ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY
School of Mechanical, Chemical and Material Engineering

DESIGN AND MANUFACTURING OF CEMENT TILE VIBRATOR MACHINE

A Thesis/project submitted in partial fulfillment of the requirement for the award of the degree of Masters of Science

in

Manufacturing Technology Teacher Education

By:

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Advisor: Dr. Habtamu Beri

Department of Mechanical and Vehicle Engineering

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Approved by board of examiners

Chairman, Department Graduate Committee Signature Date

Internal Examiner Signature Date

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Advisor Signature Date

DECLARATION

We hereby declare that the work which is being presented in this project entitle **"DESIGN AND MANUFACTURING OF CEMENT TILE VIBRATOR MACHINE",** is our original design 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 work.

Candidate	Signature	Date
Fentaw Hussien	________________________	________________________
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This is to certify that the above declaration made by the candidates is correct to the best of my knowledge and belief. This project has been submitted for examination with my approval.

Dr. Habtamu Beri	____________________	______________________
(Advisor)	**Signature**	**Date**

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Abstract

Cement tile is a rich resource in Ethiopia and has a great possibility for marketing such as small and micro enterprise and private enterprise, which can drive urban and semi-urban development. Almost all cement tile production activities are done may be at risk of absence of appropriate machine because of cost, capacity and production rate. To solve this, redesigning and improving for automatic feeder and manual hydraulic machine by cement tile vibrator machine provides solutions for time wastage and cost due to slow production rate of the machine and limited with fixed size product. While cement tile vibrator machine can produce 9-16 pieces in once, very cheap comparing from the existing machines and fast production rate that is from 1-2 minutes. It also manipulate easily for necessary operation relative to existing machine and not complicated to operate, eliminate pressing operation, light in weight and easily move from site to site, produce different size of tiles and easy to maintenance.

To achieve this, an observation and interview has been made in the selected sub-cities in Addis Ababa SMEs (Yeca sub-city, Nifas silk/Lafto sub-city, Bole sub-city and Kirkos sub-city), known private enterprise (Zenebe Firaw Cement Product Enterprise) and Addis Ababa small and micro enterprise developmental agency.

Data are collected by means of observation and structured interviews with related bodies. Based on the data analyzed, an improved electrical cement tile vibrator machine is designed and manufactured to improve the efficiency of the users. The development history and existing shortcomings of cement tile machine is briefly described and the electrical operated cement tile vibrator technology is studied out with a balanced inner shaft structure driven by belt drive mechanism. Finally manufacturing operation, assembling and maintenance, testing of different components, construction, working principles and result and discussion of the project is explained in this paper.

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ABBREVIATIONS AND ACRONYMS

SMEs- Small and Micro Enterprises

IDRC- International Development Research Center

AC- Alternate Current

DC- Direct Current.

ISO- International Standard Organization

WF- Weight Factor

RPM- Revolution per Minute

ASTU- Adama Science and Technology University

ASME- American Society of Mechanical Engineer

CHAPTER ONE
INTRODUCTION

1.1. Background

Cement tiles are wall & floor tiles made of cement together with sand, gravel and optionally adding marble chips to the ingredient. This at present is used in many factories. Cement tiles of various sizes can be produced. The most common ones range from surface sized of 20 cm x 20 cm to 60 x 40 cm having thicknesses in the range of 1 to 6 cm. The raw materials required for manufacture of the product are Portland cement and aggregates which are available locally in every part of the country.

Cement tiles find applications in side of the road, footpaths, gardens, passenger waiting sheds, bus-stops, industry and other public places. The product is commonly used in urban areas for the above applications. Hence, the unit may be set up in urban and semi-urban areas, near the market. A lot of face-lift is being given to roads; footpaths along the roadside. Tiles are ideal materials on the footpaths for easy laying, better look and finish. Whereas the tiles find extensive use outside the large building and houses, lots of these materials are also used in flooring in the open areas of public offices and commercial buildings and residential apartments.

Cement tiles use plastic moulds and vibrating tables. The different materials such as sand, cement and marble chips are assumed to be ready at the site of the plant. The ready-made raw materials together with water are mixed in the right proportion by a mixer and measured amounts are poured into the flexible moulds. Mixing and pouring can be done manually or automatically. Each mould containing the measured mix is made to travel the length of the vibrating table for about one minute. The mixed cement with mould is place in the table, after moulding vibrate the table only one minute for compacting and shaping tiles.

Allowing the concrete mix in the plastic mould to travel along the vibrating table has the advantage of eliminating air bubbles and water vein. This will create an exceptionally high compactness of the aggregates and the cement in the mix. The main advantages of cement tile vibrator machines are as the following.

- It is not complicated to operate and manipulate easily
- High production capacity Relative to existing machine
- Eliminate pressing operation.
- Minimize cost and production time.

- Light weight.
- Produce different size of tiles.
- Easy to maintenance.

cement tile production is a well-established industry in many countries .In existing technology for cement tile production by means of mechanical and hydraulic process is a huge, slow, require high power and cost machine and it is more expensive to purchase small and micro enterprise (SME). The main aim behind this development of cement tile vibratory machine is solve the problem of small and micro enterprise and reduce cost, time and power of worker and increase quantity of product .So an improved cement tile vibratory machine will be fabricated which can perform compacting the concrete mix in the moulds of desired sizes and shapes. This machine is kept common for electrical operations. This will eliminate the use of hand press for compacting which is to be done existing machine.

Electrical source of the machine rotate the motor spindle and the pulley so the power transmit from motor spindle to table shaft by belt mechanisms because in the table shaft fix unbalance pin in order to sense of eccentric rotation the shaft, the spring between vibrating table and body of the machine compress and tension these causes vibrate the table and the mixing component of cement tile so cement tile is compressed and shaped to the mold.

