving pulley).

$$\theta = 2.84 \text{ rad}$$

For V-belt type A, the groove angle ($2\beta$) is usually between 32° and 38°. The groove angle of 34° was adopted.

$$\text{Therefore, } \beta = 17°$$

From the table of coefficient of friction between belt and pulley according to Khurmi and Gupta [14], the coefficient of friction $\mu$ was taken as 0.3.

$$\frac{T1}{T2} = e(\mu\theta cosec\beta) \ldots \ldots \ldots \ldots \ldots \ldots (4.10)$$

$$\frac{T1}{T2} = e(0.3x2.84xcosec17) = 8.06$$

Where T1 and T2=Tension in the tight side and in the slack side of the belt, respectively.

Substituting the values of $\mu$, $\theta$ and $\beta$ into equation 11, we obtained

$$\frac{T1}{T2} = 8.06 \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (4.11)$$

The tangential velocity of the belt is given as

$$Vb = \frac{\pi d1N1}{60} \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (4.12)$$

$$Vb = \frac{\pi d1N1}{60} = \frac{3.14x0,075mx1200rpm}{60} = 4.71m/s$$

$$Vb = 4.71m/s$$

Hence, centrifugal tension

$$Tc = mv^2 \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (4.13)$$

Where Tc= is centrifugal tension

m = mass of belt per meters length

From dimension of standard v-belt according to IS: 2494 – 1974, the weight of belt per meter length is given as 1.06N/m

$$m = \frac{W}{g} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (4.14)$$

$$m = \frac{1.06N/m}{9.81m/s^2} = 0.108kg/m$$

$$m = 0.108kg/m$$

$$Tc = mv^2 = 0.108kg/mx(4.71m/s)^2 = 2.3N$$

The power transmitted by the motor for one belt was obtained from the following equation

$$P = 1.5KW$$

$$P = (T1 - T2)v \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (4.15)$$

$$T1 - T2 = \frac{P}{V} \dots\dots\dots\dots\dots\dots\dots\dots.\dots\dots.. (4.16)$$

$$T1 - T2 = 318.5$$

$$T1 = 8.06T2$$

Solving equations 4.11 and 4.16 simultaneously yielded T2 = 45.1N and T1 = 363.06N.

The initial belt tension to therefore be:-

$$T0 = \frac{T1 + T2}{2} = \frac{45.1N + 363.06N}{2}$$

$$T0 = 204.08N$$

The true initial tension of belt at rest is given as

$$T01 = T0 + Tc \dots\dots\dots\dots\dots\dots\dots\dots\dots (4.17)$$

$$TO1 = 204.08N + 2.3N = 206.38N$$

B. Second belt design analysis

Similarly the design analysis of the second belt which used to transmit motion from sieve shaft to screw conveyor will be conducted as follow.

A tentative minimum center distance was determined from equation(4.6).

Using the above equation the tentative minimum center distance for the first belt will be calculated as follow.

$$C = (2)(d3 + d4) = 2(75mm + 150mm) = 450mm$$

Where d3 is diameter of pulley on the sieve shaft

d4 is diameter pulley on the screw conveyor shaft

T$he\ pitch\ length\ of\ the\ belt, Lp\ was\ determined\ as\ follow$ from equation (4.7 )

$$Lp = 2C + 1.57(d3 + d4) + \frac{(d4 - d3)2}{4C}$$

$$= 2x450 + 1.57(150mm + 75mm) + \frac{(150mm - 75mm)2}{4x450} = 1253.3mm$$

Where Lp = length of belt (pitch length), C = center distance.

Lp = 2089.05.From the standard pitch length of V-belt according to IS: 2494 - 1974, the standard pitch length of belt adopted is Lp = 1255mm.

By substituting the actual standard pitch length to the equation (4.7 ) calculate the actual center distance

$$1255mm = 2C + 1.57(75mm + 150mm) + \frac{(150mm - 75mm)2}{4C}$$

C = 957.9mm.

The tension in the belt was determined based on the following procedure.

$$sin\alpha = \frac{d2 - d1}{2C} = \frac{150mm - 75mm}{2x957.9} = 0.039$$

Where α = Angle between the vertical axis and a line joining inside point of contact of belt with pulley to the Centre of the pulley is determined by equation(4.9 ) *as follow.*

α = 2.23°

$$\theta = \frac{(180 - 2\alpha)\pi}{180} = \frac{(180 - 2x2.23)3.14}{180} = 3.06$$

Where θ = Angle of contact (wrap) at the smaller pulley (in this case, driving pulley).

θ = 3.06 rad

For V-belt type C, the groove angle (2β) is usually between 34°, $36^0$and 38°. The groove angle of 34° was adopted. Therefore, β = 17°

From the table of coefficient of friction between belt and pulley according to Khurmi and Gupta [13], the coefficient of friction μ was taken as 0.3.

$$\frac{T3}{T4} = e(\mu\theta cosec\beta) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.18).$$

$\frac{T3}{T4} = e(0.3x3.06xcosec17) = 8.81$N

Where T3 and T4=Tension in the tight side and in the slack side of the belt, respectively.

Substituting the values of μ, θ and β into equation, we obtained

$$\frac{T3}{T4} = 8.81\ N$$

The tangential velocity of the belt is given as

$$Vb = \frac{\pi d3N3}{60} \dots\dots\dots\dots\dots\dots\dots\dots (4.19)$$

$$Vb = \frac{\pi d3N3}{60} = \frac{3.14x0{,}075mx300rpm}{60} = 1.2m/s$$

$$Vb = 1.2m/s$$

Hence, centrifugal tension

$$Tc = m\,v^2 \dots\dots\dots\dots\dots\dots\dots. (4.20)$$

Where m = mass of belt per metre length

From dimension of standard v-belt according to IS: 2494 – 1974, the weight of belt per metre length is given as 3.43N/m

$$m = \frac{W}{g} = \frac{3.43kg\ m/s^2}{9.81m/s^2} = 0.35kg$$

m = 0.35kg

$$Tc = mv2 = 0.35kgx(1.2m/s)^2 = 4.93N$$

The power transmitted by the motor for one belt was obtained the following equation

$$P = 7.5KW$$

$$P = (T3 - T4)v \dots\dots\dots\dots\dots\dots\dots\dots.. (4.21)$$

$$T3 - T4 = P/V$$

$$T3 - T4 = 318.5N$$

$$T3 = 8.06T4 \dots\dots\dots\dots\dots \ From\ equation\ (4.18)$$

Solving equations (4.18) and (4.21) simultaneously yielded T2 = 45.1N and T1 = 363.06N.

The initial belt tension to therefore be:-

$$T0 = \frac{T3 + T4}{2} \dots\dots\dots\dots\dots\dots\dots. (4.22)$$

$$To = \frac{45.1N + 363.06N}{2}$$

T0 = 204.08N

The true initial tension of belt at rest is given as

T02 = T0+Tc=204.08N+2.3N=206.38N

#### 4.3.2.2 Screw Conveyor Design

Screw conveyer is designed in these for feeding sand to the sieve machine.

##### 4.3.2.2.1 Introduction

Screw feeders are devices suitable for handling a wide variety of materials that have good flow ability characteristics. The screw feeder has a helicoid surface fitted on a shaft that rotates inside a fixed tube. The material which comes out of the feed storage is pushed by the helicoid flight along the base of the tube in the direction of transport. The advantages of the screw feeder include the possibility of having different openings, each with its own shut-off organ for unloading the material. A number of years ago Rexnord proposed a set of selection guidelines, one for conveyors and the other for elevators that are useful for an indicative choice of conveyors on the basis of loading and unloading methods, the course of transport and the features of the material (flow ability, composition granulometry, temperature, friability, abrasiveness and corrosively).

In fact, the features of the material are a decisive factor in the selection of the conveyor/feeder device as regards both aspects: how the material affects the conveyor and, at the same time, how the conveyor affects the material. That is why, in a correct application, experience plays a fundamental role. There are, in fact, a number of devices that help and/or actually extract material in powder form from silos or hoppers: an initial classification is based on the fact that some of these merely aid the flow. Fluidification devices or mechanical vibrators are typical examples. These devices do not actually bring about extraction and can therefore be considered as accessories for correct functioning of the silo. As a rule, these devices are associated with batching systems having the function of controlling the gravity flow (screw feeder, rotary cell or drag chain) which alone cannot bring about complete emptying of the silo. Then there are specific devices, which are capable of ensuring complete emptying even in capacity batching conditions. These are usually found to be more expensive than a system comprising a flow aid device (vibrator) and a batching device (screw feeder); however, these are generally much more effective and for this reason are indispensable in all applications involving products that do not flow easily.

In brief, the strong points of the screw devices are:

- Reduced risk of environmental pollution;
- Flexibility of use;
- Functional reliability;
- Low investment costs;
- Easy to install;
- Flow, speed and dimensions.

Calculation of the nominal flow can be done once the screw geometry, its rotation speed and the filling coefficient are known [14].

The flow rate of a screw conveyor or feeder depends on a number of interlinked factors:

- Geometry of the screw;
- Rotation speed;
- Inclination;
- Geometry of the feed hopper and tube;
- Flow ability of the material.

The minimum pitch must be no less than one half the screw diameter (logging),the maximum pitch approx. one screw diameter.

#### 4.3.2.2.2 Design Consideration for Screw Conveyors

The trough is commonly fabricated from flat sheet from 2mm and 8mm thick.

The screw pitch t=(0.5 to 1.0)D. where D is the screw diameter. The screw diameter D is governed by the lump size. By being at least twelve times that for loads for uniform lump size and at least four times the maximum lump size in case of un-sized bulk materials. The screw speed is influenced by the nature of load and screw diameter. It increases inversely with the bulk weight. Screw diameter and the intensity of abrasive action of the material. Conveyors handling heavy material operate at around 50RPM and those designed to convey light loads at up to 150RPM.

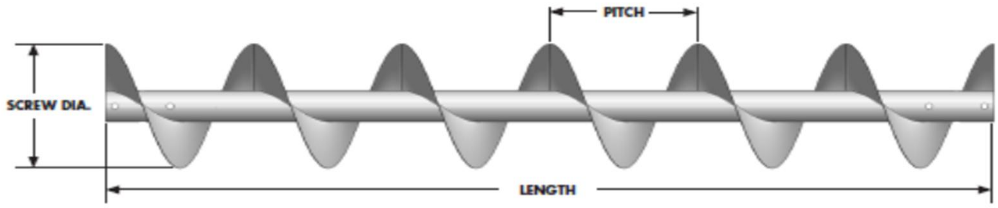



Figure 4. 2 Screw Conveyor

**4.3.2.2.3 Selecting a Screw Shaft**

***4.3.2.2.3.1 Maximum Length of the Screw Shaft***

Table 4.12 shows the manufacturing limit lengths of precision Ball Screws by accuracy grades

Unit: mm

Maximum length of the screw shaft

Table 4.12 Maximum Length of the Screw Shaft (screw conveyors engineering guide and part catalogue 2006)

| *Screw shaft outer diameter* | *Over all shaft length in mm* | | | | | |
|---|---|---|---|---|---|---|
| | C0 | C1 | C2 | C3 | C6 | C7 |
| 4 | 90 | 110 | 120 | 120 | 120 | 120 |
| 6 | 150 | 170 | 210 | 210 | 210 | 210 |
| 8 | 230 | 270 | 340 | 340 | 340 | 340 |
| 10 | 350 | 400 | 500 | 500 | 600 | 500 |
| 12 | 440 | 500 | 630 | 600 | 680 | 600 |
| 13 | 440 | 600 | 630 | 680 | 680 | 680 |
| 14 | 530 | 620 | 770 | 870 | 690 | 680 |
| 15 | 570 | 670 | 830 | 950 | 950 | 690 |
| 16 | 620 | 730 | 900 | 1050 | 1100 | 1100 |
| 18 | 720 | 840 | 1050 | 1220 | 1360 | 1400 |
| 20 | 820 | 950 | 1200 | 1400 | 1600 | 1600 |
| 25 | 1100 | 1400 | 1600 | 1800 | 2000 | 1800 |
| 28 | 1300 | 1600 | 1900 | 2100 | 2360 | 2400 |
| 30 | 1450 | 1700 | 2050 | 2300 | 2570 | 2700 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 32 | 1600 | 1800 | 2200 | 2600 | 2800 | 2950 |
| 36 | 2000 | 2100 | 2550 | 2950 | 3250 | 3200 |
| 40 | | 2400 | 2900 | 3400 | 3700 | 3650 |
| 45 | | 2750 | 3350 | 3950 | 5000 | 4300 |
| 50 | | 3100 | 3800 | 4500 | 6050 | 5800 |
| 55 | | 3460 | 4150 | 5300 | 6700 | 6600 |
| 63 | | 400 | 5200 | 6000 | 7650 | 7700 |
| 70 | | | 6300 | 6450 | | 9000 |
| 80 | | | | 7900 | | 10000 |
| 100 | | | | 10000 | | |

According to the standard table for screw selection for conveyor shaft length 1430mm the recommend screw diameter and shaft outside diameter is 76.2 mm and 30 mm respectively. Based on this standard data the following necessary parameter will be calculated [15].

The cross-sectional loading of a screw conveyor is given by

$$A = \varphi \frac{\pi d^2}{4} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots. (4.23)$$

Where $\varphi$ =the capacity factor which take account of the accumulation of load at inner bearing

D=screw Diameter

Table 4. 13 Table for values capacity factors (screw conveyors engineering guide and part catalogue 2006)

| *Material* | $\varphi$ |
|---|---|
| Heavy weight abrasive loads | 0.125 |
| Heavy weight mildly abrasive | 0.250 |
| Light weight mildly abrasive | 0.320 |
| Light weight non abrasive | 0.400 |

1. $A = \varphi \frac{\pi d^2}{4}$=0.320 $\frac{3.14x76.2^2}{4}$=1458.6mm2
2. The speed of conveyor

$$V = \frac{tn}{60} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.24)$$

$$t = (0.5\ to\ 1.0)D \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. (4.25)$$

Where t=pitch of screw (lead) (m)

n= rpm of the screw

t=0.75x76.2mm=57.15mm=0.05715m

$$V = \frac{0.05715mx150rpm}{60} = 0.13m/s$$

3. The hourly capacity can be calculated by

$$Q = 3.6Av\gamma k \frac{tons}{hr} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.26)$$

Where Q is hourly capacity of the screw

k = is a factor introduced in designing inclined conveyor

V= the speed of the conveyor (m/s)

γ = specific weight of the material ( kg/m3)

Table 4. 14 Values for K Corresponding the Inclination β

| *β(degrees)* | *0* | *5* | *10* | *15* | *20* |
|---|---|---|---|---|---|
| K | 1.0 | 0.9 | 0.8 | 0.7 | 0.75 |

Most natural aggregates have particle densities of between 2400 kg/m$^3$ and 2900 kg/m$^3$.

$$Q=3600\varphi \frac{\pi D^2}{4} \gamma \frac{tn}{60} k = 3600x0.320x \frac{3.14x0.0762^2}{4} x2400kg/m3 \frac{0.05715mx150rpm}{60} x1$$

$$Q = 1800.53kg/\text{hr}$$

Where Q =is hourly capacity of the screw

4. The power requirement in kW at the drive shaft for horizontal conveyors

$$Nh = Co\frac{QL}{367} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(4.27)$$

Where Nh=power requirement for horizontal conveyors

Co=friction factors from table 4.14.

L=Conveyor length (m)

The power required can be calculated as below

$$N_h = C_O\frac{QL}{367} = 4\frac{1800.53kg/hrx1.2m}{367} = 23.5kg.m = 6.2652x10^{-5}KW$$

5. Load per meter (kg.m)

$$q = \frac{Q}{3.6v} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(4.28)$$

$$q = \frac{1800.53kg}{3.6x0.13m/s} = 64.12kg.m$$

6. Axial force P(kg)

$$P = \frac{\boldsymbol{M}}{\boldsymbol{rtan(\alpha+\varphi)}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.29)$$

$$M_O = \frac{102No \times 60}{2\pi n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(4.30)$$

$$m = 975\frac{23.5kg.m}{150rpm} = 152.75kg.m$$

Where Mo= the resisting moment

No= Nh for horizontal conveyor

r= radius at which the force P is applied r= (0.7 to 0.8) x$\frac{D}{2}$=$0.75\frac{0.0762m}{2} = 0.03m$

μ=reduced friction angle.

$\tan\varphi = tan0.320 = 0.005585$

$\mu = 0.32$

α=screw helix angle

Screw helix angle can be calculated

$$tan\alpha = \frac{2\pi r}{lead} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(4.31).$$

$$tan\alpha = \frac{2x3.14x0.03m}{1.2m} = 0.157$$

α=8.9

The friction factors Co is adopted based on the experimental data

Table 4.15 Friction factors (screw conveyors engineering guide and part catalogue 2006)

| *Material* | *Co* |
|---|---|
| Flour, cereal, saw dust | 1.2 |
| Peat, soda ash, pulverized coal, finely ground chalk | 1.6 |
| Coal (lump anthracite and bituminous, air dry brown) rock salt | 2.5 |
| Gypsum, dry clay, sand, cement, ash, lime, molding sand | 4.0 |

Substituting the above calculated value to equation (4.29)

$$P = \frac{M}{rtan(\alpha + \varphi)} = \frac{152.75kgm}{0.03mtan(8.9 + 0.32)} = 2940.7kg$$

Where P is axial force in kg

#### 4.3.2.3 Design of shaft

## The shafts may be designed on the basis of

- Strength, and
- Rigidity and stiffness.

In designing shafts on the basis of strength, the following cases may be considered :

- Shafts subjected to twisting moment or torque only;
- Shafts subjected to bending moment only;
- Shafts subjected to combined twisting and bending moments, and
- Shafts subjected to axial loads in addition to combined torsional and bending loads[9].

By considering the above basic elements for shaft design the analysis for the shaft is performed as follow;-

a. Twisting moment of the shaft is:-

$$\frac{T}{J} = \frac{\tau}{r} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots. (4.32)$$

WhereT = Twisting moment (or torque) acting upon the shaft,

J = Polar moment of inertia of the shaft about the axis of rotation,

$\tau$= Torsional shear stress, and

r = Distance from neutral axis to the outer most fibre

$$r = \frac{d}{2} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (4.33)$$

Where d is the diameter of the shaft

$$J = \frac{\pi}{32} x d^4 \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (4.34)$$

$$T = \frac{\pi}{16} x \tau x d^3 \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (4.35)$$

The yield strength for steel SAE 1040 is 414Mpa and the ultimate tensile strength is 621Mpa[12].

$$J = \frac{\pi}{32} x d^4 = \frac{\pi}{32} x (30mm)^4 = 79{,}521.56mm^4$$

$$T = \frac{\pi}{16} x \tau x d^3 = \frac{3.14}{16} x 414N/mm^2 x (30mm)^3 \text{=2,194,795.2N/mm}$$

b. Bending moment of the shaft

$$\frac{M}{I} = \frac{\delta_b}{y} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots. (4.36)$$

Where M=bending moment of the shaft

I=moment inertia of the cross-sectional area of the shaft about its axis of rotation.

$\delta_b = bending\ stress$

Y=distance from the neural axis to the outer most fibre

$$I = \frac{\pi}{64} x d^4 \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (4.37)$$

$$y = \frac{d}{2} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (4.38)$$

$$M = \frac{\pi}{32} x \delta_b x d^3 \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (4.39)$$

Since the diameter of the shaft is 30mm the moment of inertia and bending moment can be calculated as follow.

$$I = \frac{3.14}{64} x(30mm)^4 = 39760.8mm^4$$

$$\delta_b = \frac{\delta_{tu}}{F.S} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (4.40).$$

$$= \frac{621N/mm^2}{5} = 124.2N/mm^2$$

$$where\ \delta_{tu} = is\ ultimate\ tensile\ stress$$

$$F.S = factor\ of\ safety$$

$$M = \frac{\pi}{32} x \delta_b x d^3 = \frac{\pi}{32} x 124.2N/mm^2 x (30mm)^3$$

$$M = 329219.3N/mm$$

For the solid shaft with a diameter 30mm carrying two pulley at a distance of 20mm and 80 mm and the mass of pulley 0.5kg and 1kg.

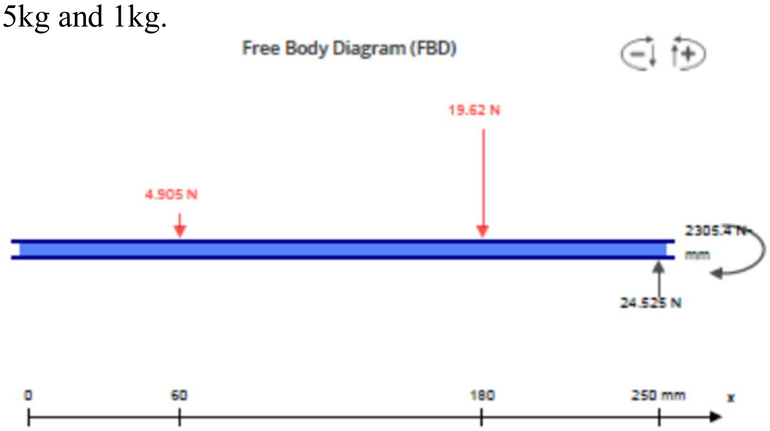



Figure 4. 3 Free Body Diagram

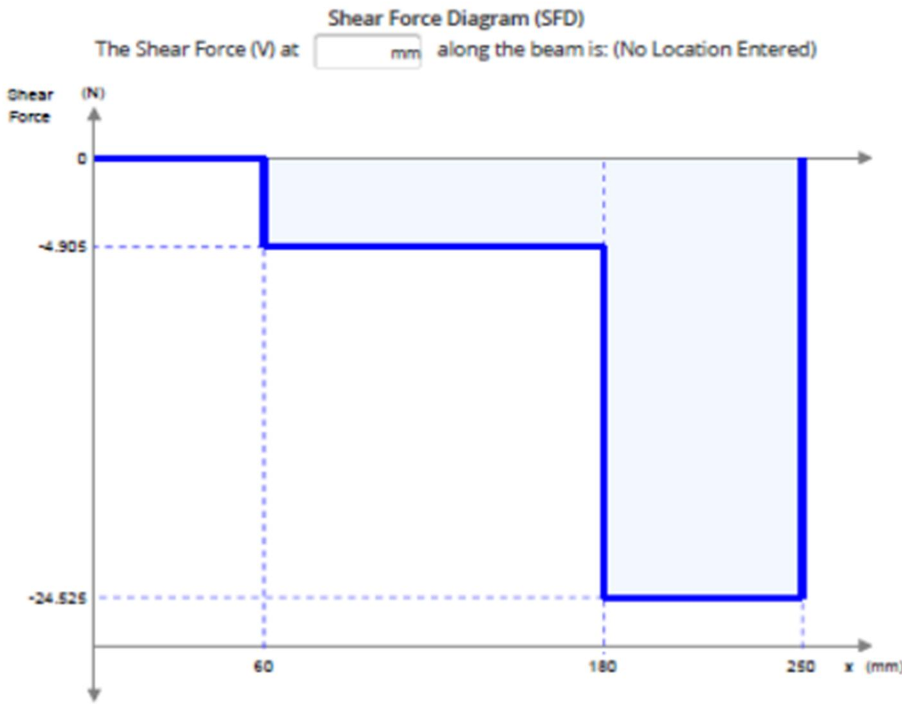



Figure 4. 4 shear Force diagram

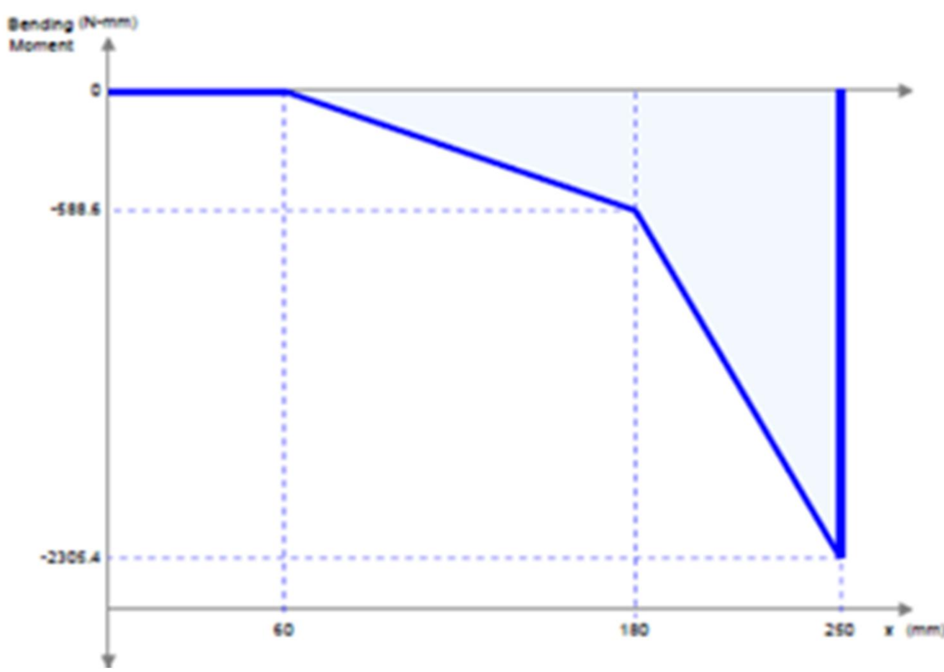



Figure 4.5 Bending Moment Diagram

$$FL = mg \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.41)$$

$$where\ FL = weight\ of\ larger\ pulley\ is\ given$$

$$m = 2kg$$

$$A = \pi r2 = 3.14x(150mm)2 = 70{,}685.8mm2$$

$$Fl = 2kg \times 9.81m/s2 = 19.62m/s2 = 19.62N$$

$$Fl = 19.62N$$

$$Fs = mg = weight\ of\ smaller\ pulley$$

$$m = 0.5kg$$

$$Fs = 0.5kgx9.81m/s2 = 4.905/s2 = 4.905N$$

I. Vertical load at larger pulley (B)

$$Wb = T1 + T2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.42)$$

$$Wb = 363.06N + 45.1N = 408.16N$$

II. The vertical load at smaller pulley(C) is zero

$$Wc = 0$$

III. Torque action on a pulley

$$T = (T1 - T2)R_B \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4.43)$$

Where RB is radius of larger pulley

T= (363.06N-45.1N) 0.15m=47.7Nm

T3=Tension in the tight side of the belt on smaller pulley at C

T4=Tension in the slack side of the belt on smaller pulley at C

Since torque on both pulley is the same at B and C

$$(T3 - T4)Rc = T \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots.. (4.44)$$

$$T3 - T4 = \frac{T}{Rc}$$

$$T3 - T4 = 1272N$$

$$\frac{T3}{T4} = \frac{T1}{T2}$$

$$\frac{T3}{T4} = 8.05$$

$$T3 = T4x8.05N$$

$$(T48.05N - T4)0.0375m = 47.7N.m$$

$$T4 = 180.408N$$

$$T3 = 180.40x8.05 = 1452.3$$

IV. Horizontal load at smaller pulley at point C is

$$Wc = T3 + T4 = 1452.3N + 180.408N = 1632.7N$$

$$Wc = 1632.7N$$

V. Horizontal load at point B is zero

The maximum bending moment at vertical and horizontal load will be analyzed as follow

Fist let us consider the vertical load at B

$$R_{AV} + R_{DV} = 408.16N \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (4.45.)$$

Where $R_{DV}$ $is\ rection\ force\ at\ free\ ende$

$$R_{AV}\ is\ reaction\ force\ at\ piont\ A\ or\ at\ flanged\ ende$$

$$R_{AV} = 0$$

$$R_{AV}x0.3 = 408.16Nx0.215$$

$$R_{AV} = 292.5N$$

VI. Bending moment at B and C of vertical load

$B.M\ at\ B = MBV = RAVx0.215 = 292.5Nx0.125 = 36.56N$

$B.M\ at\ C = MCV = RDVx0.215 = 0x0.0.1 = 0$

- Bending moment at horizontal load at C reaction force

$$RAH + RDH = 1632.7\ N$$

$$RAHx0.3 = 1632.7Nx0.4$$

$$RAH = 2176.9N$$

$$RDH = 2176.9N - 1632.7N = 544.23N$$

Bending moment for horizontal loading

$$B.M\ at\ B = MBH = RAHx0.215 = 2176.7Nx0.125 = 272.08N$$

$$B.M\ at\ C = MCH = RDHx0.215 = 544.23Nx0.1 = 54.4N$$

VII. Resultant bending moment at B

$$MB = \sqrt{(MBV)^2 + (MBH)^2} = \sqrt{(36.56)^2 + (272.07)^2} = 276.9N$$

$$MC = \sqrt{(MCV)^2 + (MCH)^2} = \sqrt{(0)^2 + (54.4)^2} = 54.4N$$

The bending moment is maximum at larger pulley at point center of larger pulley.

#### 4.3.2.4 Design of keys

When pulleys and similar machine elements are required to be fixed on shafts the most common solution is the use of a key and keyway. The section of the key is determined mainly by the diameter of the shaft requiring the connection.

a) Key on the sieve and screw conveyor shaft

A rectangular sunk key is used to fix a pulley to shaft for power transmission. The usual proportion of this is:

Width of key, $w = \frac{d}{4}$ … … … … … … … (4.46)

And thickness of key, $t = \frac{2w}{3} = \frac{d}{6}$ … … … … … … … .. (4.47)

Where d = diameter of the shaft or diameter of the hole in the hub.

$$w = \frac{30mm}{4} = 7.5mm$$

Where W is width of key

$$t = \frac{2w}{3} = \frac{d}{6} = \frac{30}{6} = 5mm$$

Where t is thickness of key

The yield strength for steel SAE 1040 is 414Mpa and the ultimate tensile strength is 621Mpa.The diameter of shaft is 30mm, so from standard table width, w = 7.5mm and thickness, t= 5mm. The length of key, L is obtained by considering the key in shearing and crushing.

- Yield strength of material 414Mpa
- Allowable stress (without key) $=\frac{414Mpa}{5} = 82.8Mpa$
- Allowable stress (with key)=0.85x82.8Mpa=70.38Mpa
- Shearing strength =82.8Mpa
- Crushing strength =of 70.38 Mpa of the shaft material, we know that the shearing strength (or the torque transmitted) of the key.

$$T = L\,x\,w\,x\,\tau\frac{d}{2} = L\,x\,7.5\,x\,82.8Mpa\,x\,\frac{30}{2} = 9315N\,x\,L \text{ … … … … … … … (4.48)}$$

And torsional shearing strength or torque transmitted of the shaft;

$$T = \frac{\pi}{16}\tau x d^3 \text{ … … … … … … … … … … … .. (4.49)}$$

$$T = \frac{\pi}{16}x\;82.8N/mm^2\;x(30mm)^3 = 437{,}368.6Nmm$$

From the equation (4.48 and 4.49) we have

9315N (L) = $437{,}368.6Nmm$

L =49.6mm

Now, considering crushing of key taking tensile strength (torque transmitted) of the key

$$T = L\,x\,\frac{t}{2}x\sigma c x\frac{d}{2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.(4.50)$$

$$T = L\,x\,\frac{8}{2}x\,70.38\,x\frac{30}{2} = 4222.8N(L)$$

$$T = L\,x\,\frac{8}{2}x\,70.38\,x\frac{30}{2} = 4222.8N(L)$$

$$T = \frac{\pi}{16}70.38x(30mm)^3 = 373{,}115.18Nmm$$

$$T = 373{,}115.18Nmm = 4222.8N(L)$$

$$L = \frac{373{,}115.18Nmm}{4222.8N} = 88mm$$

Since the length obtained in crushing case is greater than shearing which is 88mm is taken as length of the key.

#### 4.3.2.4 Drum or Trammel Design Analysis

For this machine as a drum or trammel standard barrel used for oil container made of steel with outside diameter of 570mm, inner diameter 562m and thickness of 0.8mm is selected.

The analysis of the trammel is performed as follow:-

D= Outer Diameter

d = Inner diameter

T = Thickness

If the outer diameter of the rolled material is D, the inner diameter d, the thickness of the material T, and the length L, then the following equation is true:

$$LT = \pi\left[\frac{D2}{4} - \frac{d2}{4}\right] \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(4.49)$$

$$L = \frac{\pi\left[\frac{D2}{4} - \frac{d2}{4}\right]}{T} = \frac{\pi\left[\frac{(580mm)^2}{4} - \frac{(579mm)^2}{4}\right]}{0.1mm} = 9094.9mm$$

$$A = 2\pi\mathrm{r}(\mathrm{r} + h) = 2x3.14x290mm(290mm + 9094.9mm) = 17.1m^2$$

$$W = m.g = 2kgx9.81m/s^2$$

$$W = 19.62kg.m/s2 = 19.62N$$

Torque required to Rotate

$$T = WxRxg \ldots\ldots\ldots\ldots\ldots\ldots\ldots.(4.50)$$

$$T = 19.62Nx0.290mx9.81m/s2 = 55.81N$$

Power required producing the above torque

$$P = \frac{Tx2\pi xN}{60} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4.51)$$

Where P =is power required to produced torque

$$N = \frac{60}{2\pi}\sqrt{\frac{g}{r}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4.52)$$

$$N = \frac{60}{2x3.14}\sqrt{\frac{9.81m/s^2}{0.29m}} = 55.54\ rpm$$

Where N is speed of the trammel

$$P = \frac{55.81x2x3.14x55.4}{60} = 323.656Nm$$

Velocity of sand

$$Vest = ND = 29.9m/s2x0.57m = 17.043s^2$$

Volume of the trammel is

$$V = \pi r^2 h \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots. (4.53)$$

$$Where\ V = is\ volume\ of\ the\ trammel$$

$$R = \ is\ radius\ of\ trammel$$

$$h = \ is\ length\ of\ the\ trammel$$

$$V = 3.14x(290mm)^2x9094.9mm) = 2.4m^3$$

#### 4.3.2.5 Screw fastener design analysis

In this machine the joining of barrel with sieve of different opening size is performed by screw with M6. According to the design dimension of I.S.O screw threads for screw, bolts and nuts of coarse and fine series table (Design dimensions of screw threads, bolts and nuts according to IS: 4218 (Part III) 1976 (Reaffirmed 1996)). For bolts M6 [9].

- Pitch is 1mm
- Major or Minor diameter nut and bolt (d=D)in mm is 6mm
- dp 5.350mm

  Where dp is diameter pitch of the screw
- dc 4.773mm for bolts and 4.918mm for nuts

Where dc is core diameter of the screw

- depth of thread(bolts)=0.613mm
- stress area is 20.1mm$^2$

The stress induced in this connection is analyzed as follows:-

a. Stresses in Screwed Fastening due to Static Loading

The following stresses in screwed fastening due to static loading are important from the subject point of view:

- Internal stresses due to screwing up forces,
- Stresses due to external forces, and
- Stress due to combination of stresses.

1. Initial Stresses due to Screwing up Forces

The following stresses are induced in a bolt, screw or stud when it is screwed up tightly.

A. Tensile stress due to stretching of bolt.

$$Pi = 1420dN \dots \dots \dots \dots \dots \dots \dots \dots \dots .. (4.54)$$

Where Pi= is initial tension stress

d =is diameter of bolt

$$P = permissible\ stress\ x\ crossectional\ area\ at\ a\ bottom\ of\ the\ thread$$

$$Stress\ area\ = \frac{\pi}{4}\left(\frac{dp + dc}{2}\right)^2 \dots \dots \dots \dots \dots \dots \dots . (4.55)$$

$$Where\ dp =\ is\ pitch\ diameter$$

$$dc =\ is\ core\ or\ minor\ diameter$$

From the equation(4.54)

$$Pi = 1420x6mmN = 8520N$$

$$Stress\ area\ = \frac{\pi}{4}\left(\frac{5.350mm + 4.773mm}{2}\right)^2 = 20.1mm^2$$

$$permissible\ stress = \frac{P}{stress\ area} = \frac{8520N}{20.1mm^2} = 423.9N/mm^2$$

B. Torsional shear stress caused by the friction resistance of the threads during tightening

$$\frac{T}{J} = \frac{\tau}{r} \dots \dots \dots \dots \dots \dots \dots \dots . (4.56)$$

$$\tau = \frac{16T}{\pi(dc)^3} \dots \dots \dots \dots \dots \dots \dots \dots \dots \dots (4.57)$$

Where $\tau$ = Torsional shear stress

T= Torque

C. Shear stress across the threads

$$\tau_s = \frac{P}{\pi dcxbxn} \dots\dots\dots\dots\dots\dots.. (4.58)$$

Where b= width of the thread section at the root

Average shear stress

$$\tau_s = \frac{P}{\pi dxbxn} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (4.59)$$

Where d is major diameter

$$\tau_s = \frac{8520N}{\pi x6x0.3707x10} = 94.7N/mm^2$$

$$T = \frac{\tau_s x3.14x(dc)^3}{16} = \frac{94.7N/mm^2 x3.14x(4.773mm)^3}{16} = 2020.85N.mm$$

D. Compression or crushing stress on threads

$$\delta_c = \frac{P}{\pi[d^2 - (dc)^2]n} \dots\dots\dots\dots\dots\dots\dots\dots\dots (4.60)$$

- Where $\delta_c is\ crushing\ stress$
- d is major diameter
- dc is core diameter
- n is number of threads in engagement

$$\delta_c = \frac{8520N}{\pi[6^2 - (4.773)^2]10} = 20.42N/mm^2$$

#### 4.3.2.6 Machine Frame Welding Strength Analysis

Strength analysis of welded frame supporting mechanism of machine. The frame sieve or barrel, roller used for barrel rotational motion, screw conveyor hopper and motor from the bottom is welded together by a closed fillet. The fillet joint is obtained by overlapping the plates and then welding the edges of the plates. The cross-section of the fillet is approximately triangular. In order to determine the strength of the fillet joint, it is assumed that the section of fillet is a right angled triangle ABC with hypotenuse AC making equal angles with other two sides AB and B. the length of each side is known as leg or size of the weld and the perpendicular distance of the hypotenuse from the intersection of legs (i.e. BD) is known as throat thickness. The minimum area of the weld is obtained at the throat BD, which is given by the product of the throat thickness and length of weld.

We find that the throat thickness

$$t = sxsin45^0 = sx0.707 \quad \dots\dots\dots\dots\dots\dots. (4.61)$$

$$A = txl = sx0.707xl$$

$$P \ = \ Ax \ \sigma t \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (4.62)$$

where t = Throat thickness,

s = Leg or size of weld, Thickness of plate, and

l = Length of weld,

A= Maximum area of the weld or throat

l = length of weld = 40mm on a square pipe of 40mmx40mmx1.5mm mild steel in dimension

σt allowable tensile stress for the weld

p = total load on the frame.

S=1.5mm

$$t = 1.5mmx0.707 = 1.06mm$$

$$A = 1.06mmx40mm = 42.42mm^2$$

Recommended Allowable tensile stress for steady load of welding with coated electrode is 90MPa from the table.

Table 4.16 Recommended Allowable Tensile Stress welding (text book of machine design R.S KHURMI and J.K GUPTA 20050

| *Types of weld* | *Bare electrode* | | *Coated electrode* | |
|---|---|---|---|---|
| | Steady load(MPa) | Fatigue load(MPa) | Steady load(MPa) | Fatigue load(MPa) |
| Fillet welds all types | 80 | 21 | 98 | 35 |
| Butt welds | | | | |
| Tension | 90 | 35 | 110 | 55 |
| Compression | 100 | 35 | 125 | 55 |
| Shear | 55 | 21 | 70 | 35 |

The allowable tensile stress for steady load of all with coated fillet welds is 98 MPa.

$$P = 2x0.707sxlx\sigma t = 2x1.06mmx40mmx98N/mm^2 = 8310N$$

For the metal thickness 1.5mm and welding length 40mm of double fillet weld the maximum area of the weld should be 42.2mm$^2$ and the total load is 8310N which sufficient for our machine.

#### 4.3.2.6 Bearing selection

There are two types of rolling contact bearings. The ball and roller bearings consists of an inner race which is mounted on the shaft or journal and an outer race which is carried by the housing casing. In between the inner and outer race, there are balls or rollers. A number of balls or rollers are used and these are held at proper distance by retainers so that they do not touch each other. The ball bearings are used for light loads and the roller bearings are used for heavier loads. Since medium load is required for sand sieving machine medium size radial ball bearing. In addition, the machine is designed on small scale ball bearings can efficiently run the machine assembly. There is only radial load (Wr) on the bearing as there is no load applied to shift the plane of rotation of the balls.