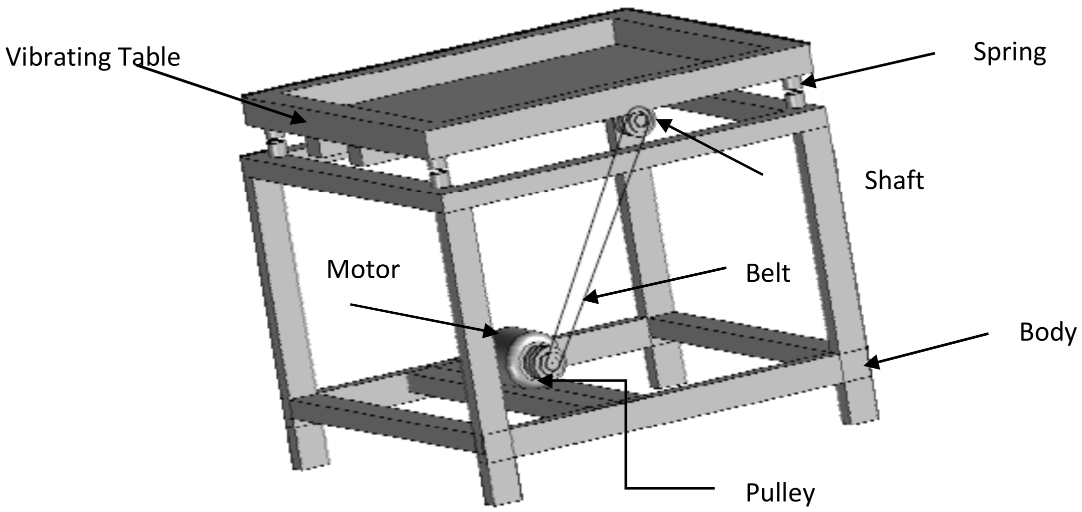


Fig.1.1 Cement tile vibrator machine

1.2. Statement of the problem

Today construction is become more concern for our country Ethiopia. So number of tile productions is increase. Availability of appropriate machines is important to perform compacting operations. We have visited those who produce cement tile. In our visits we have observed the following problems:

- Wastage of power, time and cost.
- Require excess work force.
- Difficult to maintenance.
- Difficult to duplicate in MSE.
- Require high space.
- Low productivity.
- The imported modern machines are more expensive and not easily available.

So by considering the above problems, we propose to design and manufacture cement tile vibrator machine to overcome the above mentioned problems.

1.3. Objective of the project

1.3.1. General objective

The general objective of this project is to design and manufacture cement tile machine which is operated electrically to improve productivity of small and micro enterprise in Ethiopia reducing wastage of time, money and energy in existing processing of tile production.

1.3.2. Specific objectives

- Design belt mechanism for vibrating the table
- To select appropriate material for each machine components.
- Changing hydraulics in to electrical mechanism to increase productivity
- Design machine elements for appropriate operation.
- To minimize wastage of time, money and energy by producing 8-16 pieces in one operation.
- To minimize the cost of machine by using local material.
- Manufacture cement tile vibrator machine in simple operating method.

1.4. Scope and target group

The project’s intension is to design and manufacture cement tile vibrator machine that compact mixed cement concrete. The operation can be set electrically. Our target community for a proof-of-concept design is all the small and micro enterprise .Cement tiles are modern construction materials and as such are used in all the footpaths, gardens, passenger waiting sheds, bus-stops, industry and other public places. Whereas the tiles find extensive use outside the large building and houses, lots of these materials are also used in flooring in the open areas of public offices and commercial buildings and residential apartments.

Construction industry is a growing sector. The demand for this product is always high in all urban and semi-urban areas due to construction of side of main roads, residential apartments, commercial and industrial buildings.

Growing public awareness of the advantages of the product coupled with increase in the government and financial institutions support for housing and road which is a basic human necessity would ensure a healthy growth in the demand. .

This machine will be designed to be produced and maintained in any situation where small and micro enterprise that organize in metal works. It will help to initiate the way for appropriate technologies that would help the society.

1.5. Methodology

Our methodology to make the project successfully will include qualitative and quantitative approaches:

- Performing realistic cement tile manufacturer studies through interview and observations (qualitative and quantitative data collection) to get more information about cement tile producing.
- Making qualitative and statistical data analysis related to vibrating machines.
- Referring to documents of different existing machine technology.
- Constructing vibrate cement tile machine using different manufacturing processes.
- Choosing & modifying a better design, cheap cost and easy to operate.
- Testing the machine and redesigning.

1.6 Significance of the project

- In Ethiopia the construction sectors becomes a major issue. Due to this peoples need cement tiles processing machine. From this it can be understood how important the cement tile vibrating machines
- Cement tile vibrating machine could be in generating economic advantages to the country as a whole and to individuals in particular.
- The construction sector is a highly profitable business for micro and small scale cement tile product producers.
- In general, this machine has many purposes which include the researchers can acquire knowledge and experience, SMEs can duplicate the machine and sell to the market and users of the machine can get optimum efficiency with minimum cost.

This project enables to

- Develop designing and manufacturing skill
- Learn collaboration skills and encourage technology transfer in Ethiopia.
- Increase income for micro and small enterprise those who works in cement tile processing activities
- Increase productivity
- Reduce cost by using local available materials
- Substitute other imported machines. This is beneficial to save foreign exchange currency.

1.7. Limitations

Some limitation of the improve cement tile machine are listed below:-

- Cement tile vibrator machine perform only compacting that do not grind and polish.
- The machine cannot produces more than 16 pieces of cement tiles at one operation.

1.8. Working principles

Existing cement tile machine made by manually and hydraulically compact one piece in one operation and wastage of time and energy but in our improved cement tile machine will be compact 8-16 tiles at once by changing different size moulds and vibrating a special purpose machine.

In the first step a concrete mix of 1:2:4 (cement: sand: stone chips) by volume with water to cement ratio of 0.62. Is feed in to the special plastic moulds and place on the vibrate table to compact required strength.

After compacting the tiles are de-molded and kept for 24 hours in a shelter away from direct sun and winds. The tiles thus hardened are cured with water to permit complete moisture for 14 to 21 days.

After curing, tiles are allowed to dry in shade so that the initial shrinkage of the tiles is completed before they are used in the work. A drying period of 7 to 15 days would normally complete the drying shrinkage after which they can be used.

Estimated design specifications

- The capacity of the machine to compact the tile is estimated to be between up to 16 pieces with one minute.
- Estimated Cost: approximately 12002.46 birr
- Materials: sheet, plate, square pipe, angle Iron, aluminum ingot, bearing, spring, belt, hinge, Motor, rod etc.
- Overall dimensions: 920x920x930 mm

1.9. Feasibility of the project

1.9.1. Technical feasibility

The cement tile vibrator machine will be manufactured using Belt mechanisms. And the materials that will be used to make the machine are always available in the market. If any defect or failure occurs the machine can be maintained easily. Parts can also be replaced easily if it is necessary because they are available in the market. Therefore, by taking these points in to consideration we can say that the cement tile vibrator machine is technically feasible.

1.9.2. Operational feasibility

We have already mentioned that the cement tile vibrator machine will have simple mechanisms. This makes it simple to operate. Any person with small skills can operate the machine by taking a one or two days training. Hence the machine is operationally feasible.