The selected deep groove ball bearings, as the balls are symmetrically located by the use of a retainer or case. The deep groove ball bearings are used due to their high radial load capacity and suitability for high running speeds.

i. Radial bearing selection for the shaft of screw conveyor

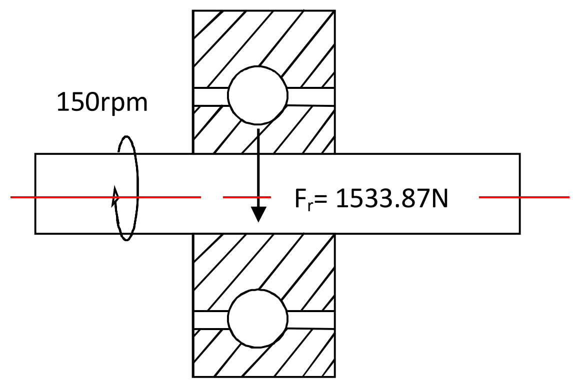



Figure 4.6 Bearing for Screw Shaft

Where 150 is speed of screw shaft

Fr is radial load on the shaft

Decisions and Assumptions:-

- A Conservative Design For Light To Moderate Impact Is Required
- A Compressive Design For 8hr Per Continuous Service Is Required
- A 90% Reliability Is Required
- A radial ball bearing (A = L04Should Be Chosen)
- Ball Bearing life varies inversely with $\frac{10}{3}$ power of the load

#### 4.3.2.6.1 Design analysis

Only radial load, Fr is applied

From bearing catalogue ka = 1.5 (moderate impact) and 8hrs every working day has 30000 hr life.

The shaft rotates at 150 rpm

Hence, life corresponding to radial load (Fr),or life required by the application

$$L = rpm\,x\,hr\,life \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4.63)$$

$$L = 150rpm\,x\,30000hrs\,x\,60min/hr = 27x107rev$$

From standard catalogue for standard 90% reliability life corresponding to rated capacity ( Lr = 90 x 106 rev)

The required value of rated capacity, Creq

$$Creq = Fr\left(\frac{L}{LR}^{0.3}\right) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4.64)$$

Where Fr- radial load, L- design life evolution

$$Creq = 1.533\,x\,10\,3\,N(\frac{27\,x10^{7}\,rev}{90\,x10^{6}rev})0.3 = 1379.7N$$

Based on the analysis and assumption radial ball bearing from the standard catalogue, the appropriate radial bearing would be: bearing basic number L04, bore = 30mm, outer diameter = 63mm, and width = 23mm is selected since it can satisfy the analysis and assumption.

#### 4.3.2.7 Roller Design Analysis

##### 4.3.2.7.1 Design analysis of the shaft holding roller

Similar Material is that selected for sieve is used for roller shaft design analysis because it can fulfill the functional requirement. Material selected for the shaft is SAE 1040 for designing and the required safety factor are 5. The yield strength for steel SAE 1040 is 414Mpa and the ultimate tensile strength is 621Mpa [12].

Yield strength of SAE 1040 = 621Mpa

Allowable stress (without keyway) = 621Mpa/5 =124.2Mpa

Peripheral speed, $V_p$ of a shaft holding roller

$$Vp = \omega r \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4.65)$$

where ω – angular speed and r-peripheral radius

Angular speed $=\frac{2x3.14x300rpm}{60} = 31.4$

$$Vp = \frac{2\pi Nr}{60}X0.01 = \frac{2\,x\,\pi\,x\,300\,x\,0.01m}{60}X0.01 = 0.0314m/s$$

Force required holding the roller is

$$Fr = m.a \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (4.66)$$

Where m is mass of roller

a = acceleration due to gravity which 9.81m/s$^2$

**Mass of the roller is 0.13kg**

**F=0.13kgx9.81m/s$^2$=3.08N**

The power P, required to turn the shaft is,

$$P = Frx\,Vp \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (4.67).$$

$$P = 3.08N\,x\,0.314m/s = 0.967Nm/s$$

Bending moment M, of the shaft holding the roller is caused by the shearing force of trammel and weight of the roller.

$$W = mg \dots\dots\dots\dots\dots\dots\dots\dots. (4.68)$$

where W- weight trammel and g-acceleration due to gravity

= 2kg x9.8N/kg = 19.62N

Bending moment M, on the shaft is

M =19.6N x 0.08m= 1.57Nm

The torque T, on the shaft is

$$T = \frac{P}{\omega} \dots\dots\dots\dots\dots\dots\dots\dots\dots (4.69)$$

Where P-power on the shaft and ω- is angular speed

$$T = \frac{967N}{31.4} = 30.8\text{Nm}$$

#### 4.3.2.7.2 Roller support welding strength analysis

Strength analysis of welded joint of the roller supporting the mechanism of the machine. The roller used for trammel rotational motion, have a support is welded together by a closed fillet. The fillet joint is obtained by overlapping the plates and then welding the edges of the plates. The cross-section of the fillet is approximately triangular. In order to determine the strength of the fillet joint, it is assumed that the section of fillet is a right angled triangle ABC with hypotenuse AC making equal angles with other two sides AB and B. the length of each side is known as leg or size of the weld and the perpendicular distance of the hypotenuse from the intersection of legs (i.e. BD) is known as throat thickness. The minimum area of the weld is obtained at the throat BD, which is given by the product of the throat thickness and length of weld [13].

t = Throat thickness,

s = Leg or size of weld, Thickness of plate, and

l = Length of weld,

We find that the throat thickness

$$t = sxsin45^0 = sx0.707 \dots\dots\dots\dots\dots\dots (4.70)$$

$$A = txl = sx0.707xl \dots\dots\dots\dots\dots\dots. (4.71)$$

$$P = Ax\, \sigma t \dots\dots\dots\dots\dots\dots\dots\dots\dots (4.72)$$

Where :

A=Maximum area of the weld or throat

l = length of weld = 75mm because the frame is 4mm in dimension

σt =allowable tensile stress for the weld

p = total load on the support

Since the thickness plate is 4mm we can take it as S=4mm

$$t = 4mmx0.707 = 2.828mm$$

$$A = 2.828mmx75mm = 212.1mm^2$$

$$P = Ax\sigma t = 2x0.707sxlx\sigma t = 2x0.707x4mmx75mmx21N/mm^2 = 8908.2N$$

For the metal thickness 4mm and welding length 75mm of single fillet weld the maximum area of the weld should be 212.1 $mm^2$ and the total load is 8908.2N which sufficient supporting of the roller.

#### 4.3.2.8 Sieve selection

In manufacturing of this machine types sieve size used is selected based on the grain size of sand needed in construction.

Using the above motioned standard in table 2.2 and 2,3 and information we obtained from our observation the sieve N0.4 and N0.8 is the most commonly used in construction industry in our country. Therefore the selected sieve size for this machine is No.4 and No.8 types additionally sieve with opening 37.5mm is selected as a coarse [1].

# CHAPTER FIVE

# MANUFACTURING PROCESS, ASSEMBLY AND MAINTENANCE OF THE MACHINE

## 5.1. Manufacturing Process

Manufacturing Processes is refers to science and technology of manufacturing products effectively, efficiently, economically and environment-friendly through application of any existing manufacturing process and system, proper selection of input materials, tools, machine sand environments, improvement of the existing materials and processes and development of new materials, systems, processes and techniques. All such manufacturing processes, systems, techniques have to be technologically acceptable, technically feasible, economically viable and eco-friendly. Manufacturing process develops tremendously to increase ***production, capacity, productivity and quality*** to get higher profit. In broad outlines man's discovery and invention of materials and processes to make things, since 6000 years ago and principle of division of labour → Adam Smith (~1750).A manufacturing process is a designed procedure that results in physical and/or chemical changes to a starting work material with the intention of increasing the value of that material. A manufacturing process is usually carried out as a unit operation ,which means that it is a single step in the sequence of steps required to transform the starting material into a final product[8].

### 5.1.1 Basic Manufacturing Processes

It is the manufacturing processes that create or add value to a product. Manufacturing operations can be divided into two basic types:

(1) Processing operations and

(2) Assembly operations.

**A processing operation** transforms a work material from one state of completion to a more advanced state that is closer to the final desired product. It adds value by changing the geometry, properties, or appearance of the starting material. In general, processing operations are performed on discrete work-parts, but certain processing operations are also applicable to assembled items.

**An assembly operation** joins two or more components to create a new entity, called an assembly, subassembly, or some other term that refers to the joining process[17].

#### 5.1.1.1 Processing Operations

A processing operation uses energy to alter a work part's shape, physical properties, or appearance to add value to the material. The forms of energy include mechanical, thermal, electrical, and chemical. More than one processing operation is usually required to transform the starting material into final form. The operations are performed in the particular sequence required to achieve the geometry and condition defined by the design specification. The three categories of processing operations are:

1. **Shaping processes:** Most shape processing operations apply heat, mechanical force, or a combination of these to effect a change in geometry of the work material. The common operations used for this process are casting, forging, extruding, rolling, drawing, bending, shearing, spinning, powder metal forming, squeezing, etc.

2. **Property-enhancing operations** add value to the material by improving its physical properties without changing its shape. Heat treatment is the most common example.

3. **Surface processing operations:** are performed to clean, treat, coat, or deposit material onto the exterior surface of the work. Common examples of coating are plating and painting[17].

#### 5.1.1.2 Assembly Operations

The second basic type of manufacturing operation is assembly, in which two or more separate parts are joined to form a new entity. Components of the new entity are connected either permanently or semi permanently. Permanent joining processes include welding, brazing, soldering, and adhesive bonding. They form a joint between components that cannot be easily disconnected. Certain mechanical assembly methods are available to fasten two (or more) parts together in a joint that can be conveniently disassembled. The use of screws, bolts, and other threaded fasteners are important traditional methods in this category. Other mechanical assembly techniques form a more permanent connection; these include rivets, press fitting, and expansion fits [8].

### 5.1.2 Production Machines and Tooling

Manufacturing operations are accomplished using machinery and tooling (and people). The extensive use of machinery in manufacturing began with the Industrial Revolution. A machine tools is power driven machines used to operate cutting tools previously operated by hand. Machine tools are among the most versatile of all production machines. They are used to make not only parts for consumer products, but also components for other production machines. The production machines include presses for stamping operations, forge hammers for forging, rolling mills for rolling sheet metal, welding machines for welding, and insertion machines for inserting electronic components into printed circuit boards. The name of the equipment usually follows from the name of the process.

### 5.1.3 Production Systems

To operate effectively, a manufacturing firm must have systems that allow it to efficiently accomplish its type of production. Production systems consist of people, equipment, and procedures designed for the combination of materials and processes that constitute a firm's manufacturing operations. Production systems can be divided into two categories:

(1) Production facilities and

(2) Manufacturing support systems,

**Production facilities** refer to the physical equipment and the arrangement of equipment in the factory. **Manufacturing support systems** are the procedures used by the company to manage production and solve the technical and logistics problems encountered in ordering materials, moving work through the factory, and ensuring that products meet quality standards [17].

### 5.1.4 Manufacturing process Planning and Selection

Manufacturing planning are to ensure product quality, minimize cost and maximize efficiency, depending on production systems emphasis. Process planning involves determining appropriate manufacturing processes and the order to produce a product specified by design Engineering based on available equipment and productive capacity. The process planning activities are:

- Interpretation of design drawings. Analyses of materials, dimensions, tolerances, surface finishes, etc.

- Processes and sequence. Selecting required processes and their sequence (brief description).
- Equipment selections - utilize existing equipment or purchase or invest in new equipment.
- Tools, dies, mold, fixtures, and gages for each processing step. Design, fabrication and contract of these tools is delegated to a tool design / room department and tool
- Methods analysis. Workplace layout, small tools, material handling and motions must be specified.
- Work standards. Time standards for each operation.
- Cutting tools and cutting conditions. for machining operations, with reference to standard recommendations[14].

#### 5.1.4.1 Process planning

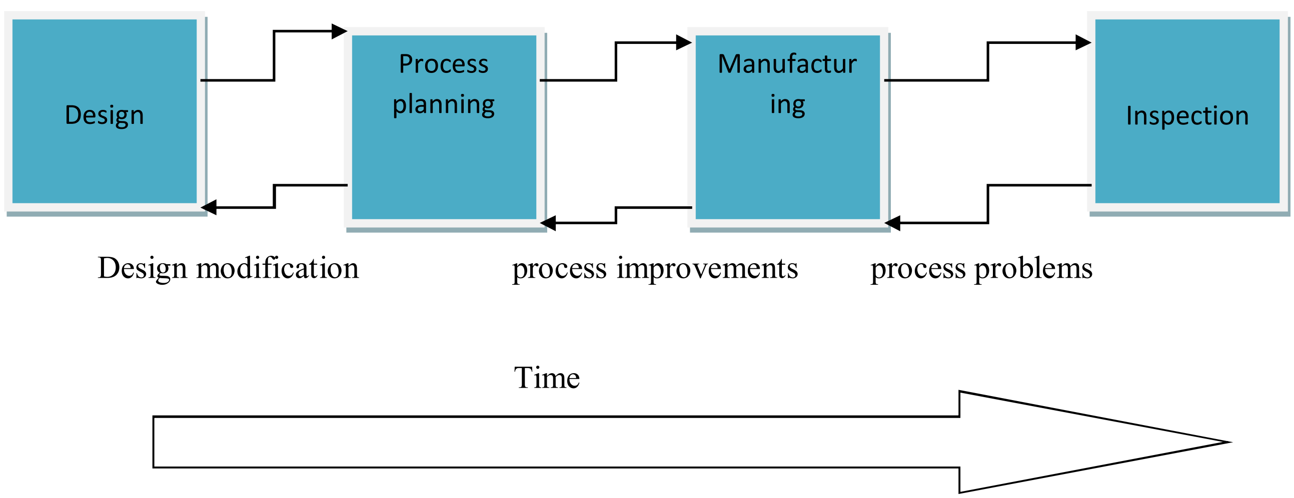



Figure 5.1 Process planning – the design and manufacturing interface

### 5.1.4.2 Flow chart for multipurpose sieving machine assembly

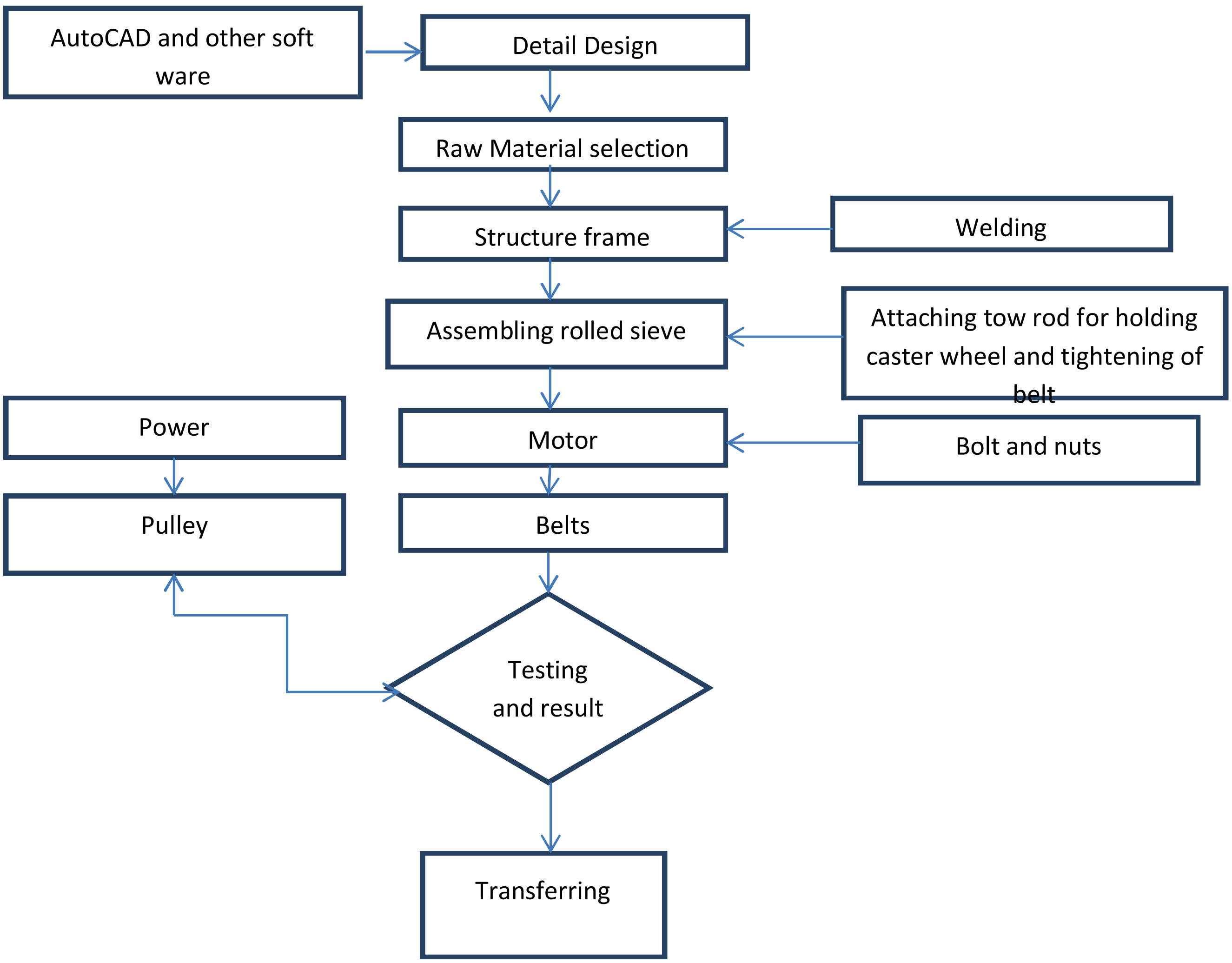



Figure 5. 2 Flow Chart

#### 5.1.4.3 Operation Processes Sheet for Assembly

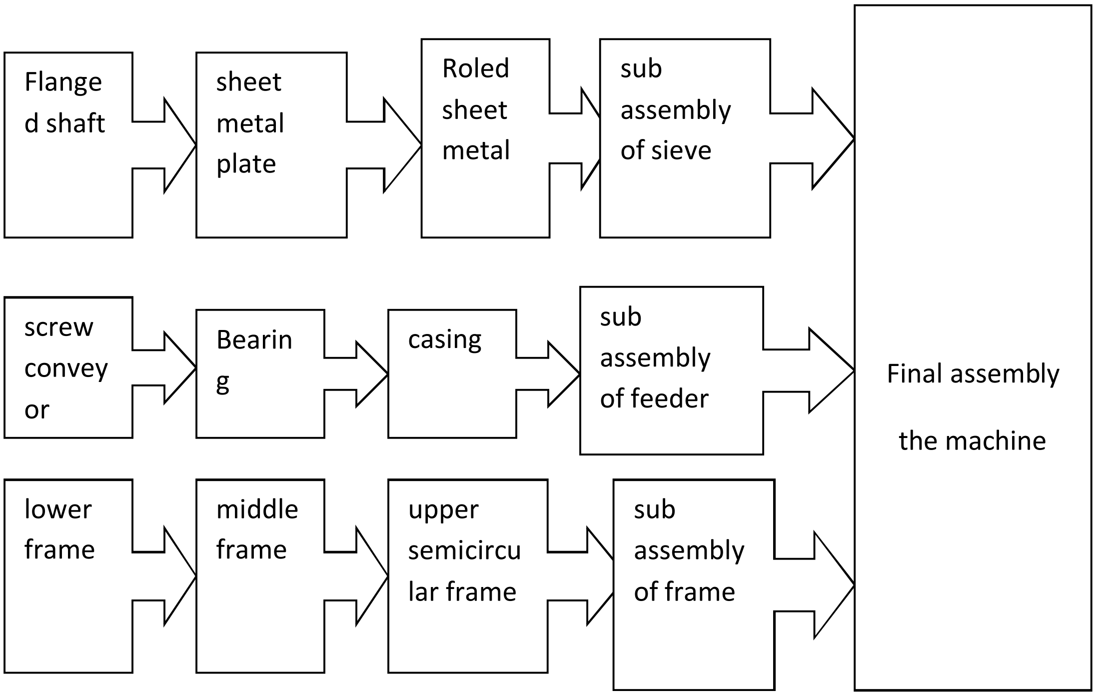



Figure 5.3 Operation Processes

## 5.2 Designs for Manufacture (DFM)

Design is a communication-intensive activity in which both words and pictures are used; written and oral forms are employed. Engineers have to communicate effectively and work with people of many disciplines. These are important skills, and an engineer's success depends on them.

Design for manufacture (DFM) is a series of guidelines that should follow to produce a product easily and profitably. DFM guidelines focus on two issues:

1. Design simplification means reducing the number of parts and features of the product whenever possible. A simpler product is easier to make, costs less, and gives us higher quality.
2. Design standardization refers to the use of common and interchangeable parts. By using interchangeable parts possible to can make a greater variety of products with less inventory and significantly lower cost and provide greater flexibility [12].

### 5.2.1 Basic DFM Guidelines Used in this Job Are:

The engineers should be respect design considerations. When expression designs consideration, are referring to some characteristic that influences the design of the element or, perhaps, the entire system. Usually quite a number of such characteristics must be considered and prioritized in a given design situation. According to machine as follow: Functionality, Noise, Strength/stress, Styling, Distortion/deflection/stiffness, Shape, Wear, Size, Corrosion, Control, Safety, Reliability, Surface, Manufacturability, Lubrication, Utility, Marketability, Cost, Maintenance, Volume, Weight, Remanufacturing/resource recovery.

## 5.3 Manufacturing of Multi-Purpose SIEVES MACHINE

In manufacturing, material things (goods) are made to satisfy human wants. The result of the project is manufacture multi-purpose sieves machine. Products can be manufactured by fabricating or by processing. Fabricating is the manufacture of a product from pieces such as parts, components, or assemblies. Individual products or parts can also be fabricated. Processing is also used to refer to the manufacture of a product by continuous means, or by a continuous series of operations, for a specific purpose. We will evaluate the form, fit and function of the parts by making prototype. The prototype will use the same material of the final product if technology permitted. The reasons of developing prototype are:

- The conceptualization of a design and part geometry
- The fabrication of product parts
- The mechanical performance of the fabricated parts
- The functionality test

## 5.4 Part description, function and Fabrication procedures of the basic components of the machine

### 1. Main Frame

The frame works as main a body in the multipurpose sieve machine on which all other parts are mounted (attached). The frame is made up of mild steel square pipe (40 × 40 × 1.5 mm) welded together to provide the desired strength and rigidity. The container openers are attached to the frame which is used to sieve the sand and soil. While the screw conveyor is attached on it to feed sand and soil.

**2. Sieve**

Sieve is the material used to separate coarse grain size from fine grain size material. It's made from different size hole that can help separation of particle. **A** motorized trammel is a rotating cylindrical screen or sieve that separates fine sand and compost material from rough. It's especially good at rotating out fine sand and compost from coarse material a heap of rot and leaves respectively.

**3. Screw conveyor**

Screw conveyors are bulk material transportation systems composed of a rotating, spiral screw inside tubular casing or a trough. Screws can be constructed from a range of materials including mild steel, stainless steel, abrasion resistant alloys, and nickel alloys.

**4. Sand and compost feeder /container or casing**

The trammel receive sand and compost that are dropped by the rotary screw and then give out the sands and compost to the sieve delivery.

**5 Sand and compost guider**

Is used to guide the sand and compost to the container or storage area.

## 5.5 Power Transmission Unit/ Pulley Mechanism/ and the Power Source

The power transmission unit has the following main components'

Table 5.1 Power Transmission Unit

| ***No.*** | ***Unit*** |
|---|---|
| 1. | Pulley wheel |
| 2. | Shaft |
| 3. | Belt |
| 4. | Roller |
| 5. | Motor |
| 6. | Key |

The function of power transmission unit is to provide drive from ground motor to all parts of the sieve machine. First the motor belt connects the trammel shaft to the pulley wheel with shaft connected to the screw conveyor. Pulley and belt drive the sieve and screw parts.

## 5.6 Operation sheet of the main parts of the machine

### 5.6.1 Main frame

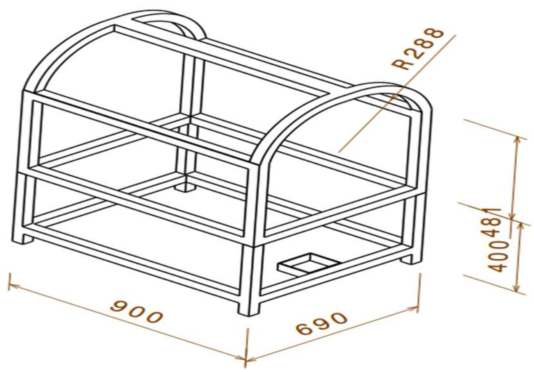



Figure 5.4 Main Frame Assembly

Table 5.2 Manufacturing Procedure of the Main Frame

| No | Part Name | Operation sequence | Materials | Dimension in mm (L x W x H x T) | Tools | Machines | Quantity required |
|---|---|---|---|---|---|---|---|
| 1 | Main vertical frame | Laying out and cutting | Mild Steel Square Pipe | 40x40x881x2 | Scriber Tape rule Try-square Hack saw | Power hack saw | 4 |
| 2 | Main horizontal frame(front & back) | Laying out and cutting | Mild Steel Square Pipe | 40x40x610x2 | Scriber Tape rule Try-square Hack saw | Power hack saw | 2 |
| 3 | Main horizontal frame(left & right side) | Laying out and cutting | Mild Steel Square Pipe | 400x40x920x2 | Scriber Tape rule Try-square Hack saw | Power hack saw | 2 |
| 4 | Horizontal frame for supporting sieve (front & back) | Laying out and cutting | Mild Steel Square Pipe | 40x40x610x2 | Scriber Tape rule Try-square Hack saw | Power hack saw | 2 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | Horizontal frame for supporting sieve (left&right side) | Laying out and cutting | Mild Steel Square Pipe | 400x40x920x2 | Scriber<br>Tape rule<br>Try-square<br>Hack saw | Power hack saw | 2 |
| 6 | Curvature frame for supporting sieve (front & back) | Laying out and cutting | Mild Steel Square Pipe | 400x40x288x2 | Scriber<br>Tape rule<br>Try-square<br>Hack saw | Power hack saw | 2 |
| 7 | Frame for motor support | Laying out and cutting | Mild Steel Square Pipe | 40x40x112x2 | Scriber<br>Tape rule<br>Try-square<br>Hack saw | Power hack saw | 2 |
| 8 | Frame for motor support (front&back) | Laying out and cutting | Mild Steel Square Pipe | 40x40x122x2 | Scriber<br>Tape rule<br>Try-square<br>Hack saw | Power hack saw | 1 |
| 9 | All the above parts | Cleaning and Welding | Mild Steel Square Pipe | 40x40x881x2<br>40x40x610x2<br>400x40x920x2<br>40x40x610x2<br>400x40x920x2<br>400x40x288x2<br>40x40x112x2<br>40x40x122x2 | Face shield<br>Chipping hammer<br>File card<br>Leather gloves<br>Steel square | Arc welding Machine | 15 |

### 5.6.2 Sieve

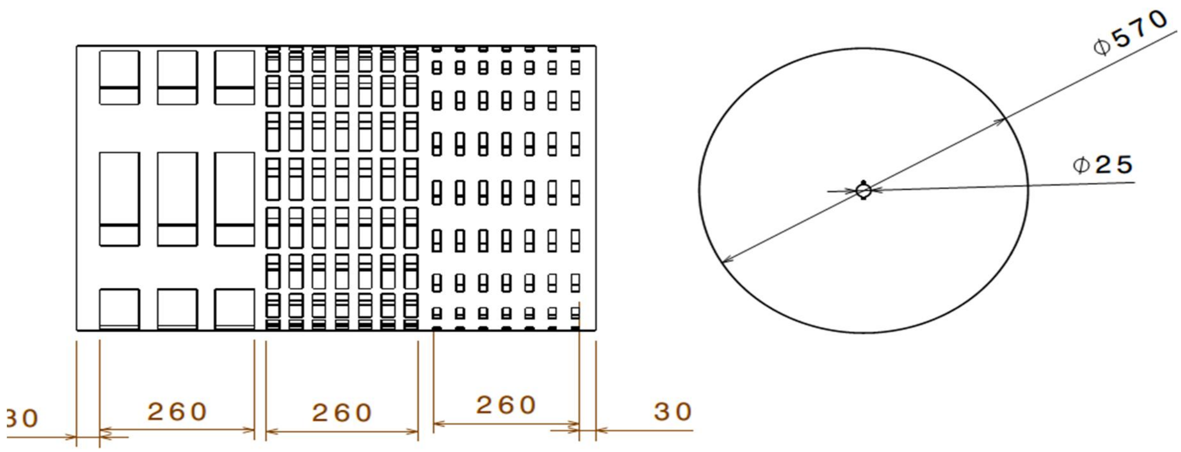



Figure 5.5 Sieve

Table 5. 3 Manufacturing Procedure of the Sieve

| No. | Part name | Operation sequence | Materials | Dimension in mm | Tools | Machines | Quantity required |
|---|---|---|---|---|---|---|---|
| 1 | Sheet metal screen (sieve) | Laying out, cutting drilling bending and bolting | Mild steel sheet , bolt | 570x900x2 | Steel rule<br>Scriber<br>Try-square<br>hammer<br>Center punch<br>Drill bit<br>Riveting gun | Shearing machine<br>Bending machine<br>Drilling machine | 1 |
| 2 | shaft and pulleys support hole | Laying out, cutting drilling | Mild steel sheet , screws | Ø30 | Steel rule<br>Scriber<br>Try-square<br>hammer<br>Center punch<br>Drill bit Screw driver | Shearing machine<br>Drilling machine | 1 |

### 5.6.3 Screw conveyor

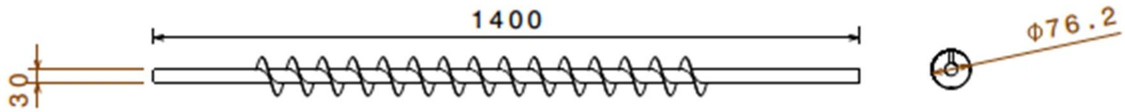



Figure 5.6 Screw conveyor

**The procedures to produce the roller shaft are:**

1. First, material selection
2. We prepare a bar of diameter 30mm.
3. With a power hack saw, we cut the bar to a length of 110mm.
4. Then, using a lathe machine the end of bar is faced and finished to a length of 110 mm. Similarly, turn the other end of the bar is faced and finished to a length of 30mm.
5. The bar is first rough turned to 34mm diameter on a lathe and then, it is finish turned to 30mm.
6. Chamfer the both ends to the angle of $2x45^0$
7. Then, key way is cut on the shaft on a milling machine to assemble it with pulley.
8. Cut sheet metal by the defended pith and thickness for the blade of screw
9. Weld the cutted sheet metal of screw blade
10. Finally gets crew conveyor

### 5.6.4 Roller shaft

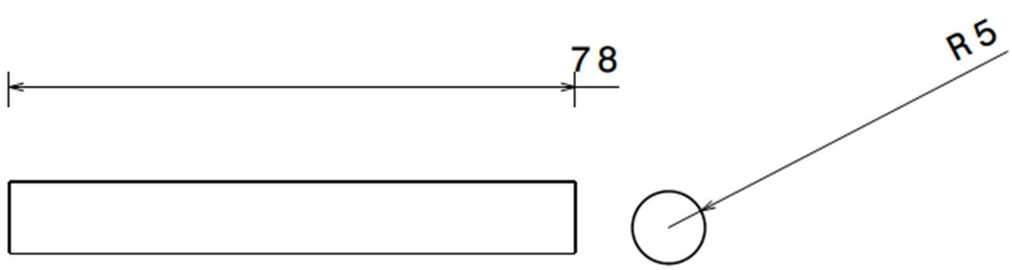



Figure 5.7 Roller Shaft

**The procedures to produce the roller shaft are:**

1. First, we prepare a bar of diameter 12mm.
2. With a power hack saw, we cut the bar to a length of 83mm.
3. Then, using a lathe machine the end of shaft is faced to a length of 78 mm.
4. Rough turn both end of the shaft
5. Finish turn both end of the shaft

### 5.6.5 Pulleys production

**I. Roller pulley**

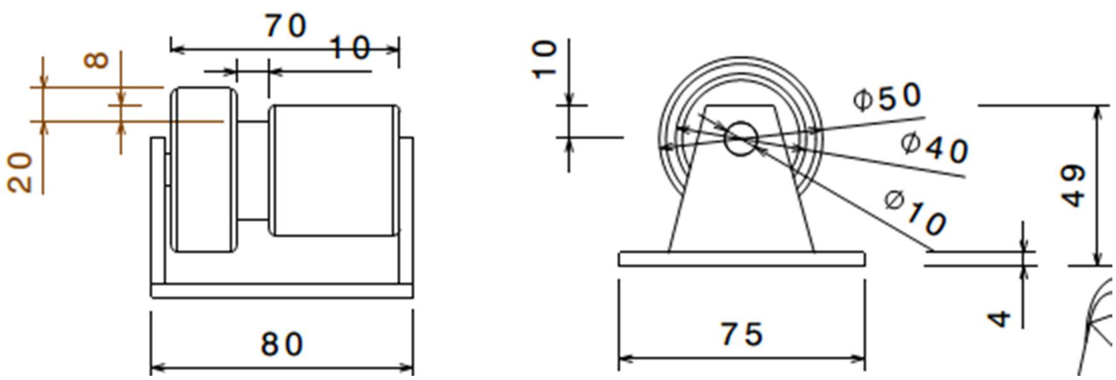



Figure 5.8 Roller Pulley

**The procedures to produce the pulley are:**

1. First, we prepare a bar of diameter 60mm.
2. With a power hack saw, we cut the bar to a length of 75mm.
3. Then, using a lathe machine the end of bar is faced and finished to a length of 70 mm. Similarly, turn the other end of the bar is faced and finished to a length of 50mm.
4. The bar is first rough turned to 51mmdiameter on a lathe and then, it is finish turned to 50mm.
5. Chamfer the both ends to the angle of $2x45^0$
6. The blank is drilled using 10mm diameter drill by inserting it in chuck on lathe machine
7. By form tool make the grill seat groove to the depth of 10 mm
8. Insert the 10 mm diameter of role pin
9. Make frame from side
10. Finish the roller pulley

## II. Screw pulley

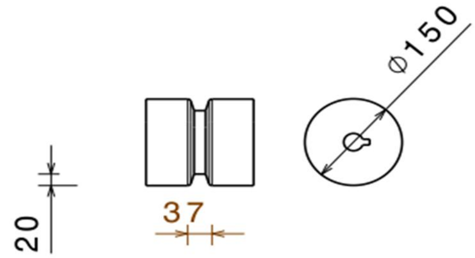



Figure 5.9 Screw pulley

**The procedures to produce the pulley are:**

1. First, we prepare a bar of diameter 155mm.
2. With a power hack saw, we cut the bar to a length of 370mm.
3. Then, using a lathe machine the end of bar is faced and finished to a length of 366 mm. Similarly, turn the other end of the bar is faced and finished to a length of 150mm.
4. The bar is first rough turned to 151mm diameter on a lathe and then, it is finish turned to 150mm.
5. Chamfer the both ends to the angle of $2x45^0$
6. The blank is drilled using 10mm diameter drill by inserting it in chuck on lathe machine. The hole is rough enlarged to 29mm and then finish enlarged to 30mm using boring tool on lathe machine.
7. Then, key way is cut through the inner bore on a milling machine to assemble it on a shaft.
8. By form tool make the v belt seat groove to the depth of 20 mm for sp B belt section based on the standard given.

## III. Larger pulley

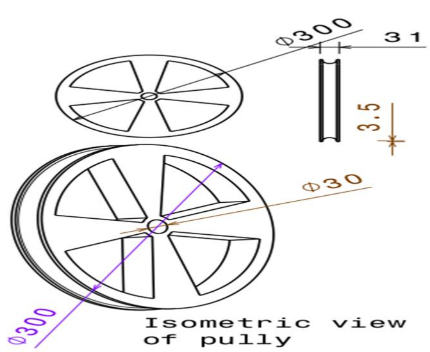
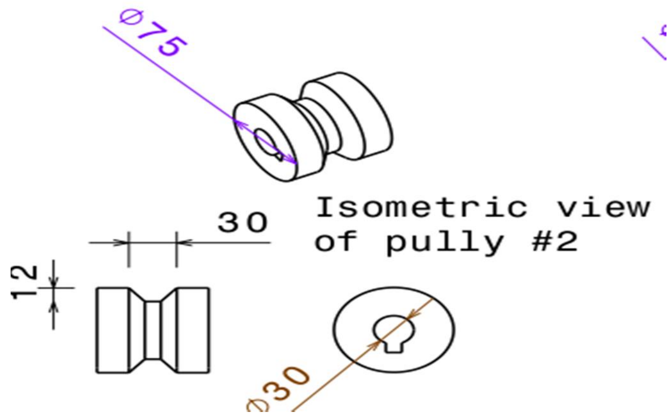



Figure 5.10 Larger pulleys

Table 5.4 Operation Sheet for Larger Pulley

| No. | Operation | Machine used | Tools & Equipment's used | Dimension |
|---|---|---|---|---|
| 1 | Preparing pattern from wood to the required size | Wood lathe and jig saw | Varner caliper, steel rule | Ø = 305 mm<br>W= 26 mm |
| 2 | Preparing Aluminum scraps | | | |
| 3 | Preparing sand for moulding | Sand conditioner | Cop and drag, Sprue, riser. rammer, etc | |
| 4 | Melting the scraps | Fuel furnace | | |
| 5 | Pouring the molten metal to the prepare cavity | | Crucible | |
| 6 | Facing one side | Lathe Machine | Carbide cutter and V. Caliper | Ø = 305 mm<br>D= 24.5 mm |
| 7 | Facing the other side | Lathe Machine | Carbide cutter and V. Caliper | Ø = 305 mm<br>W= 23 mm |
| 8 | Drilling | Lathe Machine | Center drill, Drill bit and V. Caliper | Ø = 20 mm<br>W= 23 mm |
| 9 | Turning | Lathe Machine | Carbide cutter, V. Caliper and mandrel. | Ø = 300 mm<br>W= 23mm |
| 10 | V- groove turning | Lathe Machine | HSS, parting tools, and V. caliper | Ø = 280 mm<br>W= 13x8mm<br>2β = 34 O |
| 11 | Milling key way | Milling machine | Slotting attachment with HSS tool | 6x3.5x23 mm |
| 12 | Side milling and finishing | Milling machine | End mill | |

## IV. Motor pulley




Motor pulley

Figure 5.11 Motor Pulley

**The procedures to produce the pulley are:**

1. First, we prepare a bar of diameter 80mm.
2. With a power hack saw, we cut the bar to a length of 50mm.
3. Then, using a lathe machine the end of bar is faced and finished to a length of 45 mm. Similarly, turn the other end of the bar is faced and finished to a length of 40mm.
4. The bar is first rough turned to 76mm diameter on a lathe and then, it is finish turned to 75mm.
5. Chamfer the both ends to the angle of $2x45^0$
6. The blank is drilled using 10mm diameter drill by inserting it in chuck on lathe machine. The hole is rough enlarged to 24mm and then finish enlarged to 25mm using boring tool on lathe machine.
7. Then, key way is cut through the inner bore on a milling machine to assemble it on a shaft.
8. By form tool make the v belt seat groove to the depth of 11 mm for sp B belt section based on the standard given.

## 5.7. Assembly of the machine

A machine is an assembly of various parts. It is necessary to understand the relation between the various parts of the unit for the purpose of design and production. An assembly drawing of multipurpose sieve machine is one which represents various parts of a machine in their working position. The multipurpose sieve machine is designed in such a way that it will be convenient and simple for assembly purpose. The screw conveyor, sieve, frame, motor, belt, container, guider way of sieve, so on are the necessary part of the machine.

Table 5.5 Basic Hand Tools for Assembling The Machine

| No | Item description with technical specification | Unit | Quantity | Remark |
|---|---|---|---|---|
| 1 | Open end wrench No.18-19 | Pcs | 1 | |
| 2 | Open end wrench No. 20-22 | Pcs | 1 | |
| 3 | Open end wrench No. 22-24 | Pcs | 1 | |
| 4 | Adjustable wrench | Pcs | 1 | |
| 5 | Rubber Mallet | Pcs | 1 | |
| 6 | Ball peen hammer 1.5kg | Pcs | 1 | |
| 7 | Engineering level | Pcs | 1 | |

## 5.7 Tolerance and fit on sieve shaft, screw conveyor shaft, and its pulley.

### 5.7.1 Tolerance

Tolerance is the difference between the maximum limit of size and the minimum limit of size. It is equal to the algebraic difference between the upper and lower deviations and has an absolute value without sign. Its value is a function of the basic size and is designated by a number symbol, called the grade. There are two basic ways of specifying the working tolerance:

1. Bilateral tolerances are used where the parts vary in both directions from the desired or nominal size. And
2. Unilateral tolerances are used where it is important for the dimension to vary in only one direction. Components produced will fall close to the desired dimension but can vary in only one direction [16].