1.9.3. 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 enterprise that want to manufacture and provide tile products to the market can afford to buy the cement tile vibrator machine with a reasonable price. Due to these reasons we can say that the cement tile vibrator machine is economically feasible.

1.9.4. Cost and Benefit analysis

cement tile table vibrator machine is more cheaper than automatic feeder, mixer and press machine and manual hydraulics press machine the cost of cement tile vibrator machine up to 12,002.46 birr and the cost of other imported machines are more than 100,000 birr due to these reasons we can say that the cement tile vibrator machine is costly feasible.

The benefit of cement tile vibrator machines are not complicated to operate and manipulate easily, high production capacity relative to existing machine, eliminate pressing operation, minimize cost and production time, light weight, produce different size of tiles, easy to maintenance.

1.9.5. Efficient

It is much more efficient to produce cement tile and requires less energy using the cement tile vibrator machine than to use existing manual and hydraulic machine.

1.9.6. Affordable

The target buyer for our machine is those who work in tile processing micro and small enterprise and any person that manufacture tile products. Since the machine can be set electrically, it can be used everywhere urban whether electric

CHAPTER TWO
LITRATURE REVIEW

2.1. Introduction

The production of cement tiles use rubber moulds and vibrating tables. The different materials such as sand, cement, aggregates (gravel) and marble chips are assumed to be ready at the site of the plant. The ready-made raw materials together with water are mixed in the right proportion by a mixer and measured amounts are poured into the flexible moulds. Mixing and pouring can be done manually or automatically. Each mould containing the measured mix is made to travel the length of the vibrating table for about one minute. Allowing the concrete mix in the rubber mould to travel along the vibrating table has the advantage of eliminating air bubbles and water veins. In addition to this, the mix is pressed with tiles press. This will create an exceptionally high compactness of the aggregates and the cement in the mix. After a period varying from one to two hours, a second and thicker layer of concrete is added to the first, and the moulds are vibrated again. The result of vibration is a perfect compaction and firm hold between the two layers. The tile hardens in the mould is then remolded on the following day without the need of any remolding products. The concrete then dries in controlled conditions of temperature and humidity. It is to be noted that during preparation of mix, pigments are added to give different colures to the product.

2.2. Terminology

For the purpose of this standard, the following definitions shall apply.

- **Plain Cement Tiles —** Tiles having a plain wearing surface, in the manufacture of which pigments and stone chips are not used in the wearing surface.
- **Plain Colored Tiles —** Tiles having a plain wearing surface wherein pigments are used but not stone chips.
- **Terrazzo Tiles —** Tiles at least 25 percent of whose wearing surface is composed of stone chips in a matrix of plain or colored Portland cement, mixed with or without pigments and mechanically ground and filled, if required.
- **Single Layer/Monolayer Tiles —** Tiles, plain or terrazzo, in which there is only one layer that is wearing layer, and which do not contain a backing layer.
- **Double Layer Tile —** Tiles which contain a wearing layer as well as a backing layer

2.3. Classification

Cement concrete flooring tiles shall be of two classes as given below depending on the duty they perform:

- **General Purpose Tiles** -Used in such places where normally light loads are taken up by the floors; such as office buildings, schools, colleges, hospitals and residential buildings (usually indoor floors).
- **Heavy Duty Floor Tiles-** Used for heavy traffic conditions; such as foot paths, ramps, entrances and staircases of public buildings, passages of auditoriums and storage go downs (public path or industrial floors).

2.4. Materials

Cement

Cement used in the manufacture of tiles shall be 33 grade ordinary Portland cement conforming to IS 269 or 43 grade ordinary Portland cement conforming to IS 8112 or 53 grade ordinary Portland cement conforming to IS 12269 or Portland pozzolana cement (flyash based) conforming to IS 1489 (Part 1) or Portland pozzolana cement (calcined clay based) conforming to IS 1489 (Part 2) or Portland slag cement conforming to IS 455 or rapid hardening Portland cement conforming to IS 8041 or white Portland cement conforming to IS 8042. Source (*Indian Standard* cement concrete flooring tiles — specification *(Second Revision))*

Aggregates

Aggregates used in the backing layer of tiles shall conform to the requirements of IS 383. For the wearing layer, unless otherwise specified, aggregates shall consist of marble chips or any other natural stone chips of similar characteristics and hardness, marble powder or dolomite powder, or a mixture of the two.

Pigments

Pigments, synthetic or otherwise, used for colourings tiles shall have durable colour. It shall not contain matters detrimental to concrete and shall according to the colour required be one of the following or their combination:

Pigments	Ref to IS No.
Black or red or brown	IS 44
Green pigments	IS 54
Blue pigments	IS 55 or IS 56 or IS 3574
White pigments	IS 411
Yellow pigments	IS 50 or IS 3574.

The process of manufacture of cement concrete paving blocks involves the following steps:

- Proportioning
- Mixing
- Compacting
- Curing
- Drying

A concrete mix of 1:2:4 (cement: sand: stone chips) by volume may be used for cement concrete paving blocks with water to cement ratio of 0.62. Fineness modules of combined aggregates should be in the range of 3.6 to 4.0.

All the raw materials are placed in a concrete mixer and the mixer is rotated for 15 minutes. The prepared mix is discharged from the mixer and consumed in the next 30 minutes. Vibrating table may be used for compact the concrete mix in the moulds of desired sizes and shapes.

After compacting the tiles are de-molded and kept for 24 hours in a shelter away from direct sun and winds. The blocks thus hardened are cured with water to permit complete moist ration for 14 to 21 days. Water in the curing tanks is changed every 3 to 4 days. After curing, the tile are dried in natural atmosphere and sent for use. The concrete paving tiles gain good strength during the first 3 days of curing and maximum gains in strengths are secured in the first 10 to 15 days of curing. After curing, tiles are allowed to dry in shade so that the initial shrinkage of the tiles is completed before they are used in the work. A drying period of 7 to 15 days would normally complete the drying shrinkage after which they can be used.

The concrete tiles are similarly produced with the help of semi-dry pressing of the mixture and allowed to set for 24-36 hours.

It is cured in the tanks for 15 days. If need be water can also be sprinkled to gain maximum physical strength in 15-21 days.

2. 5. History of Tile

At the turn of the 19th century tile was used in the United States primarily as accent tiles around a fireplace, entry ways, worship spaces, and other accent areas. Toward the end of that century the trend was toward more sanitary hygiene. This led to the use of ceramic tile in kitchens, bathrooms, lobbies and foyers in wealthy homes. Fired clay tiles were more common, and becoming more affordable, most clay brick manufacturers were making tile as well as clay brick which was used for sidewalks and roads. The trend started on the east coast and moved west with the growing population and demand. The primary raw materials to manufacture clay tiles in the US were ball clay, kaolin and feldspar. All of these were abundant raw materials, and were readily available to fill a growing demand for this industry. This time period saw the beginning developments of the monocottura or the single firing method of producing ceramic tile.