### 5.7.2 Fit

The relationship existing between two parts, shaft and hole, which are to be assembled, with respect to the difference in their sizes before assembly is called a fit. When the parts are assembled into sub-assembly units and sub assembly units are assembled into full assembly, the mating surfaces of different components are joined together for proper functional requirement. One of them may fit into the other in form of joint or fit. The fit may be with suitable degree of tightness and freedom for required relative movement between mating parts for specific functional requirements of the fit. The classifications of fits are: [16]

1. Clearance fit
2. Interference fit
3. Transition fit

### 5.7.3 Shaft and Pulley Hole Tolerance of Multipurpose Sieve Machine

The Basic size of shaft and pulley hole of multipurpose sieve machine is 30mm. The standard symbol for light press is 30H7/p6, the tolerance grade is IT11. The tolerance for hole of pulley is +0.021, and for shaft +0.035 and +0.022, where designated as:

- Hole dimension $\varnothing 30 \begin{pmatrix} +0.021 \\ 0 \end{pmatrix}$
- Shaft dimension $\varnothing 30 \begin{pmatrix} +0.035 \\ +0.022 \end{pmatrix}$

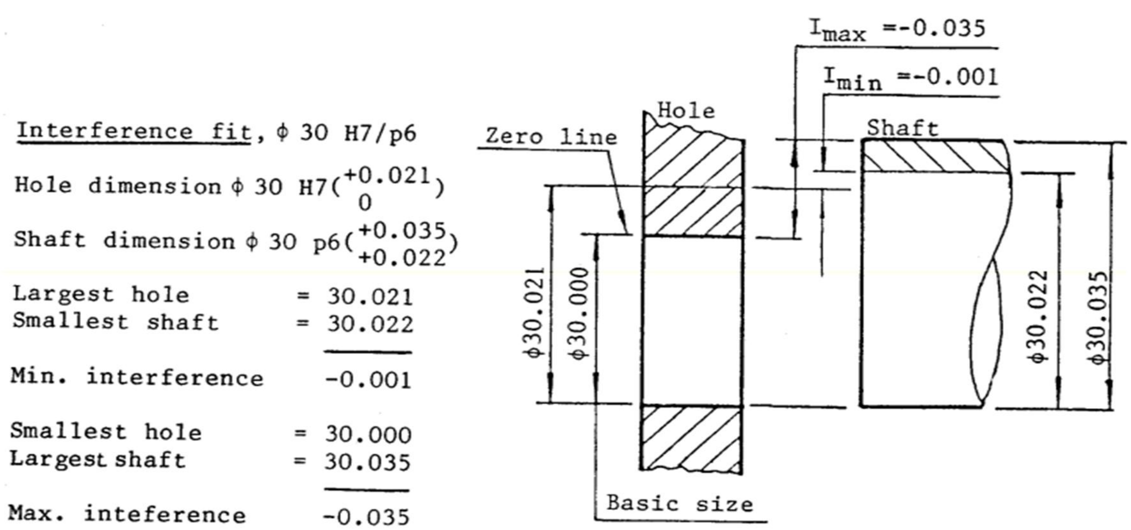
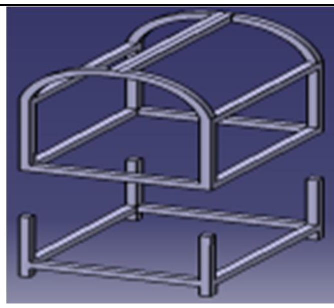
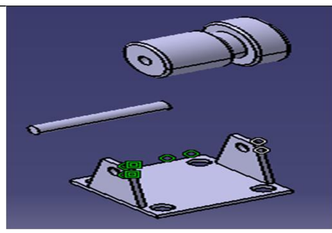
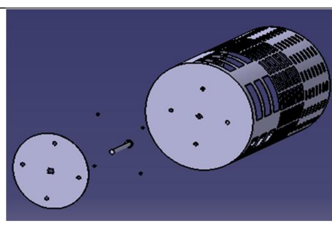
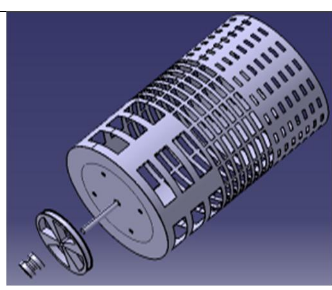
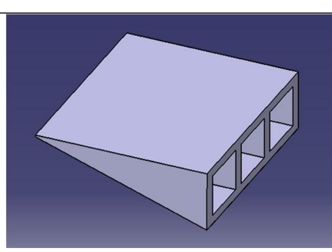
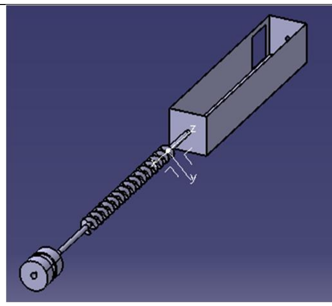
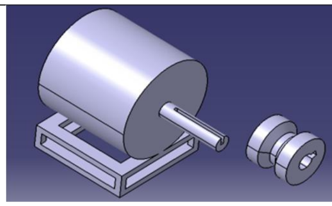
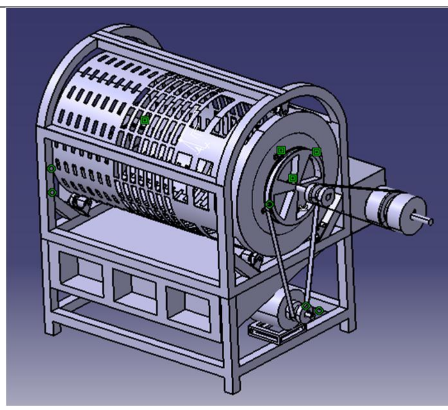



Figure 5. 12 Interference Fit of Pulley and Shaft

## 5.8 Assembling procedures of components

Table 5.6 Assemble Procedure

| *No.* | *Sub Parts* | *Procedures* |
|---|---|---|
| 1 |  Upper and lower frame | - Fix Each Reinforcement And Leg Of The Square Pipe.<br>- Fix Upper And Lower Frame. |
| 2 |  Roller | - Fix Roller Support.<br>- Tighten Roller And Pin. |
| 3 |  Sieve | - Tight Mish<br>- Insert Supporting Dish Into Shaft.<br>- Insert Shaft In Trammel<br>- Tighten Shaft To Trammel By Bolt. |
| 4 |  Sieve with pulley | - Insert Pulley On The Shaft. |
| 5 |  | -Fix On Lower Frame. |

| | | |
|---|---|---|
| | Guide way | |
| 6 |  Screw with pulley and container | - Fix Guide Way On Frame.<br>- Insert And Tight Screw Conveyor In Guide Way.<br>- Tight Pulley On The End Of Screw. |
| 7 |  Motor with pulley | - Tight The Motor On The Leg Of Frame. |
| 8 |  Assembley of the Machine | - First Fix Frame.<br>- Fix Roller On Frame.<br>- Insert The Sieve In The Upper Frame.<br>- Insert Pulley On The Shaft Of Sieve.<br>- Fix Guide Way On Lower Frame.<br>- Fix Screw With Pulley And Container On The Side Of Frame.<br>- Tight The Motor On The Frame Leg.<br>- Tighten The Belt.<br>- Final Accomplish The Job. |

## 5.9 Painting of the Machine

Good surface finish quality on part has become an essential requirement of a product quality and for its better life. Paint is the most widely used finish on manufactured products, and great varieties are available to meet the wide range of product requirements. Paints are used for a variety of reasons, usually to provide protection and decoration but also to fill or conceal surface irregularities, change the surface friction, or modify the light or heat absorption or radiation characteristics. Multipurpose sieve machine first painted by antirust consequently or followed by aesthetic paint.

## 5.10 Maintenance of the machine

### 5.10.1. General considerations

Past and current maintenance practices in both the private and government sectors would imply that maintenance is the actions associated with equipment repair after it is broken. The dictionary defines maintenance as follows: "the work of keeping something in proper condition; upkeep." This would imply that maintenance should be actions taken to prevent a device or component from failing or to repair normal equipment degradation experienced with the operation of the device to keep it in proper working order. Maintenance Engineering is the discipline and profession of applying engineering concepts to the optimization of equipment, procedures, and departmental budgets to achieve better maintainability, reliability, and availability of equipment. Maintenance engineering is the occupation that uses engineering theories and practices to plan and implement routine maintenance of equipment and machinery. This must be done in conjunction with optimizing operating procedures and budgets to attain and sustain the highest levels of reliability and profit.

### 5.10.2 Scope of Responsibilities

Unique though actual maintenance practice may be to a specific facility, a specific industry, and a specific set of problems and traditions, it is still possible to group activities and responsibilities into two general classifications: primary functions that demand daily work by the department; secondary ones assigned to the maintenance department for reasons of expediency, know-how, or precedent.

## I. Primary Functions

- Maintenance of Existing Plant Equipment.
- Maintenance of Existing Plant Buildings and Grounds.
- Equipment Inspection and Lubrication.
- Utilities Generation and Distribution
- Alterations and New Installations.

## II. Secondary Functions

- Stores keeping.
- Plant Protection.
- Waste Disposal.
- Salvage.
- Insurance Administration.
- Other Services.

### 5.10.3 Maintenance and Maintenance Engineering Objectives

## The contributing objectives of maintenance engineering include:

- ✓ improve maintenance operations,
- ✓ reduce the amount and frequency of maintenance,
- ✓ reduce the effect of complexity,
- ✓ reduce the maintenance skills required,
- ✓ reduce the amount of supply support,
- ✓ establish optimum frequency and extent of preventive maintenance to be carried out,
- ✓ improve and ensure maximum utilization of maintenance facilities, and
- ✓ improve the maintenance organization.

### 5.10.4 Preventive maintenance activities of the multipurpose sieve machine

Table 5.7 Preventive Maintenance Activities

| No. | Activities (Detail Of Work) | Frequency | Estimated Time | Comment |
|---|---|---|---|---|
| **1** | Electrical | | | |
| **2** | Check Up Of Motor State | 1 Week | 1hr | |
| **3** | Check Operation Of Start/Stop Switch | 5 Weeks | 30 Minutes | |
| **4** | Shaft Check Up | 2 Weeks | 30min | |
| **5** | Lubrication System Check Up For Bearings | 1 Weeks | 1hrs | |
| **6** | Screw Conveyor | 1 Weeks | 30 Minutes | |
| **7** | Check Up For Belt Tension | 2weeks | 20 Minutes | |
| **8** | Check Up For Sieve | 1 Week | 1hr | |
| **9** | Check Up For Loosened Bolts And Nuts | 1 Week | 1hr | |
| **10** | Servicing And Lubrication | 1 Week | 3 Hr | |

### 5.10.5 List of Spare Parts Required For Repairing

In maintenance activity, it is important to estimate the number of spare parts required for a system/equipment. This need directly influences the maintenance inventory. The spare that needs replacement through the time of work worn out are: bearings, sieve, belts, bolt, motor and screw. All of these parts are easily purchased and available from market.

## 5.11 Inspection

Inspection or checking of components or products with required specifications is very minutely related with quality control. It is generally an accepted fact that no two things can ever be exactly same. It also holds true with manufactured parts. Therefore certain variations or deviations in dimensions and other product specifications are accepted. However, only few produced articles or parts may be rejected if the deviations go beyond the specified quality standards. Therefore it becomes essential to detect errors so that the manufacturing of faulty product does not go uncorrected. The philosophy of inspection is only preventive and not remedial. In other words the inspection of products is measuring or checking its quality in terms geometrical tolerances of other specified feature of needed design. Generally, there are three basic areas of inspection namely receiving inspection, in-process inspection and final inspection. In the receiving inspection, inspections are performed on all incoming materials and purchased parts. In the in-process inspection the products are inspected as they are in processed in stages from starting station to finished station. In the final inspection, all finished products or parts are inspected finally prior to delivering them to the customer.

The manufacturing process of multipurpose sieve machine is indicted above, while the inspection is made starting from design, and selection of material. After selecting the material the well purchased metals like shaft, pulley, and so on are processed with the limited range of tolerance from standard. The assembly a part of multipurpose sieve machine is well inspected on dimension, joint, surface finish quality and so on. The manufactured machine is transferred to consumer. Then, the consumer of the machine can be inspect the machine when received and on the job. The on job machine inspected per day by making or checking tightens and service on the roller, belt, and pulley of machine.

# CHAPTER SIX

# COST ANALYSIS

## 6.1 Cost Analysis

For any system where cost is specified as per Multipurpose sieve machine the total cost by adding costs of raw materials and standard items, labor cost for manufacturing and assembling components, Electrical power consumption cost and machine depreciation cost to manufactured parts required for Multipurpose sieve machine.

### 6.1.1 Cost Elements of Selling Price

Design and manufacture a product according to a certain specification by minimizing total cost of the product, or the machine to meet service requirements is only one aspect of production. Based on these the design and manufacture of certain sieving processing machine analysis should be done in order to be competitive. The way element of cost builds up to establish a selling price is shown on figure below

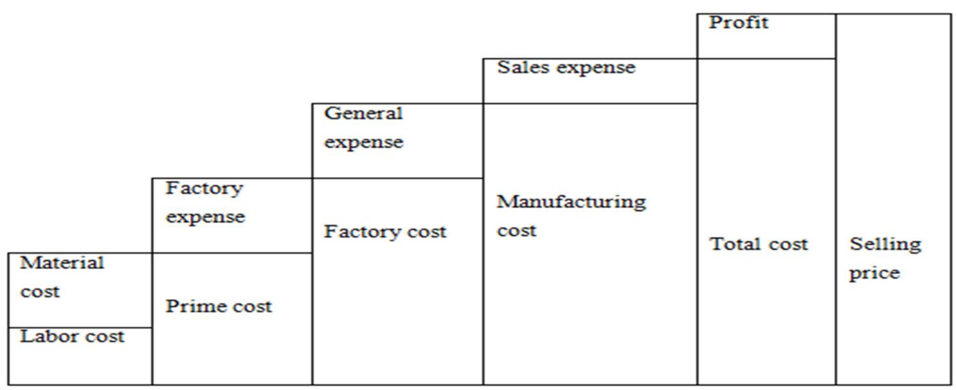



Figure 6.1 Establishing of Selling Price

The chief cost elements of direct material cost and direct labor cost determines prime cost. The factory expense such as light, power, maintenance, supply plus prime cost gives factory cost. The general expense such as marketing and sales cost, legal expense, and security cost, financial, and administrative plus factory cost gives manufacturing cost. The sales expense such as taxes, office stuff, and purchasing plus manufacturing cost gives total cost.

(Total cost=manufacturing cost + sales expense).

Finally the selling price established by adding a profit to the total cost for a business.

### 6.1.2 The Costs of Raw Materials and the Cost of Standard Items

The material costs are refer to those materials which are consumed to produce a real components of our machine and the standard item costs are those costs which is purchased from a local markets/they are a finished product.

Table 6. 1 Raw Material Cost

| No | Material Description | Specification and Size Required | Unit | Qty | Unit price | | Total price | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Birr | Cent | Birr | Cent |
| 1 | Mild steel sheet metal | 1mm thick | Pcs | 02 | 345 | 00 | 690 | 00 |
| 2 | Square pipe | 40x40x1.5mm | Pcs | 03 | 250 | 00 | 750 | 00 |
| 3 | Barrel | Ø570x900mm | Pcs | 01 | 450 | 00 | 450 | 00 |
| 4 | Square pipe | 50x50x2mm | Pcs | 01 | 110 | 00 | 110 | 00 |
| 5 | Round pipe | Ø30x1000mm | Psc | 01 | 100 | 00 | 100 | 00 |
| 6 | Mild steel plate | 80x75x4 mm | Pcs | 06 | 50 | 00 | 300 | 00 |
| 7 | Angle iron | 25x25x3mm | Pcs | 01 | 250 | 00 | 250 | 00 |
| 8 | Round bar | Ø30x500mm | Pcs | 01 | 70 | 00 | 70 | 00 |
| 9 | Round bar | Ø10x480mm | Pcs | 01 | 45 | 00 | 45 | 00 |
| 9 | Round bar | Ø50x560mm | Pcs | 01 | 150 | 00 | 150 | 00 |
| 10 | Aluminum ingot | Ø80x500mm | Pcs | 01 | 400 | 00 | 400 | 00 |
| 11 | Aluminum ingot | Ø150x500mm | Pcs | 01 | 600 | 00 | 600 | 00 |
| 12 | Sieve for fine | No. 4 | M | 2m | 40 | 00 | 40 | 00 |
| 13 | Sieve medium | No. 8 | M | 2m | 50 | 00 | 100 | 00 |
| 15 | Fly wheel | Φ300mmx40mm | Pcs | 01 | 300 | 00 | 300 | 00 |
| Total costs | | | | | 3010 | 00 | 4175 | 00 |

Table 6.2 Standard Item Cost

| No | Name of material | Size | Unit | Qty | Unit price | | Total price | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Birr | Cent | Birr | Cent |
| 1 | Bolt and nut | M6x60 mm | Pcs | 60 | 2.50 | 00 | 150 | 00 |
| 2 | Bolt and nut | M12x60 mm | Pcs | 10 | 5 | 00 | 50 | 00 |
| 3 | Bolt and nut | M10x40 | Pcs | 8 | 4 | 00 | 32 | 00 |
| 4 | Plain washer | M10 | Pcs | 10 | 2 | 00 | 20 | 00 |
| 5 | Plain washer | M12 | Pcs | 10 | 2.50 | 00 | 25 | 00 |
| 7 | Radial ball bearing | 200 | Pcs | 02 | 250 | 00 | 500 | 00 |
| 8 | V-belt | 55A | Pcs | 01 | 90 | 00 | 180 | 00 |
| | V-belt | A43 | Pcs | 01 | 100 | 00 | 200 | 00 |
| 9 | Push button switch | 3phase | Pcs | 01 | 110 | 00 | 110 | 00 |
| 10 | Cable wire | ∅2.5x40 | M | 4m | 57 | 00 | 228 | 00 |
| 11 | Hack saw blade | 18T/inch | Pcs | 8 | 30 | 00 | 240 | 00 |
| 12 | Anti-rust | Litter | Pcs | 01 | 80 | 00 | 80 | 00 |
| 13 | Paint yellow | Litter | Pcs | 01 | 80 | 00 | 80 | 00 |
| 14 | Grinding disk | ∅180 | Pcs | 01 | 40 | 00 | 40 | 00 |
| 15 | Cutting disk | ∅180 | Pcs | 02 | 40 | 00 | 80 | 00 |
| 16 | Electrode | ∅2.5 | Pkt | 01 | 200 | 00 | 200 | 00 |
| 17 | Carbide cutter | 20x20x150 | Pcs | 02 | 250 | 00 | 500 | 00 |
| 18 | Drill bit | ∅6 | Pcs | 04 | 10 | 00 | 20 | 00 |
| 19 | Drill bit | ∅8 | Pcs | 01 | 10 | 00 | 10 | 00 |
| 20 | Drill bit | ∅10 | Pcs | 01 | 10 | 00 | 10 | 00 |
| 21 | Brush | 2.5” | Pcs | 02 | 15 | 00 | 30 | 00 |
| 22 | Thinner | | Liter | 01 | 65 | 00 | 130 | 00 |
| Total costs | | | | 128 | 1453 | 0 | 2915 | 00 |

Total Materials Cost = Cost of raw materials+ Cost of Standard items= 4175Birr + 2915 Birr

Total material Cost = 7090Birr

### 6.1.3 Labor Cost for Manufacturing and Assembling Components

#### 6.1.3.1 Labor Cost for Manufacturing

It is the cost of the worker spend and making a product. The cost includes all the labor from the time materials are first handle to the time the product is finished.