This was a major innovation; tile production became more efficient and cost effective. It was a process where both glaze and clay were fired at the same time. This eliminated the extra firing that was necessary with the bicottura method, which was how tile was produced previously. Red body clay is typically extruded into the shape of the tile; an example of this is quarry tile, which is then fired. Both red body clay tile and white body feldspar tiles became mass produce using roller kilns with hotter firing temperatures and a shorter firing cycle. This new method also created a much thinner product which reduced shipping and production costs. Whatever the production method, all tile must be fired in a kiln to become durable.

One cannot give a history of tile without touching upon one of the major advancements to the installation of tile – Portland cement. In 1824, English inventor, Joseph Aspdin invented Portland cement. Joseph Aspdin created the first true artificial cement by burning ground limestone and clay together. The burning process changed the chemical properties of the materials and the result was stronger cement than using plain crushed limestone would produce. While this material did not differ much from what was used previously throughout history, the advancement came with determining the correct proportions of the necessary elements and control of the ingredients.

Tile in the United States

1903 was when the TCAA (Tile Contractor’s Association of America) was first started by James Hegan in Louisville, KY who initiated the idea by writing to other tile dealers in the surrounding states and suggested they get together and form a trade association. This was the beginning of what is now the TCNA – Tile Council of North America. It was also the beginning of differentiating “Tile” from other flooring materials such as rubber, plastic, cork, and other flooring materials, all which at the time were using “tile” as a description of their materials. Another important part of this original council was to create a “standard” of acceptable conduct and best practices for installing tile properly for a permanent and lasting installation. Many of these first tile installers started in the business as “mantel and tile” companies, as they installed fireplaces and the tile that went around the fireplace surround and hearth. When the New York City Subway System opened in 1904, the world was introduced to “subway tile” and the ornate mosaics and decorative techniques used to differentiate one subway stop from another. The rectangular, ceramic tile used to cover the walls of this underground transit system can be credited with helping to popularize the use of tile in subways around the world. What's more, in addition to the miles of white tile that protected the walls of the subways and tunnels, stunning mosaic artwork decorated the underground halls.

Figure 2.1 Times Square subway station

The Italian influence

Italy has been one of the leaders in the ceramic tile industry since the middle Ages; they borrowed from other cultures and then improved upon the products using Italian ingenuity and artistic creativity. Today the Italian tile industry is made up of approx. 250 companies of various sizes, from small artisan studios producing hand made products in the old traditions to large corporations which produce the latest in porcelain material. In the 1980's glazed tiles became more important as a design element, with new technological advancements to achieve floor tile with a high resistance to abrasion and wear. Technology in the early '90's allowed manufacturers to use a color body or through body technique so that the color and movement on the surface of the tile is throughout the body of the tile, which creates a very durable material with no surface to wear off. The Italian tile industry has always emphasized new technology and takes great care to reinvest in research and development. According to Assopiastrelle (chamber of commerce for the Tile industry and tile museum located in Sassuolo, Italy) approximately 6 – 10 % is reinvested into new technology and design. As the Italians continue to lead the tile industry, other countries including domestic manufacturers are quick to follow the Italian lead with design and technology. While Italy remains the largest exporter of tile to the United States, other countries such as Mexico, China, Brazil, Turkey, Spain, and others are quick to replicate the Italian lead in design. Italian tile is responsible for 40% of the entire world trade in ceramic tiles, of this total, 43% is made up of porcelain tile production. In fact Italy is the largest seller of tile producing equipment to the rest of the world. Even our best sources of supply from the United States have factories full of Italian equipment.

2.6. Types of cement tiles production machineries

Machinery and equipment required by cement tile plant consists of

- Hydraulic press machine
- Automatic feeding , mixing and compacting machine
- Cement Tile vibrating machine

2.6.1. Hydraulic press

Hydraulically operated machine: used to press the mixed concrete in order to get desired sizes and shapes of tiles. The hydraulic press machine which exists in the market is a huge, slow in rate, require high power and space and produce single tile in one time.

Fig. 2.2 Hydraulics press compacting cement tile machine

2. 6.2. Automatic feeding, mixing and compacting machine

This ma chine is very fast and accurate machine used to feed the mixed concrete automatically, mix it in desire proportion and compact it. All this processes are performing in sequence and automatically. Automatic feeding and mixing and compacting machine which exist in the market is very high cost machine (above 200,000 Ethiopian birr) and it is more expensive to purchase small and micro enterprise (SME). In our visits we have seen only one production center in Addis Ababa Gotera Zenebe Firew Cement Product Factory.

Fig. 2.3 Automatic mixer and feeder cement tile machine

Fig. 2.4. Automatic grinder and washer cement tile machine

2.6.3. Cement Tile vibrating machine

Cement Tile vibrating machine is used for compact the concrete mix in the moulds of desired sizes and shapes. This machine is very simple to manufacture and very low cost (up to 12,002.46 Ethiopian birr).

The main advantages of cement tile vibrator machines are as the following.

- It is not complicated to operate and manipulate easily
- High production capacity Relative to existing machine
- Eliminate pressing operation.
- Minimize cost and production time.
- Light weight.
- Produce different size of tiles.
- Easy to maintenance.
- Can produce up to 16 pieces with one minute.

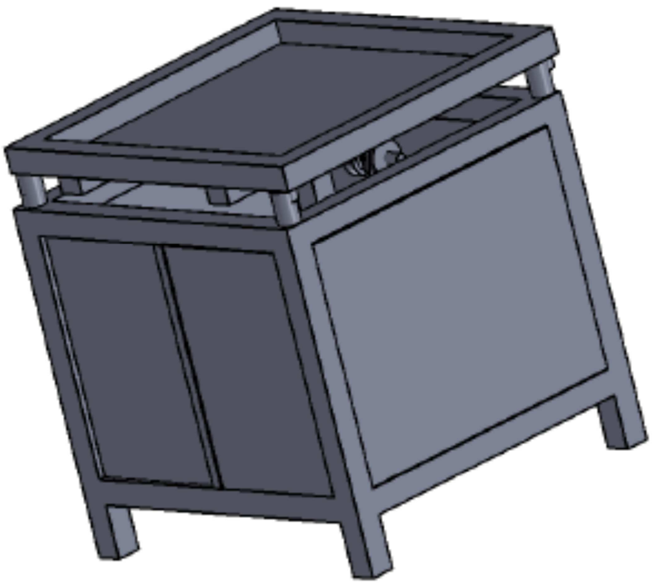


Fig. 2.5 Cement tile vibrator machine

CHAPTER THREE

RESEARCH METHODOLOGY

The objective of the study was to identify factors that hold back cement tile product. Assess the existing situation and practice exploratory method is potentially suitable. Exploratory research method is concerned with carrying out cement tile vibrating machine surveys which help to solve the problems of various aspects of cement tile i.e. the production rate, quantity of product, and production systems. Hence, exploratory method was applied in this study. In order to conduct the research, both quantitative and qualitative techniques were applied. That is, the quantitative data obtained through observation was supplemented with the qualitative data from inter exploratory view and document analysis.

3.1. Source of Data

Primary as well as secondary sources of data were used in the study. The primary sources of data were cement tile worker. The reason to use those subjects was based on the expectation that they have had better exposure and information about the issue studied.

Various reports and official documents, work plans, proposal were used as a secondary source of data to strengthen the data obtained from the primary sources and for additional information.

3.2. Sample Size and Sampling Techniques

Four sub city namely: Yeka sub city, Bole sub city, kirkos sub city and Nefs/lafto sub city. were taken by simple random sampling technique among the sub cities found in Addis Ababa and ten enterprise were randomly selected from four sub-cities in order to conduct the study. The total number of cement tile workers taken from ten enterprise and simple random sampling technique was applied in order to select the cement tile worker. For interview, ten cement tile workers- were selected by purposive sampling.

3.3. Instrument development

For better achievement of the thesis objective, exploratory research method is used. Exploratory research might involve a literature search or conducting focus group interviews. 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.

3.4. 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, Addis Ababa Town cement tile workers are selected purposely as the total population since the result can be considered for the whole cement tile workers in the country.

A total of 10 numbers of cement tile workers are randomly selected from the population of 20 number of cement tile workers including SMEs at Addis Ababa Town that are currently working in the field of cement tile makings.

The reason why Addis Ababa Town is selected for this study is because the town includes several SMEs and several cement tile users. The sampling is selected by using random sampling method. The sample ratio can give sufficient information because it is taken 50% out of total population.

3.5. Data Collection

Three data gathering techniques have been used to understand current problems of cement tile vibrating machine and for the need of this machine; Data are collected by interviewing and direct observation. The documents which are analyzed for the project are internet, and many types of reports and researches about cement tile processing machine.

After the quantitative and qualitative data are gathered from those sources, cement tile vibrating machine is designed and manufactured as a solution to facilitate cement tile products and to avoid exhausting and time consuming of compacting activities

3.5.1. Interview

The interview included from different private sectors and customers especially small and micro enterprise and private production center. Structured interviews (face to face) conducted with different cement tile production workers and cement tile product users.

A structured interview is one in which the procedure to be followed same type of questions is presented in the same order to each interviewers and wording of the instruction to the interviewees is specified

Objectives of conducting the interviews:

- To investigate feeling of the people who use existing machine in Addis Ababa.
- To observe overall activities and processes in the respective areas of cement tile producers.
- To assess the existing system of method and identify the drawback of existing process.
- To assess the needs of users and getting idea that how to be changed existing in to Cement tile vibrating machine.

3.5.2. Direct observation

- We have also used this method for collecting the required data and information from different documents. We have observed the existing cement tile working methods.
- Also we have observed to identify the problems that faced during cement tile hydraulic press
- We have also visited some cement tile production site that made from cement tile product.

3.6. Data Analysis and Interpretation

The collected data through the means of interviews and direct observation of documents are analyzed& interpreted. It is believed that the current situation of the existing cement tile production methods has exactly reflected the problems in these interviews. This analysis is important to get wide and in depth information from the respondents. The interview also prepared for the respondents openly that he/she can describe freely much information. It helps to get genuine information from respondents because the researchers do not interfering the participant's idea.

The findings indicate that, there exists scarcity of tile processing machine and cement tile vibrating machine is highly wanted by the cement tile makers at Addis Ababa Town.

Number of Questions is 4 and Number of respondents is 10

1. Have you ever bought and used cement tile machines?

   Yes.100% No. 0

2. At this time, is there a need cement tile processing machine on the market?

   Yes.90% No.10%

3. Are you interesting to buy if cement tile vibration machine will be made at Adama Science and Technology University with reasonable cost?

   Yes 95%   No 5%

4. Are there different cement tile machines on the market that help to increase productivity of cement tile?

   Yes 5%   No 95%

The respondents, as they replied according to their experiences, there were to use cement tile vibrating than rather they used existing cement tile machine. These cement tile machines have side effect that cause high costly and less productive.

According to them, the reasons why they are using cement tile vibrating machine are due to not available on the market. To minimize cost, time and to increase productivity of cement tile products, they understand cement tile vibrating machines are very important and they are delighted to see this machine when it is solving their problems in the near time.

After studying the above need assessment developers arrived on conclusion to design and manufacture electrical cement tile vibrating machines.

CHAPTER FOUR

DESIGN AND MATERIAL SELECTION

This chapter introduces the design analysis and material selection of critical components for electrical operated cement tile vibrator machine.

4.1 Material selection processes and its factors

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. The selection of materials and the processes used in fabrication are integral parts of the design of a machine component.

The characteristics that are usually considered when selecting a material for a given application can be classified into the following categories:-

1. Mechanical behavior including shear strength, yield strength, tensile strength, elongation Percent, reduction in area percent, hardness, toughness, fatigue strength and stiffness resistance to abrasion and erosion are also related to mechanical behavior;
2. Chemical properties which include corrosion and oxidation resistance;
3. Physical characteristics including electrical, magnetic and thermal properties. Density is also included in this category;
4. Process ability which includes cast ability, workability, weld ability and machinability.

In selecting materials for a given application it is useful to classify them according to the major function they are expected to perform in service.

The selection of proper materials for engineering purpose is one of the most difficult problems for the designer. The best material is one which services the desired objectives at the minimum cost. 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.