Note:-The group members are agreed about a labor cost should have paid 25.00 Birr per hour. For all components, our project labor cost is indicated as follows

Table 6. 3 Manufacturing Labor cost

| No. | Parts name to be made | Qty | Operation | Working time in hour | Payment per hour | Labor cost price in Birr | Total cost of part in Birr |
|---|---|---|---|---|---|---|---|
| 1 | Shafts | 02 | Measuring & cutting to size | 0:15 | 25.00 | 6.25 | 51.83 |
| | | | Facing on both end side | 0:20 | 25.00 | 8.33 | |
| | | | Turning and chamfering | 1:00 | 25.00 | 25.00 | |
| | | | Milling key ways | 0.30 | 25.00 | 12.25 | |
| 2 | Barrel | 01 | Measuring & layout | 0:30 | 25.00 | 50.00 | 79 |
| | | | Cutting the removed part | 1:00 | 25.00 | 25.00 | |
| | | | Grinding cut parts | 0:10 | 25.00 | 4.00 | |
| 3 | Sieve | 09 | Measuring & cutting to size | 1:00 | 25.00 | 25 | 25 |
| 4 | Large Pulley | 01 | Preparing pattern from wood to the required size | 4:00 | 25.00 | 100.00 | 227.1 |
| | | | Preparing Aluminum scraps | 0:30 | 25.00 | 12.50 | |
| | | | Preparing sand for mounding | 0:50 | 25.00 | 20.80 | |
| | | | Melting the scraps | 1:00 | 25.00 | 25.00 | |
| | | | Pouring the molten metal to the prepared cavity | 0:05 | 25.00 | 2.10 | |
| | | | Facing one side | 0:30 | 25.00 | 12.50 | |
| | | | Facing the other side | 0:30 | 25.00 | 12.50 | |
| | | | Drilling | 0:10 | 25.00 | 4.20 | |
| | | | V-groove turning | 0:30 | 25.00 | 12.50 | |
| | | | Milling a key way | 0:30 | 25.00 | 12.50 | |
| | | | Side milling and finishing | 0:30 | 25.00 | 12.50 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 5 | Small pulley | 02 | Measuring & cutting to size | 0:40 | 25.00 | 33.40 | 83.60 |
| | | | Facing on one side | 0:05 | 25.00 | 4.20 | |
| | | | Turning and chamfering | 0:20 | 25.00 | 16.70 | |
| | | | Facing on the other side | 0:05 | 25.00 | 4.20 | |
| | | | Drilling | 0:10 | 25.00 | 8.40 | |
| | | | Milling a key way | 0:20 | 25.00 | 16.70 | |
| 6 | Medium pulley | 01 | Measuring & cutting to size | 0:40 | 25.00 | 16.70 | 41.80 |
| | | | Facing on one side | 0:05 | 25.00 | 2.10 | |
| | | | Turning and chamfering | 0:20 | 25.00 | 8.35 | |
| | | | Facing on the other side | 0:05 | 25.00 | 2.10 | |
| | | | Drilling | 0:10 | 25.00 | 4.20 | |
| | | | Milling a key way | 0:20 | 25.00 | 8.35 | |
| 7 | Screw conveyer | 01 | Measuring & cutting to size shaft | 0:10 | 25.00 | 8.40 | 129.23 |
| | | | Cutting and Rolling sheet metal based on the pitch | 3:00 | 25.00 | 75.00 | |
| | | | Joining(welding) | 1:30 | 25.00 | 37.50 | |
| | | | Grinding | 0:20 | 25.00 | 8.33 | |
| 8 | Roller | 06 | Measuring & cutting to size | 0:20 | 25.00 | 8.33 | 258.33 |
| | | | Facing both ends | 1:00 | 25.00 | 25.00 | |
| | | | Turning | 6:00 | 25.00 | 150.00 | |
| | | | Drilling | 1:00 | 25.00 | 75.00 | |
| 9 | Frame | 01 | Measuring &cutting to size | 4:00 | 25.00 | 100.00 | 237.55 |
| | | | Drilling holes | 0:40 | 25.00 | 16.70 | |
| | | | Welding | 4:00 | 25.00 | 100.00 | |
| | | | Grinding to surface | 0:50 | 25.00 | 20.85 | |
| 10 | Hopper | 01 | Measuring &cutting to size | 1.00 | 25.00 | 25.00 | 62.50 |
| | | | Bending | 0:30 | 25.00 | 12.50 | |
| | | | Joining (welding or rivet) | 1.00 | 25.00 | 25.00 | |
| | | | | | | Total | 1195.94 |

### 6.1.3.2 Labor Cost for Assembling Components

Detail assembling of manufacturing components is indicated in section manufacturing process.

To the total cost of labor, we should calculate the time spend for manufacturing & assembling of parts (components) of the project.

The time needed for assembling components of our project is indicated as follows:-

Table 6. 4 Assembling Labor Cost

| No. | Types of assembly | Method of assembling | Working time in hour | Payment per hour in Birr | Labor cost price in Birr |
|---|---|---|---|---|---|
| 1 | Assembly of frame with ground wheel | Manual | 0:40 | 25.00 | **16.70** |
| 2 | Assembling of six roller with frame (sub-assembling 11) | Manual | 0:05 | 25.00 | **2.10** |
| 3 | Assembling of trammel with sub-assembly 02 | Manual | 0:10 | 25.00 | **4.20** |
| 4 | Assembling of shaft with sub-assembly-02 | Manual | 0:05 | 25.00 | **2.10** |
| 5 | Assembling of large pulley with shaft (Sub-assembly-03) | Manual | 0:05 | 25.00 | **2.10** |
| 6 | Assembling of sub-assembly-03 with sub-assembly-04 ….Sub-assembly-05 | Manual | 1:00 | 25.00 | 25 |
| 7 | Tightening the stud bolts with nuts and fixing bearing house with upper and lower bolts Sub-assembly | Bolting | 0:20 | 25.00 | **8.35** |
| 8 | Assembling of, keys, pulley and screw -12 | Manual and bolting | 1:30 | 25.00 | **37.50** |
| 9 | Assembling of screw conveyor blades with holder and container or housing | Welding | 2:00 | 25.00 | **50.00** |
| 10 | Assembling of sub-assembly-of frame, guide way, and roller. | Welding | 0:50 | 25.00 | **12.50** |
| 11 | Assembling of sub-assembly-of frame, container, and motor. | Welding Bolt | 1:00 | 25.00 | **25.00** |
| 12 | Assembling of belt, | -Manual | 1:30 | 50.00 | **37.50** |
| 13 | Final Assembling | Manual | 0:20 | 25.00 | **8.35** |
| | | | | **Total cost** | **218.90Birr** |

Total Labor Cost = Labor cost for manufacturing components + Labor cost for assembling components= 1195.94Birr + 218.90 Birr $\Rightarrow$ Total Labor Cost = 1414.25 Birr

### 6.1.3.3 Electrical Power Consumption Cost

It is the cost of electric power needed to machine and weld parts of the project. Electric power is expressed (measured) by a unit watt (w) or kilo watt (Kw).The cost of electric power is expressed in birr per Kw/hr. The electrical machines used and time consumed is indicated below:-

Table 6. 5 Machines & Time Consumed

| No | Manufactured parts | Qty | Types of machines &their machining time in hour | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Power hack saw | Lathe machine | Milling machine | Arc welding machine | Oxy-fuel cutting machine | Drilling machine | Portable hand grinder | Electric Furnace |
| 1 | Shafts | 02 | 0:40 | 1:05 | 0:20 | | | | | |
| 2 | Barrel | 01 | | | | | 1:00 | | 0:30 | |
| 3 | Large Pulley | 01 | | 6:00 | 1:00 | | | | | 1:00 |
| 4 | Smaller Pulley | 02 | 0:40 | 0:40 | 0:20 | | | | | |
| 5 | Medium pulley | 01 | 0:40 | 0:40 | 0:20 | | | | | |
| 6 | Screw conveyer | 01 | 1:00 | | | 0:40 | | | | |
| 7 | Roller | 06 | 2:00 | 1:00 | 3:00 | | | | | |
| 8 | Frame | 01 | 4:00 | | | 4:00 | | 0:40 | 0:50 | |
| 9 | Hopper | 01 | | | | 1:00 | | | | |
| | Total time | | 9:00 | 9:25 | 5:00 | 5:40 | 1:00 | 0:40 | 1:20 | 1:00 |

Now let's calculate the energy used for each machine multiplying their power rating with their machining time.

Note: - Power rating of each machine is taken from their life history card

Example-1 Power hack saw

Power rating (p) =0.75KW

Working time (t) =9:00hr

Energy consumed (E) =?

$E = Pxt = (0.75 \times 9)$

$E = 6{:}75KWH$

Example-2 Lathe machine

Power rating (p) =2.2KW

Working time (t) = 9:25H

Energy consumed (E) =?

$$E = Pxt = (2.2 \times 9) + (2.2 \times \frac{25}{60})$$

E=19.8KWH + 0.92KWH

E=19.8KWH + 0.92KWH

Energy consumed (E) = 20.72KWH

Example-3 Shield metal arc welding machine

Power rating (p) =4.9KW

Working time (t) =5:40hr

Energy consumed (E) =?

E=Pxt = (4.9x5) + (4.9x40/60)

E=24.5KWH + 3.27KWH = 27.77KWH

Note: - The energy consumed for each machine is done with the same procedure of the above three examples

Note: - The electrical power cost for 1KWH is 0.70 Birr, source from EELPA

Table 6.6 Electrical Power Consumption Cost

| No | Machine type | Power rating of the machine in KW | Total machining time in hour | Energy consumed in KWH | Payment for 1KWH in Birr | Total payment in birr |
|---|---|---|---|---|---|---|
| 1 | Power hack saw | 0.75kw | 9:00 | 6.75 | 0.70 | 4.725 |
| 2 | Lathe machine | 2.2kw | 9:25 | 20.72 | 0.70 | 14.504 |
| 3 | Milling machine | 1.5kw | 5:00 | 7.5 | 0.70 | 5.25 |
| 4 | Arc welding machine | 4.9kw | 5:40 | 27.77 | 0.70 | 19.439 |
| 5 | Oxy-fuel cutting | 0.14kw | 1:00 | 0.14 | 0.70 | 0.098 |
| 6 | Drilling machine | 1.3kw | 0:40 | 0.87 | 0.70 | 0.609 |
| 7 | Electric furnace | 5.10kw | 1:20 | 6.799 | 0.70 | 4.7593 |
| 8 | Portable hand grinder | 2.0kw | 1:00 | 2.00 | 0.70 | 1.4 |
| | | | | | Total cost | 50.784Birr |

#### 6.1.3.4 Machine Depreciation Cost

Depreciation is defined as the reduction in value of the machine over time as it is working at a specific task (Sessions, 1992). Depreciation occurs due to wear that gradually declines the capacity of the piece of equipment to perform its function. The objective of the depreciation schedule is to recover the initial investment cost of equipment each year over its economic life (Miyata, 1980).

Straight-line method assumes that the value of the equipment reduces at a constant rate for each year over its economic life. The straight-line method is the simplest way for estimating depreciation costs and may be most preferable method to calculate equipment cost per unit of time (Miyata, 1980).

The mathematical formula for the yearly depreciation charge using the straight-line method is:

$$D = \frac{P-S}{N} \qquad (6.1)$$

Where, D = Depreciation charge

P = Initial purchase price (actual price)

S = Salvage value (take average 30% initial price P)

N = Economic life (in year or scheduled machine hours)

Example -1: For our project the depreciation cost of power hacksaw is calculated as follows and the same is done for other machines.

$D = \frac{P-S}{N}$ ,    Where D = Depreciation charge

P = 40,000 Birr

S = 30% of 40,000 = 12,000 Birr

N = 10 yrs.

$D = \frac{40,000-12,000}{10}$ = <u>2800</u> Birr per year

Depreciation cost for a month, 2800/12=233.33Birr/month since there are 4 weeks in a month, the depreciation cost for a week=233.33/4= 58.33 Birr/week. In a week we have 5working days the depreciation cost per day =58.33/5= 11.67Birr/day. Further we have 8 working hours in a day so the depreciation cost per hour =11.67/8=1.46Birr/hr.

Example -2: The depreciation cost of lathe is calculated as follows

$$D = \frac{P-S}{N}$$

Where D = Depreciation charge

P = 200,000 Birr

S = 30% of 200,000 = 60,000 Birr

N = 10 yrs.

$D = \frac{P-S}{N}$ $=D = \frac{200,000-60,000}{10}$=<u>14,000</u> Birr per year

In one year we have 12 months, and the depreciation cost for a month, 14,000/12 = 1166.66Birr/month since there are 4 weeks in a month, the depreciation cost for a week = 1166.66/4 = 291.666 Birr/week. In a week we have 5working days the depreciation cost per day = 291.666/5 = 58.33Birr/day. Further we have 8 working hours in a day so the depreciation cost per hour = 58.333/8 = 7.30Birr/hr.

Therefore the time period over which hourly depreciation of the machine that we have used to manufacture our product is already calculated. Therefore, we can take the depreciation of those machines from the university scheduled data.

Therefore by summing up all the time for machining from the operation sheet we can calculate the total depreciation of these machines by multiplying the time we operated them and the hourly depreciation.

Table 6.7 Depreciation Cost of Different Machines

| No | Machine type | Life span (year) | Machine Price | | Depreciation values /hr. | | Usage time | Total depreciation value | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Birr | Cents | Birr | Cents | | Birr | Cents |
| 1 | Power hack saw | 10 | 40,000 | 00 | 1 | 46 | 9:00 | 13 | 14 |
| 2 | Lathe machine | 10 | 200,000 | 00 | 7 | 30 | 9:25 | 68 | 74 |
| 3 | Milling machine | 10 | 300,000 | 00 | 10 | 94 | 5:00 | 54 | 68 |
| 4 | Arc welding machine | 5 | 10,000 | 00 | 0 | 73 | 5:40 | 4 | 14 |
| 5 | Oxy-fuel cutting | 5 | 15,000 | 00 | 1 | 10 | 1:00 | 1 | 10 |
| 6 | Drilling machine | 3 | 2000 | 00 | 0 | 33 | 0:40 | 0 | 22 |
| 7 | Portable hand grinder | 3 | 2000 | 00 | 0 | 33 | 1:00 | 0 | 33 |
| Total Cost | | | | | | | | 142 | 35 |

### 6.1.6 Total cost of multi-purpose sieving machine

Manufacturing cost:-

Material cost ----------------------- = 7090Birr

Labor cost ------------------------- = 1414.25 Birr

Electric power consumption cost = 50.784Birr

Machine depreciation cost ------- = 142.35Birr

Manufacturing cost = 8697.384birr

Contingencies: - It is compensation due to some errors and unexpected failure of time in our project it is usually taken as 10% of the manufacturing cost.

Contingency = 10%×8547.384birr=

Contingency = 854.7384 Birr

Total manufacturing cost = Manufacturing cost + Contingency

= 8697.384birr+ 854.7384 Birr

= 9552.122birr

Profit: - It is usually taken as 15% of the total cost.

$$Profit\ =\ 0.15x9552.122Birr$$

$\Rightarrow$Profit = 1432.8183 Birr

Selling price = Profit + Total manufacturing cost

$$= 9552.122Birr + 1432.8183birr = 10{,}984.9403birr$$

Profit analysis

The enterprise $10{,}984.9403birr$ borrowed from a bank at 8% interest rate and they have to pay it back in 4 years. The debt can be repaid at end of each year 2746.325 birr principal plus interest due.

Table 6.8 Payback Description

| *A* | *B* | *C* | *D* | *E* | *F* |
|---|---|---|---|---|---|
| Year | Amount Owed | Interest Owed | Total Owed | Principal payment | Total payments |
| 1 | 10,984.9403 | 878.79 | 11863.74 | 2746.325 | 3625.115 |
| 2 | 8238.6153 | 659.089 | 8897.704 | 2746.325 | 3405.4 |
| 3 | 5492.29 | 439.38 | 5931.67 | 2746.325 | 3185.71 |
| 4 | 2745.965 | 219.6772 | 2965.6422 | 2746.325 | 2966.002 |
| sum | | | | 10,984.9403birr | 13182.227birr |

Since this machine is new for the market there is no market competitor. so it is impossible to compare with other machinery.

# CHAPTER SEVEN

# RESULT AND DISCUSSION

## 7.1 Result and Discussion

As per design considerations the machine components were designed and fabricated successfully. Screw conveyor mechanism is used for sand to be to be feed into the trammel without any problem. The length of screw 1.20mm with a diameter of screw shaft 30mm and pitch diameter 80mm and a hopper with a 80mmx80mmx1.20mm is attached to the right side of with the main frame of the of the machine. A trammel made of oil container or barrel separated part and sieve different size (for fine. medium and coarse) opening is fixed to it for effective dropping of sand according to their grain size via partitioned out let made mild steel sheet metal of 1mm thickness, the trammel rotation as well as the balance is held by roller with a support from the bottom attached at 1200 to the frame from the inside. In testing of this machine natural sand used in construction is putted in the conveyor container and observed that it pass through the sieve as expected. For this design, Trial tests were conducted to see if the conveying mechanism, trammel, and roller device are functioning properly. The results show that they are functioning properly as expected. For screw conveyor, the ability to convey the sand in to the trammel is an important factor in evaluating its performance. For the sieving operation, the conveyor hopper was filled with sands. As the pulley on the screw shaft rotates, the screw conveyor rotates, thereby conveying the sand. This sand is then interred to the trammel through the conveyor hopper and dropped to the trammel via the out let designed. The sand interred to trammel was dropped to the container through the mish opening of three types attached to trammel fine at the entrance of sand, medium at the middle and coarse at the end effectively the according their grain size via the outlet partitioned and attached below the trammel. The speed of conveyor is 0.13m/s and feeds 1800kg/day by a power of 0.6kw which is satisfactory to feed trammel running at the 55.4 m/s it he drops 2.4$m^3$sand in one hour.

Table 6. 9 Detail Specification of Developed Machine

| *No* | *Component* | *Specification* | *Material* |
|---|---|---|---|
| 1 | Frame | 900mmx1127.77mmx690mm | Mild steel square pipe 40mmx40mm |
| 2 | Trammel | Ø570mmx900mm | Steel barrel |
| 3 | Screw conveyor | 1400mmlength and 76.2mm pitch diameter | Mild steel pipe Ø 30 and sheet 2mm |
| 4 | Sand Out let | 690mmx200mmx1mm | Mild steel sheet |
| 5 | Roller | Ø50mmx70mm | Mild steel bar of Ø50 |
| 6 | Pulley | Ø75mm | Aluminum alloys |
| 7 | Pulley | Ø150mm | Aluminum alloys |
| 8 | Belt | V-belt A 2093 mm | Rubber |
| 9 | Belt | V-belts A 1255mm | Rubber |
| 10 | Fly wheel | Ø300mm | Aluminum alloys |
| 11 | Electric motor | 2hp 1.5kw | |
| 12 | Trammel Shaft | Ø30mmx50mm | Carbon Steel |
| 14 | Sieve | No.4 and No.8 | Steel mish |
| 15 | Radial ball bearing | L04 | Cast iron |

# CHAPTER SEVEN

# CONCLUSION AND RECOMMENDATIONS

## 7.1. Conclusions

The multi-purpose sieve machine has remarkable influence in construction enterprise. This machine is designed and fabricated from locally available resource at about 6723.484birr cost and driven by electric motor 2hp with 1200rpm. The motion from the motor to other part of machine is transmitted with four pulleys via v-belt. It is cheap; everyone can afford it, easy to maintain, less electric power consumption, save more time required for sand sieving. It was made of durable and cheap material affordable for the small scale enterprise. The operator can sieve large volume of sand without any sign fatigue effectively and increasing productivity of sand sieving. The conveying mechanism used for this work was screw conveyor of uniform pitch diameter which highly efficient in short distances conveying of nonabrasive material like sand. From the study conducted, it can be concluded that the manufactured multi-purpose sand sieve machine:

- Improve sieving efficiency;
- Increase in productivity;
- Separate required grain size accurately;
- Can operate at lesser maintenance cost;
- Easy to change mish size at any required time;
- Decreased labor requirement.
- Consume less time for sieving.

It can be easily manufactured and distributed to various areas of our country and easily adapted as technology transfer to SMEs. Therefore the main task of the study team is to promote this technology and have available to construction enterprise at an reasonable costs

## 7.2 Recommendations

The multipurpose sieve machine is designed to sieve sand using screw conveyor feeding mechanism of smaller size. The conveyor size can also be increased to the next higher by increasing trammel diameter and length of the machine.

Although, developers tried to make this project is successful, what developers want to recommended about the machine as follows:

- Anyone can re-design by viewing from different end user perspectives.
- TVET institutions, university's and SMEs should work for the success of manufacturing and fully distributing of this machine to small scale enterprise so as to bring about effective changes on the well-being and productivity in construction industry.