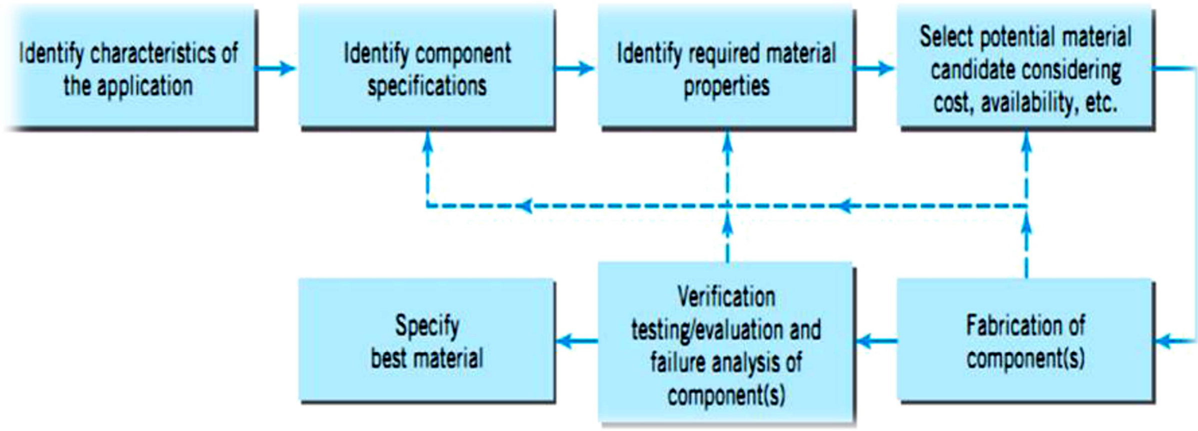


Figure 4.1 Material selections for a machine component

4.2 Material selection for critical parts/components

Selecting the right material for the machine can fulfill the functional requirement for the specific part is very important. We use to select the suitable material we follow the digital logic methods. 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;
- Total number of decision/N/= $\frac{n(n-1)}{2}$ Where n number of rating factors/properties/
- Write the most suitable candidate materials and enlist properties from standard data table/the data quantitative or qualitative/
- Normalize the outcomes of the parts;
- Value outcomes and overall satisfaction of parts. The overall satisfaction shall at last ranked, and the ranked shows the result on the basis of the allocated weight factors which gives the best overall satisfaction for the functional requirements of the part.

4.2.1 Material selection for Shafts

In order to minimize deflections, steel is the logical choice for a shaft material because of its high modulus of elasticity, though cast or nodular iron is sometimes also used, especially if gear or other attachments are integrally cast with the shaft. Most machine shafts are made from low-to-medium carbon steel, either cold rolled or hot rolled, though alloy steels are also used where their higher strength are needed.

Cold-rolled steel is more often used for small-diameter shaft(less than about 3-inch in diameter) and hot-rolled used for large size. (Textbook of machine design)

Functional requirement for Shaft

The main function of shaft is to transmit power. Since the shaft is subjected to high torque, it may be bent, so the shaft should have properties that to resist bending moment and torsion.

Material requirement for shaft

To achieve the required functional requirement of the above mentioned material s, they should have the following properties:-

No. of properties to be evaluated

- Yield strength and tensile strength
- Wear resistance
- Corrosion resistance
- Modulus of elasticity

Therefore No. of decisions (N)= $\frac{n(n-1)}{2}$= $\frac{5(5-1)}{2}$ = 10

(Material selection in mechanical design)

Where n=no. of properties to be evaluated so digital logic with different decision, material requirement with its weight factor and normalized value, performance index, etc. of shaft is shown below.

Weight factor (Wf) =$\frac{Posetive\ decision}{Total\ No.decision}$

Table. 4.1 Application of digital logic with different decisions no.

Properties	**Number of Decision**										**Weight factor**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	
yield strength	1	0	1	1							0.3
tensile strength	0				1	0	1				0.2
wear resistance		1			0			0			0.1
corrosion resistance			0			1		1		0	0.2
Elasticity				0			0		1	1	0.2

Table 4.2 Candidate material requirements for shaft

No	**Materials**	yield strength	tensile strength	wear resistance	corrosion resistance	modulus of elasticity
1	AISI NO.1010 hot-rolled	179	324	3	4	12
2	AISI No.1020 hot-rolled	207	379	4	3	12
3	ASTM No.A570-A	170	310	2	1	13
4	ASTM No. A675 Grade-45	155	380	3	2	13

Table 4.3 Normalized value of shaft

No.	Material	yield strength	tensile strength	wear resistance	corrosion resistance	modulus of elasticity
1	SAE/AISI NO.1010 hot- rolled	86.5	85.3	75	100	92.3
2	SAE/AISI No.1020 hot- rolled	100	99.7	100	75	92.3
3	ASTM No.A570-A	82.13	81.6	50	25	100
4	ASTM No. A675 Grade-45	74.9	100	75	50	100

Note: - During normalizing numbers 100 is given the maximum number for higher functional requirement of material and for the remaining number use cross multiplication to obtain similar results, but for lower requirements of material (for example specific gravity) 100 gives to the smallest no. & for the rest no. use the smaller no. multiplying by 100 divided the no. to obtain the required result.

Performance index (μ) = ε(normalized value) (weight factor)

Table 4.4 Shows performance index (value out comes)

No.	Material	Yield strength x 0.3	Tensile strength x 0.2	Wear resistance x 0.1	Corrosion resistance x 0.2	Modulus of elasticity x 0.2	Performance index	Rank
1	SAE/AISI NO.1010 hot- rolled	25.95	17.06	7.5	20	18.46	88.97	2
2	SAE/AISI No.1020 hot- rolled	30	19.94	10	15	18.46	93.4	1
3	ASTM No.A570-A	24.64	16.32	5	5	20	70.96	4
4	ASTM No. A675 Grade-45	22.47	20	7.5	10	20	79.97	3

From the above result of material selection shows that **AISI No.1020 hot rolled** is the material for the shafts so mostly shafts are made of low -to- medium carbon steel one of these materials is ***mild-steel***.

4.2.2 Material selection for Pulley

Functional requirement for pulley

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

Material requirement for pulley

- ❖ The material should possess optimal tensile strength;
- ❖ The material should have adequate value of yield strength;
- ❖ Density of the material should meet value of safe operation ;
- ❖ It possesses moderate specific heat capacity;
- ❖ Coefficient of linear expansion of the material should lie at range of minimal value;
- ❖ Wear resistance.

Therefore No. of decisions (N)= $\frac{n(n-1)}{2} = \frac{5(5-1)}{2} = 10$ where n=5

Table 4.5 Weighting factors for pulley

`Properties	Number of Decision										Weight factor
	1	2	3	4	5	6	7	8	9	10	
Tensile strength	0			0		1		1			2/10 = 0.2
Yield strength		0			0				0	1	1/10 = 0.1
Density	1	1	1				0				3/10 = 0.3
Specific heat capacity			0		1	0		0			1/10 = 0.1
Coefficient of linear expansion				1			1		1	0	3/10 = 0.3

Table 4.6 Properties of candidate materials 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 4.7 Normalized outcomes for pulley

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 4.8 Shows performance index (value out comes)

Materials	Tensile strength x 0.2	Yield strength X 0.1	Density x0.3	Specific heat capacity x 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 **AISI1035** is a best suitable for the pulley material which is relatively less weight. Therefore our selected material for the pulley is **Aluminum**.