At the end, the developers recommend that this machine can be improved, modified or modernized by anyone who has a need and interest to do it so.

The project is feasible and functional as per design .It should be distributed to all construction enterprise in the country and SMEs to create job for the people and to get government income tax. Thus, all concerned body should work on construction to get advantages from the sources. Since the design is made on sand and organic compost sieving by changing the trammel size or mish(wire sieve)it can be used for teff sieving and it also recommended that future research be done to minimize cost.

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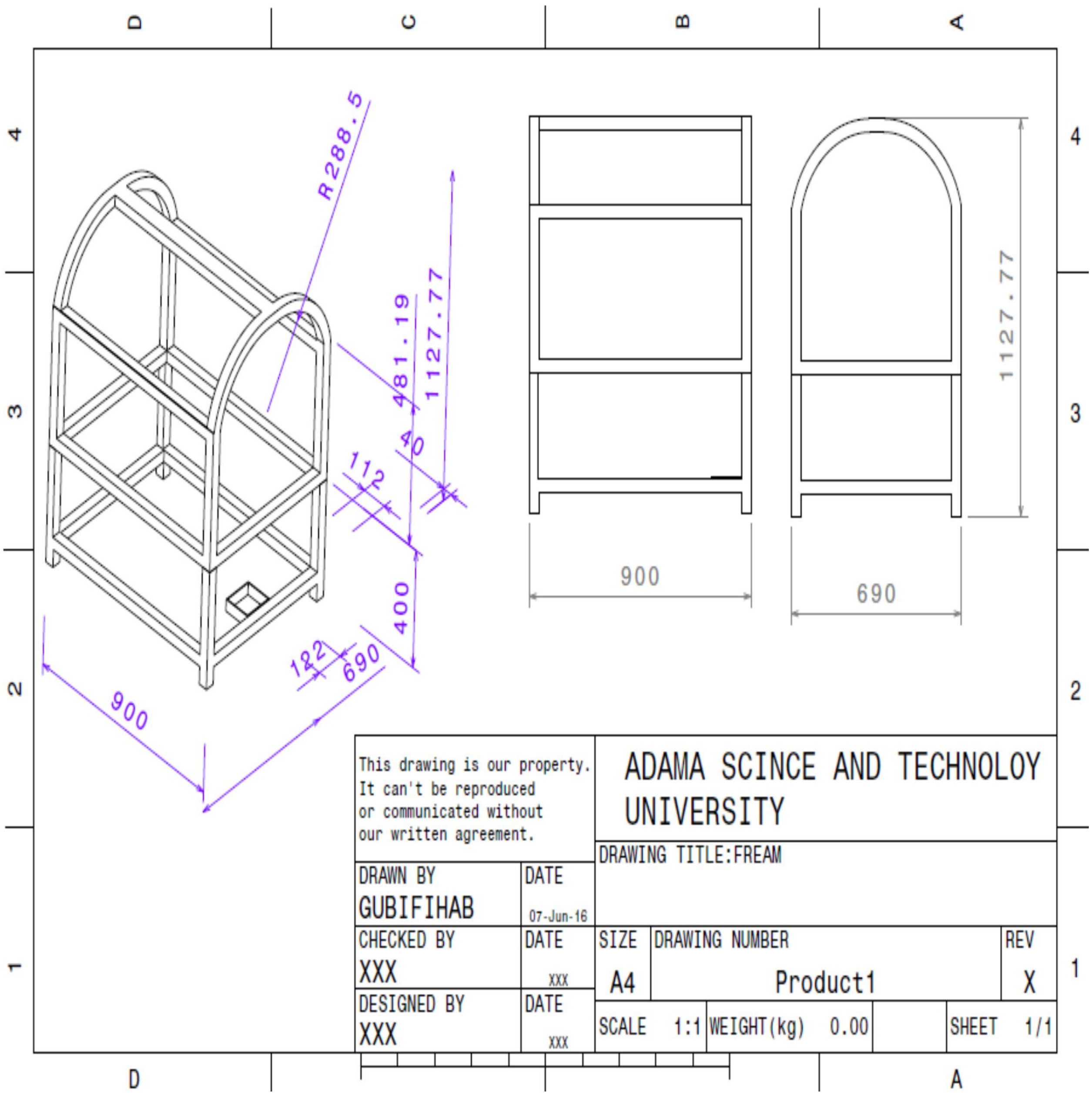
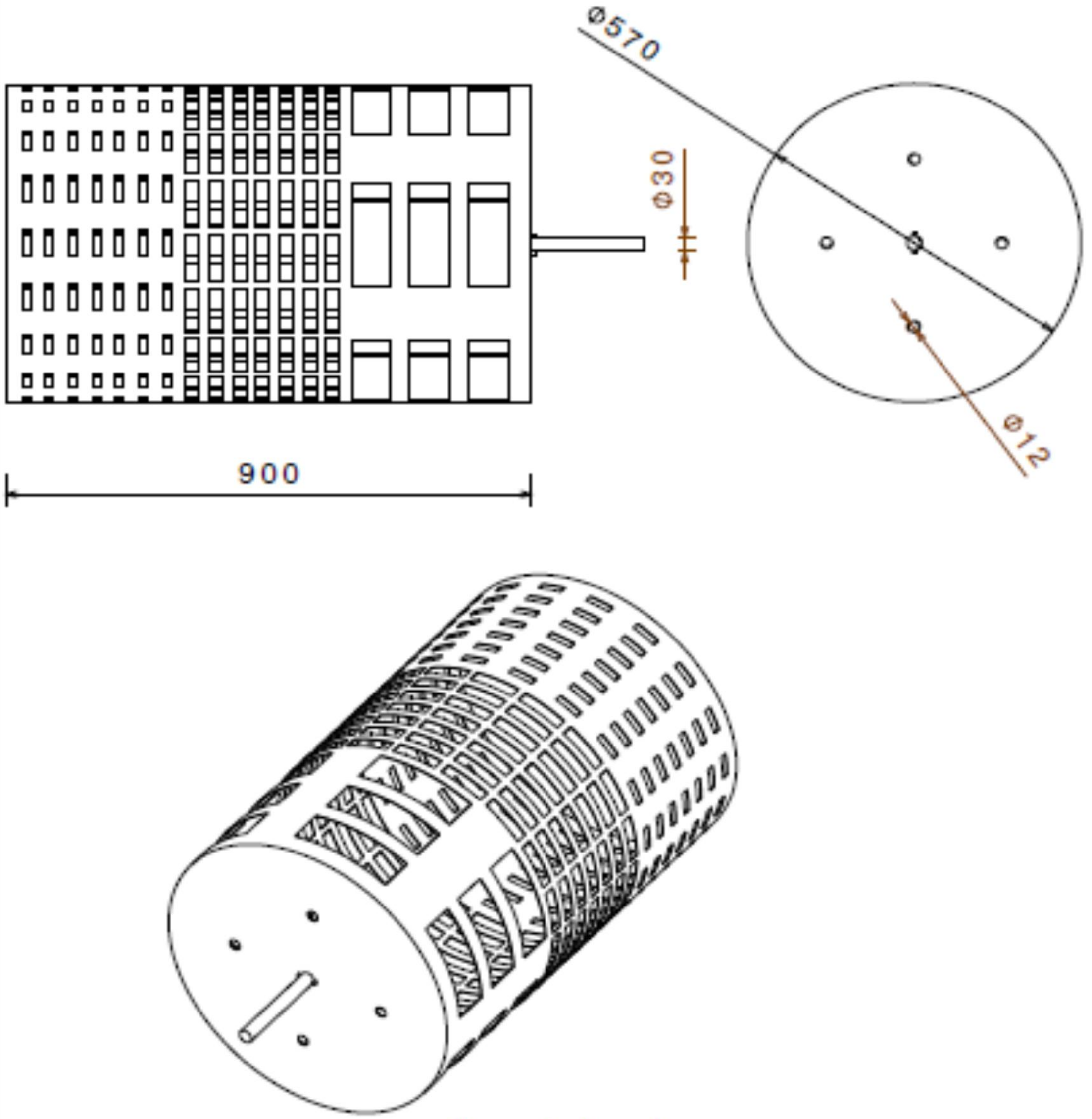
# APPENDIX-A

**Detail and assembly drawing**

Detail drawing shows each and individual part drawing of the project or machine. The parts are drawn with appropriate scale whereas assembly drawing shows the overall view of the project.






Isometric view

| | | | | | |
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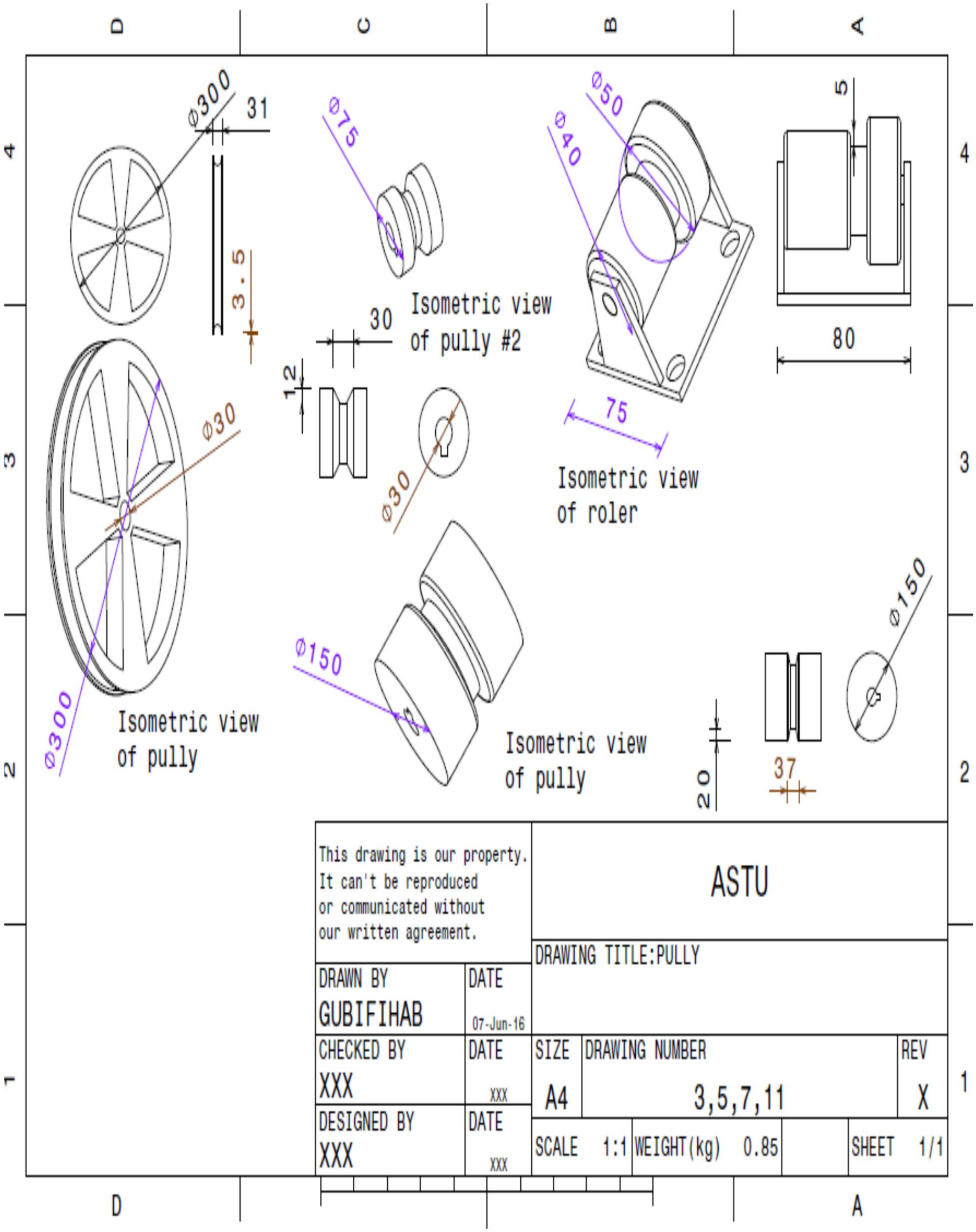
| This drawing is our property. It can't be reproduced or communicated without our written agreement. | | ADAMA SCIENCE AND TECHNOLOGY UNIVESITY | | | |
| DRAWN BY GUBIFIHAB | DATE 07-Jun-16 | DRAWING TITLE: SEIVE | | | |
| CHECKED BY XXX | DATE XXX | SIZE A4 | DRAWING NUMBER 2 | | REV X |
| DESIGNED BY GURMU | DATE 07-Jun-16 | SCALE 1:1 | WEIGHT(kg) 1.90 | | SHEET 1/1 |


Isometric view
of pully
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37
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ASTU
DRAWING TITLE:PULLY
DRAWN BY
GUBIFIHAB
DATE
07-Jun-16
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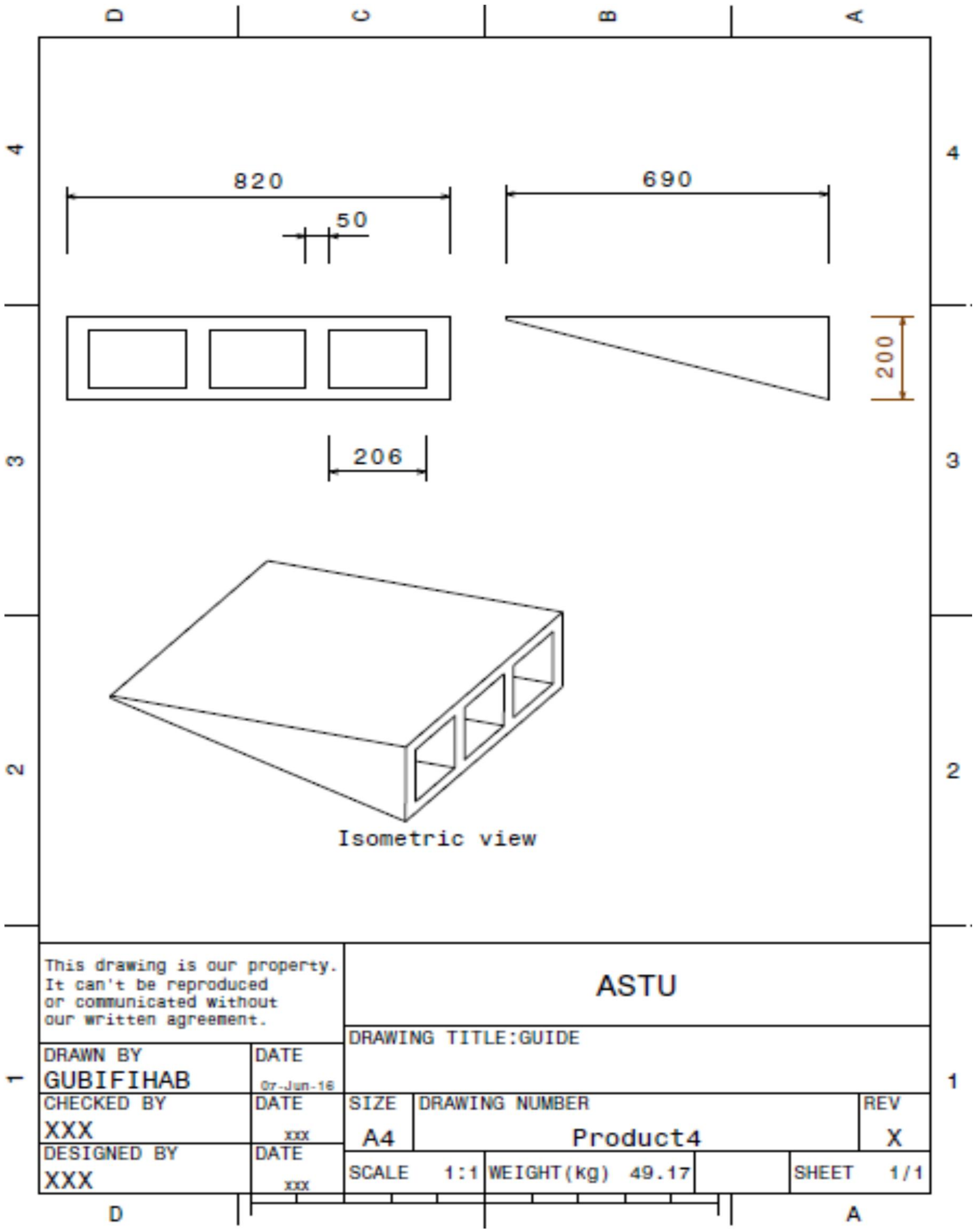
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Isometric view
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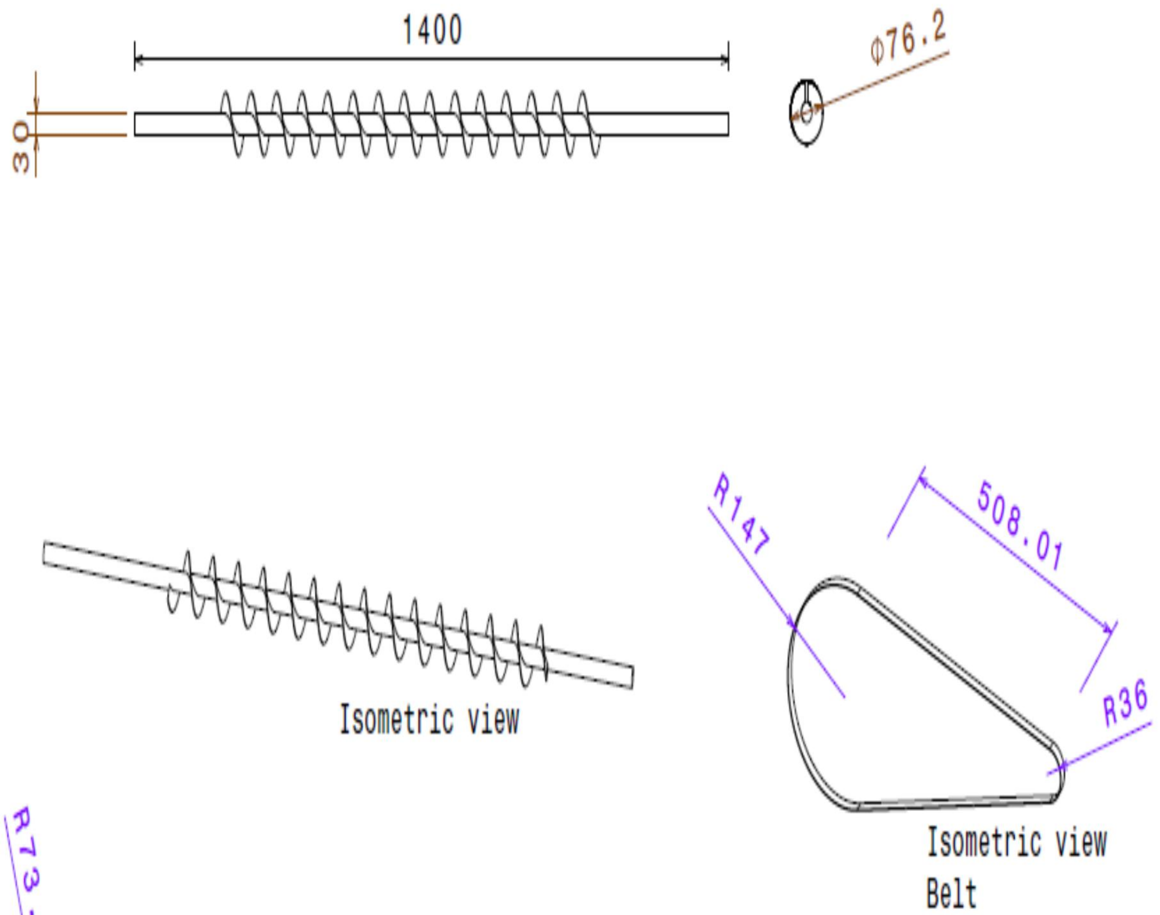