4.2.3. Material selection for bearing house

Function requirement

Since the bearing is inserted into the bearing house for supporting the shaft and facilitate its motion the bearing housing should have a property that resist the bearing stress and also it resist the torsion of the shaft due to rotational motion. The machinability of the part should be considered to have a shape of bearing.

Material Requirement

To satisfy the functional requirement for selecting bearing house, the material should have:-

- Better yield strength - better tensile strength
- Higher young's modulus of elasticity - high corrosion resistance
- it should be cast able

Cast iron is selected for bearing house because it satisfies the above requirements.

4.2.4 Material selection for bearing

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.

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 4.9 Shows bearing standards (fundamentals of machine component design)

Bearing Basic Number	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, we have designed shaft diameter to be **25mm**. therefore based on the diameter of shaft and the properties of bearing mentioned above, ball bearing with Bearing Basic Number **L05**, from the above table is selected for this project.

4.2.5 Material selection for keys

Functional requirement

A key is a piece of mild steel 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.

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

4.2.6 Selection of spring

A spring is defined as an elastic body, whose function is to distort when loaded and to recover its original shape when the load is removed. The various important applications of springs are to cushion, absorb or control energy due to either shock or vibration in:-

- A car springs
- Railway buffers
- Air-craft landing gears
- Shock absorbers and
- Vibration dampers

Types of springs

According to their shape there are many types of the springs such as helical, conical and volute, torsion, laminate or leaf etc.

To the cement tile vibrator machine we have select the helical shape springs because of the following advantages.

- These are easy to manufacture.
- These are available in wide range.
- These are reliable.
- These have constant spring rate.
- Their performance can be predicted more accurately.

- Their characteristics can be varied by changing dimensions.

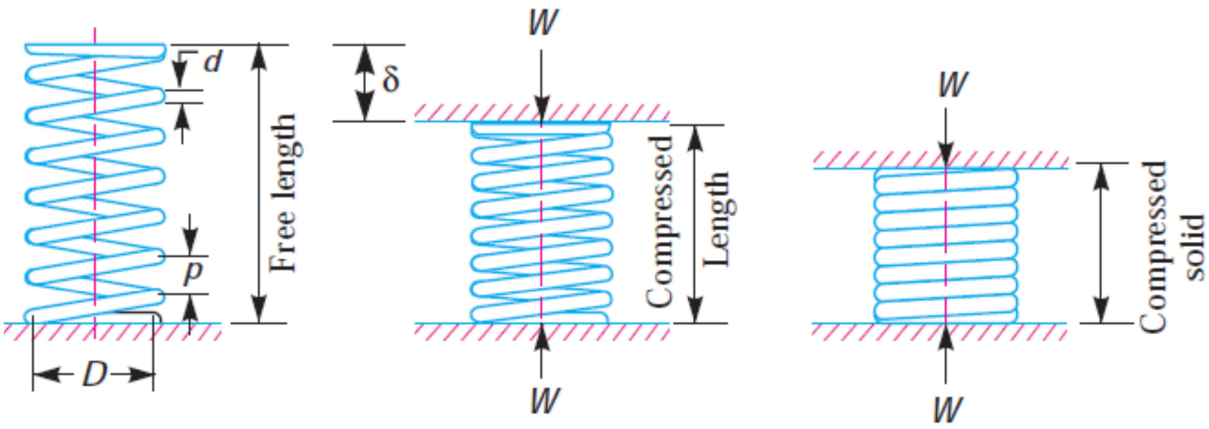


Fig..4.2. Helical spring nomenclature.

Material for Helical Springs

The material of the spring should have high fatigue strength, high ductility, high resilience and it should be creep resistant. It largely depends upon the service for which they are used *i.e.* severe service, average service or light service.

- ***Severe service*** means rapid continuous loading where the ratio of minimum to maximum load (or stress) is one-half or less, as in automotive valve springs.
- ***Average service*** includes the same stress range as in severe service but with only intermittent operation, as in engine governor springs and automobile suspension springs.
- ***Light service*** includes springs subjected to loads that are static or very infrequently varied, as in safety valve springs.

4.3 Design

From the study of existing design, 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 about money, men and 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.

General Considerations in Design

- Type of load and stresses caused by the load;
- Motion of the parts or kinematics of the machine;
- Selection of materials;
- Form and size of the parts;
- Ergonomically consideration; and
- Use of standard parts and safety operations; etc.

This designs of electrical cement tile vibrator machine focus the functions of vibrate the table by belt mechanism to compact the mixture of cement and concrete. Starting from the idea of design principles and functional requirements, the researchers designed the parts of the machine based on the design procedures.

4.3.1 Design of Critical Components

The main parts of our project includes Power, Pulley, shaft, Key, spring and vibration

4.3.1.1 Design of Power

This project is designed to vibrate machine table with one minute produce cement tile thickness 3 – 6cm, width and length of 20x20cm to 40x40cm with constant width and length based on the need of users (SMEs) who fabricate cement tile products during our survey.

Vibrating table may be used for compact the concrete mix in the moulds of desired sizes and shapes only one minute. We recommend the consumption of power to be single phase AC motor having 600 – 1000 RPM and 1.5 – 2.5 Kw by considering functional requirements and the availability of Ethiopian

Electrical power so as to the required energy and to work for 8 hours continuously. But based on most available of electric motor we take **AC motor n = 750 RPM and P = 1.9 Kw** for the case of our design.

4.3.1.2 Design of pulley

Pulleys are used to transmit power from one shaft to another by means of belts. Since the velocity ratio is the inverse ratio of the diameters of driving and driven pulleys, therefore the pulley diameters should be carefully selected in order to have a desired velocity ratio. The pulleys must be in perfect alignment in order to allow the belt to travel in a line normal to the pulley faces.

Material to be selected for the pulleys should satisfy the following requirements. These are:

- Light weight
- Should be local
- Less cost
- Have a moderate strength
- Easily manufactured
- Non-corrosive

Candidate materials to manufacture the pulleys are Aluminum, wood, Cast iron and steel.