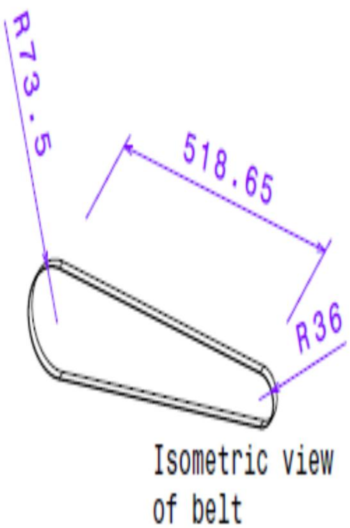


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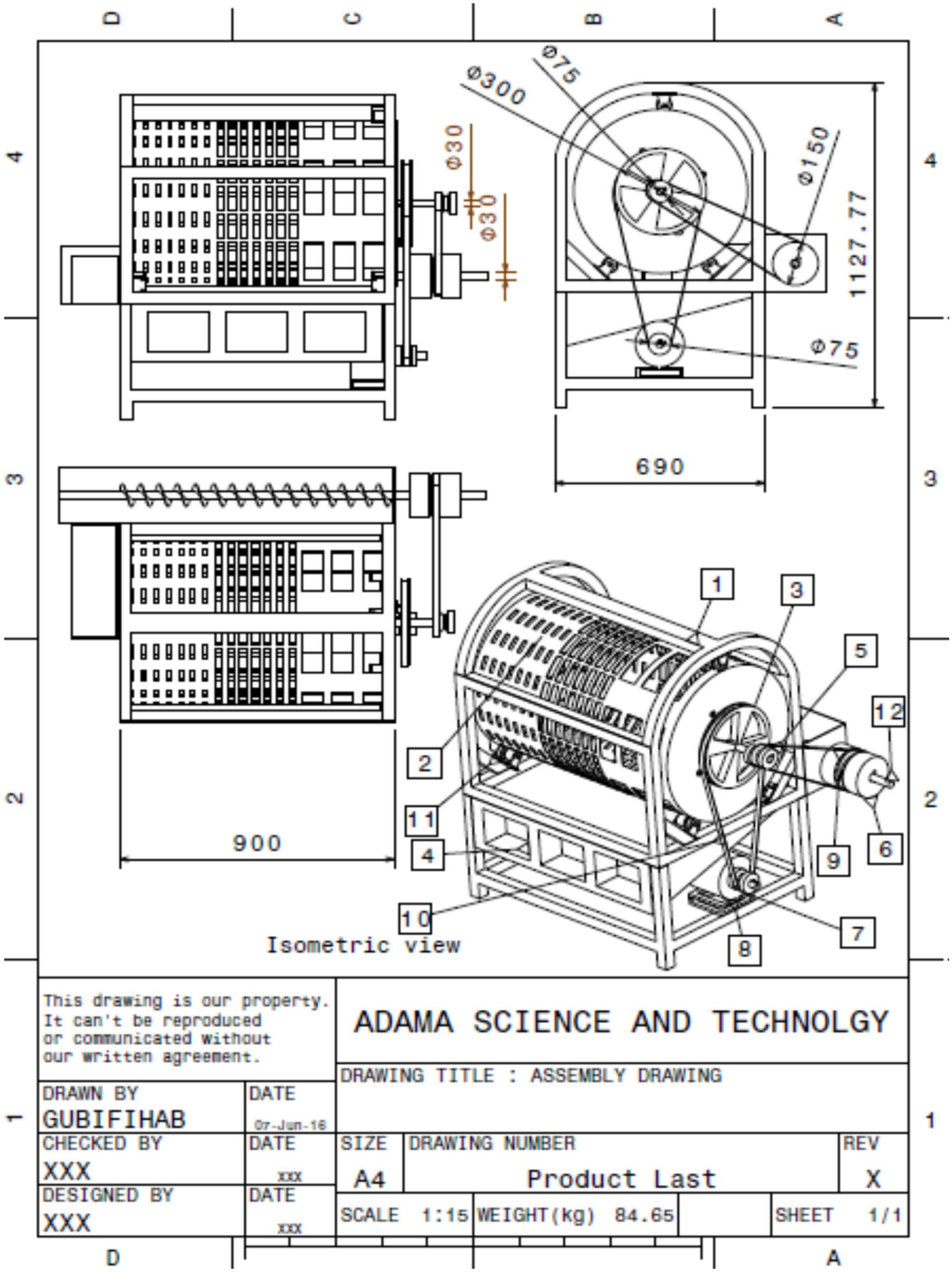
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Isometric view
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DRAWING TITLE : ASSEMBLY DRAWING
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Product Last
REV
X
SCALE 1:15
WEIGHT(kg) 84.65
SHEET 1/1

# APPENDIX-B

## ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

**Questioner for interview**

Site of data collection: Adama city

Dear participant:

The purpose of this interviewing is to identify about need assessment sand sieving machine for the project of master graduate project that to design and manufacture this machine at Adama Science and Technology University. For the ideas that you will give us genuine information about the demand and importance of this machine we would like to thank you in advance.

Part 1 :-For question written below you are expected to give us genuine information

1. What is your current role in this site?

___

2. Do you have sand sieve machine sand?

   Yes ☐ No ☐

3. If your answer is yes for question 2 what type sand sieve machine is it?

___

4. What is the problem with this machine?

___

5. What are the sieve sizes you use frequently?

___

# APPENDIX-C

Principal Dimension for Radial Ball Bearing

| *Bearing No* | *Bore (mm)* | *Outer diameter(mm)* | *Width(mm)* |
|---|---|---|---|
| 200 | 10 | 30 | 9 |
| 300 | | 35 | 11 |
| 201 | 12 | 32 | 10 |
| 301 | | 37 | 12 |
| 202 | 15 | 35 | 11 |
| 302 | | 42 | 13 |
| 203 | 17 | 40 | 12 |
| 303 | | 47 | 14 |
| 403 | | 62 | 17 |
| 204 | 20 | 47 | 14 |
| 304 | | 52 | 14 |
| 404 | | 72 | 19 |

# APPENDIX-D

**Values of service factor (KS).**

| No | Type of service | Service factor (KS) for radial ball bearings |
|---|---|---|
| 1 | Uniform and steady load | 1.0 |
| 2 | Light shock load | 1.5 |
| 3 | Moderate shock load | 2.0 |
| 4 | Heavy shock load | 2.5 |
| 5 | Extreme shock load | 3 |

# APPENDIX-E

**Basic static and dynamic capacities of various types of radial ball bearings.**

| Bearing No | Basic capacities in kN | | | |
|---|---|---|---|---|
| | Single row deep groove ball bearing | | Single row angular contact ball bearing | |
| | Static | Dynamic | Static | Dynamic |
| 200 | 2.24 | 4 | - | - |
| 300 | 3.6 | 6.3 | - | - |
| 204 | 6.55 | 10 | 6.55 | 10.4 |
| 304 | 7.65 | 12.5 | 8.3 | 13.7 |
| 205 | 7.1 | 11 | 7.8 | 11.6 |
| 305 | 10.4 | 16.6 | 12.5 | 19.3 |

# APPENDIX-F

Table for Dimensions of standard V-belts according to IS: 2494 – 1974

| *Type of belt* | *Power ranges in kW* | *Minimum pitch diameter of pulley (D) mm* | *Top width (b) Mm* | *Thickness (t) mm* | *Weight per metre length in newton* |
|---|---|---|---|---|---|
| *A* | 0.7 – 3.5 | 75 | 13 | 8 | 1.06 |
| *B* | 2 – 15 | 125 | 17 | 11 | 1.89 |
| *C* | 7.5 – 75 | 200 | 22 | 14 | 3.43 |
| *D* | 20 – 150 | 355 | 32 | 19 | 5.96 |
| *E* | 30 – 350 | 500 | 38 | 23 | – |

Table for Dimensions of standard V-grooved pulleys according to IS : 2494–1974.

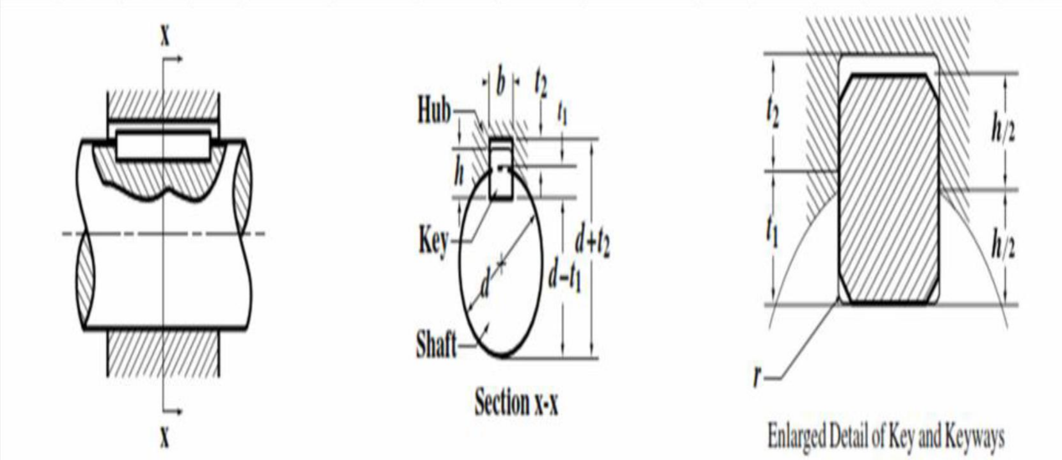
(All dimensions in mm)

| *Type of belt* | *w* | *d* | *a* | *c* | *f* | *e* | *No. of sheave grooves (n)* | *Groove angle (2□) in degrees* |
|---|---|---|---|---|---|---|---|---|
| *A* | 11 | 12 | 3.3 | 8.7 | 10 | 15 | 6 | 32, 34, 38 |
| *B* | 14 | 15 | 4.2 | 10.8 | 12.5 | 19 | 9 | 32, 34, 38 |
| *C* | 19 | 20 | 5.7 | 14.3 | 17 | 25.5 | 14 | 34, 36, 38 |
| *D* | 27 | 28 | 8.1 | 19.9 | 24 | 37 | 14 | 34, 36, 38 |
| *E* | 32 | 33 | 9.6 | 23.4 | 29 | 44.5 | 20 | – |

# APPENDIX-G

**Table 1. British Standard Metric Keyways for Square and Rectangular Parallel Keys** *BS 4235:Part 1:1972 (1986)*

| Shaft: Nonimal Diameter $d$ | | Key | Keyway: Width, $b$ | | | | | | Depth | | | | Radius r | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Free Fit | | Normal Fit | | Close Fit | Shaft $t_1$ | | Hub $t_2$ | | | |
| Over | Up to and Incl. | Size, $b \times h$ | Nom. | Shaft (H9) | Hub (D10) | Shaft (N9) | Hub ($J_S9$)[a] | Shaft and Hub (P9) | Nom. | Tol. | Nom. | Tol. | Max. | Min. |
| | | | | Tolerances | | | | | | | | | | |
| Keyways for Square Parallel Keys | | | | | | | | | | | | | | |
| 6 | 8 | 2×2 | 2 | +0.025 | +0.060 | −0.004 | +0.012 | −0.006 | 1.2 | +0.1 | 1 | +0.1 | 0.16 | 0.08 |
| 8 | 10 | 3×3 | 3 | 0 | +0.020 | −0.029 | −0.012 | −0.031 | 1.8 | 0 | 1.4 | 0 | 0.16 | 0.08 |
| 10 | 12 | 4×4 | 4 | +0.030 | +0.078 | 0 | +0.015 | −0.012 | 2.5 | | 1.8 | | 0.16 | 0.08 |
| 12 | 17 | 5×5 | 5 | 0 | +0.030 | −0.030 | −0.015 | −0.042 | 3 | | 2.3 | | 0.25 | 0.16 |
| 17 | 22 | 6×6 | 6 | | | | | | 3.5 | | 2.8 | | 0.25 | 0.16 |




Section x-x

Enlarged Detail of Key and Keyways

# APPENDIX- H

## Table of International Tolerance grade (ISO) standard

| BASIC SIZES | TOLERANCE GRADES | | | | | |
|---|---|---|---|---|---|---|
| | IT6 | IT7 | IT8 | IT9 | IT10 | IT11 |
| 0–3 | 0.006 | 0.010 | 0.014 | 0.025 | 0.040 | 0.060 |
| 3–6 | 0.008 | 0.012 | 0.018 | 0.030 | 0.048 | 0.075 |
| 6–10 | 0.009 | 0.015 | 0.022 | 0.036 | 0.058 | 0.090 |
| 10–18 | 0.011 | 0.018 | 0.027 | 0.043 | 0.070 | 0.110 |
| 18–30 | 0.013 | 0.021 | 0.033 | 0.052 | 0.084 | 0.130 |
| 30–50 | 0.016 | 0.025 | 0.039 | 0.062 | 0.100 | 0.160 |
| 50–80 | 0.019 | 0.030 | 0.046 | 0.074 | 0.120 | 0.190 |
| 80–120 | 0.022 | 0.035 | 0.054 | 0.087 | 0.140 | 0.220 |
| 120–180 | 0.025 | 0.040 | 0.063 | 0.100 | 0.160 | 0.250 |
| 180–250 | 0.029 | 0.046 | 0.072 | 0.115 | 0.185 | 0.290 |
| 250–315 | 0.032 | 0.052 | 0.081 | 0.130 | 0.210 | 0.320 |
| 315–400 | 0.036 | 0.057 | 0.089 | 0.140 | 0.230 | 0.360 |

# APPENDIX -I

## Fundamental deviation of shafts (ISO)

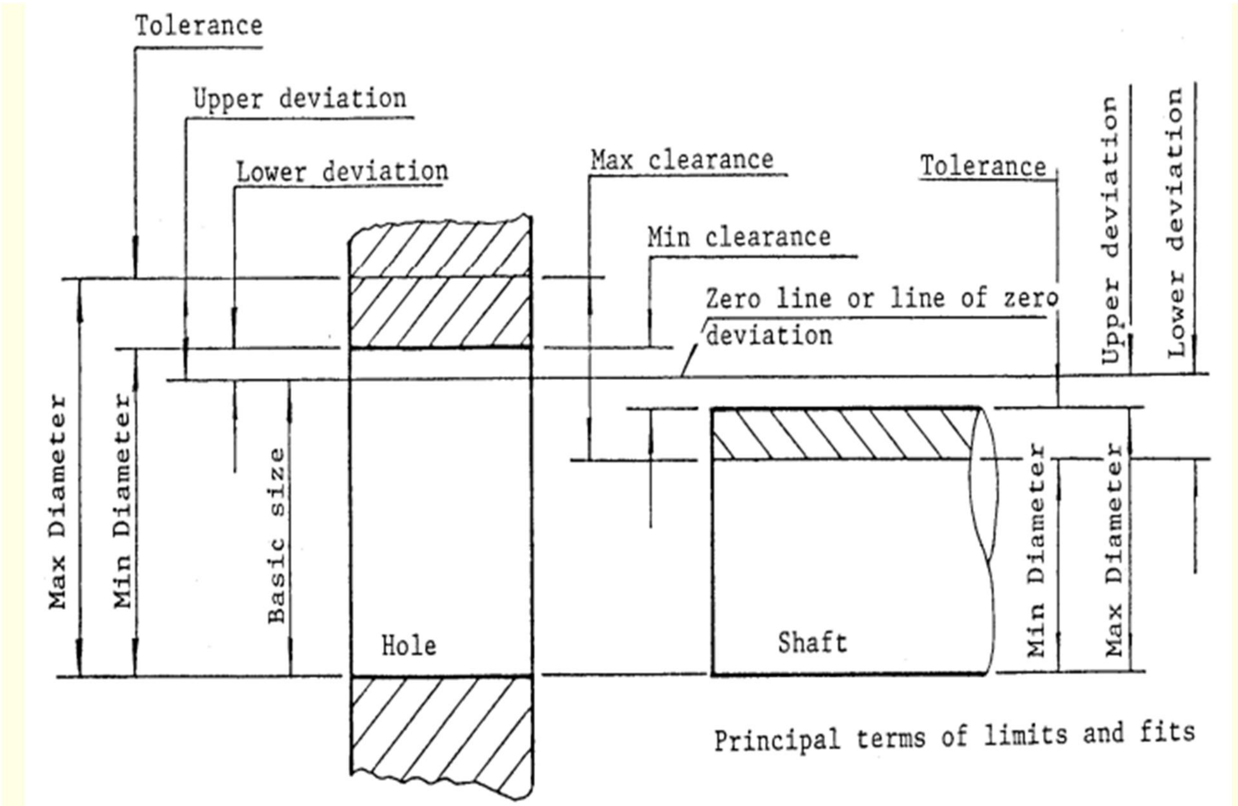
| No. | Basic sizes | UPPER- DEVIATION LATTER | | | | | LOWER- DEVIATION LATTER | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | c | d | f | g | h | k | n | p | s | u |
| 1 | 0-3 | -0.060 | -0.020 | -0.006 | -0.002 | 0 | +0 | +0.004 | +0.006 | +0.014 | +0.018 |
| 2 | 3-6 | -0.070 | -0.030 | -0.010 | -0.004 | 0 | +0.001 | +0.008 | +0.012 | +0.019 | +0.023 |
| 3 | 6-10 | -0.080 | -0.040 | -0.013 | -0.005 | 0 | +0.001 | +0.010 | +0.015 | +0.023 | +0.028 |
| 4 | 10-14 | -0.095 | -0.050 | -0.016 | -0.006 | 0 | +0.001 | +0.012 | +0.018 | +0.028 | +0.033 |
| 5 | 14-18 | -0.095 | -0.050 | -0.016 | -0.006 | 0 | +0.001 | +0.012 | +0.018 | +0.028 | +0.033 |
| 6 | 18-24 | -0.110 | -0.065 | -0.020 | -0.007 | 0 | +0.002 | +0.015 | +0.022 | +0.035 | +0.041 |
| 7 | 24-30 | -0.110 | -0.065 | -0.020 | -0.007 | 0 | +0.002 | +0.015 | +0.022 | +0.035 | +0.043 |
| 8 | 30-40 | -0.120 | -0.080 | -0.025 | -0.009 | 0 | +0.002 | +0.017 | +0.026 | +0.043 | +0.060 |
| 9 | 40-50 | -0.130 | -0.080 | -0.025 | -0.009 | 0 | +0.002 | +0.017 | +0.026 | +0.043 | +0.070 |
| 10 | 50-65 | -0.140 | -0.100 | -0.030 | -0.010 | 0 | +0.002 | +0.020 | +0.032 | +0.053 | +0.081 |
| 11 | 65-80 | -0.150 | -0.100 | -0.030 | -0.010 | 0 | +0.002 | +0.020 | +0.032 | +0.059 | +0.102 |
| 12 | 80-100 | -0.170 | -0.120 | -0.036 | -0.012 | 0 | +0.003 | +0.023 | +0.037 | +0.071 | +0.124 |
| 13 | 100-120 | -0.180 | -0.120 | -0.036 | -0.012 | 0 | +0.003 | +0.023 | +0.037 | +0.079 | +0.144 |

# APPENDIX-J

Physical Work Capacity (PWC) in kcal/minute for Females and Males as Function of Age and Work Duration

| Females | | | | |
|---|---|---|---|---|
| Age (yrs) | 120 min | 240 min | 480 min | 510 min |
| 20 | 7.26 | 5.86 | 4.46 | 4.34 |
| 25 | 7.07 | 5.71 | 4.35 | 4.23 |
| 30 | 6.82 | 5.51 | 4.20 | 4.08 |
| 35 | 6.26 | 5.05 | 3.85 | 3.74 |
| 40 | 5.94 | 4.80 | 3.66 | 3.56 |
| 45 | 5.82 | 4.70 | 3.58 | 3.48 |
| 50 | 5.69 | 4.60 | 3.50 | 3.41 |
| 55 | 5.51 | 4.45 | 3.39 | 3.29 |
| 60 | 5.19 | 4.19 | 3.19 | 3.11 |
| 65 | 4.94 | 3.99 | 3.04 | 2.96 |
| **Males** | | | | |
| Age (yrs) | 120 min | 240 min | 480 min | 510 min |
| 20 | 9.68 | 7.82 | 5.95 | 5.79 |
| 25 | 9.43 | 7.61 | 5.80 | 5.64 |
| 30 | 9.09 | 7.34 | 5.59 | 5.44 |
| 35 | 8.34 | 6.74 | 5.13 | 4.99 |
| 40 | 7.93 | 6.40 | 4.88 | 4.74 |
| 45 | 7.76 | 6.27 | 4.77 | 4.64 |
| 50 | 7.59 | 6.13 | 4.67 | 4.54 |
| 55 | 7.34 | 5.93 | 4.52 | 4.39 |
| 60 | 6.92 | 5.59 | 4.26 | 4.14 |
| 65 | 6.59 | 5.32 | 4.05 | 3.94 |

# APPENDIX-K




Principal terms of limits and fits