Aluminum is light in weight, can be easily machined non-corrosive, available on market and possesses moderated strength but comparatively it is expensive than wood and steel. However, since the torque on the pulley can easily break the wood and the steel may add extra load on the shaft and it corrodes, therefore our selected material for the pulley is **Aluminum**.

Two different diameters of pulleys with smaller diameter on the motor shaft and larger diameter on the roller shaft is designed to reduce the RPM of roller shafts to compact cement tile by vibrate table. For the case of this design, it is decided to have a **velocity ratio of 1:1.**

According to Indian Standards, the V-belts are made in five types i.e. A, B, C, D and E. The dimensions for standard V-belts are shown in Appendix A. So the smaller pulley diameter is selected from the standard table which is **75 mm.**

Now from the selected small diameter of pulley and velocity ratio (VR), it can calculate the large pulley diameter on the roller shaft.

$$VR = \frac{d}{D} \quad \text{.................................Eq. 4.1}$$

Where:- d – is diameter of small pulley on the motor shaft;

D – is diameter of larger pulley on the driven shaft;

$$\frac{1}{1} = \frac{75}{D}$$

D = 1x75 mm =**75 mm**

Now by taking **750 RPM** of motor (on smaller pulley), the RPM of the larger pulley (on the driven shaft) is given by $d x n_1 = D x n_2$

Where:- n_1 –is RPM of smaller pulley

n_2- is RPM of larger pulley

but the pulley is equal diameter so $n_1=n_2$

$n_2/d = n_1/D$ $n_2 = n_1 x d/D$

$n_2 =$ 750 RPMx75 mm/75mm = 750 RPM

$n_2 =$ **750 RMP**

Determining Length of the Belt

For any type of the belt drive it is always desirable to know the length of belt required. It will be required in the selection of the belt. The length can be determined by the geometric considerations. However, actual length is slightly shorter than the theoretically determined value.

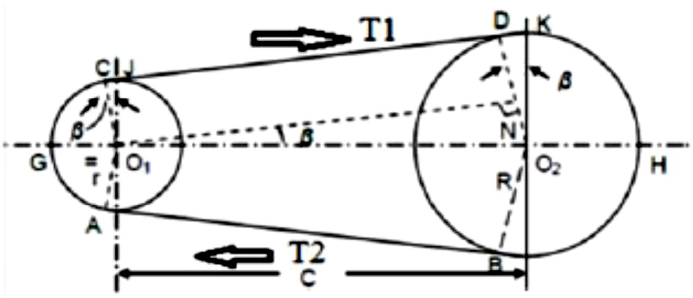


Figure 4.3 Belt drives (From Engineering Data book for v – belt.)

The belt drive is shown in Figure 4.1. Let O_1 and O_2 be the pulley centers and AB and CD be the common tangents on the circles representing the two pulleys.

The total length of the belt 'L' is given by

L = AB +Arc BH + DC+ Arc CGA, equals to the formula;

$L = 2C + 1.57(D+ d) +((D - d)_2) / 4C$

Where, C= center distance,

D = driven pulley (larger pulley),

d = driver pulley (smaller pulley)

Let r = the radius of the smaller pulley,

R = the radius of the larger pulley,

C be the center distance between the pulleys which **400 mm** for our design, and

β be the angle subtended by the tangents AB and CD with $O_1 O_2$.

So the pulley are equal diameter use only d (diameter) and r (radius)

By geometry, $< O_2 O_1 N = < C O_1 J = < DO_2K = \beta$

Arc BHD = $(\pi + 2\beta) R$, and Arc CGA = $(\pi + 2\beta) r$

$AB = CD = O_1N = O_1 O_2 \cos\beta = C \cos\beta$

$\sin\beta = (D - d)/C = (75\text{-}75)/400 = 0$

$\beta = \sin^{-1}(0) = \mathbf{0}$

$L = 2C + 1.57(D+ d) + (D - d)^2/ 4C$

$L = 2(400) + 1.57(75+ 75) + \frac{(75-75)2}{4x400}$

$= 800 + 235.5$

$L = 1035.5$

From standard table, SPZ it is close to the datum length = 1385mm and inside diameter, Li = 1365 mm.

Therefore, belt specification for this machine is **ZX 53$\frac{1}{2}$ x 1365 Li and 1385 L** is selected based on the following table. These data are suitable and ISO standard because it describes the relations of center distance, pulley diameters and belt dimensions. In addition, it guides to select standard sizes and appropriate movements. (Appendix B)

Angle of contact of the belt on each pulley

These angles are important because commercially available belts rated with on assumed contact angle of 180^0. This will occur only if the drive ratio is 1:1(no speed change). The angle of contact on the smaller of the two pulley will always less than 180^0, requiring a lower power rating. The tensile force of the belt is maximum on the tight side of the belt. The bending of the belt around the pulley, maximum at the tight side of the belt bends around the smaller pulley.

$< AGC = \theta_1 = 180^0 - 2\sin^{-1}[\frac{D\_d}{2c}]$ …………………..................................Eq. 4.2

Where:- Θ_1 = Contact angle of belt on small pulley.

Θ_2 = Contact angle of belt on large pulley.

L = Belt length.

$< BHD = \theta_2 = 180^0 + 2\sin^{-1}[\frac{D\_d}{2c}]$ …………………………………………....Eq. 4.3

Where:- C = Center distance between pulleys

d = Small pulley diameter.

D = Large pulley diameter

Contact angle of small pulley (θ_1)

$\theta_1 = 180 - 2\sin^{-1}\left[\frac{D-d}{2c}\right]$

$= 180^0 - 2\mathrm{Sin}^{-1}\left[\frac{75-75}{2X400}\right]$

$= 180^0 - 0$

$\theta_1 = 180^0$

Contact angle of large pulley (θ_2)

$\theta_2 = 180 + 2\mathrm{Sin}^{-1}\left[\frac{D-d}{2c}\right]$

$= 180 + 2\mathrm{Sin}^{-1}\left[\frac{75-75}{2X400}\right]$

$= 180^0 + 0$

$\theta_2 = 180^0$

$P=(T_1-T_2)V$

Where, T_1- is tension on the tight side of belt

T_2 - is tension on the slack side of belt

V- is velocity of the belt in small pulley

P -is power from the above design $=1.9\mathrm{x}10^3$ watt

That is $V=\frac{\pi\alpha N}{60}=\frac{\pi x75x750}{60}$ = 2945.24 m/s

Therefore, T1-T2 = P/V = $\frac{1.9\mathrm{x}103}{2945.24}$

.

T1-T2 = 0.645N

$2.3\log\left(\frac{T1}{T2}\right) = \mu\Theta$

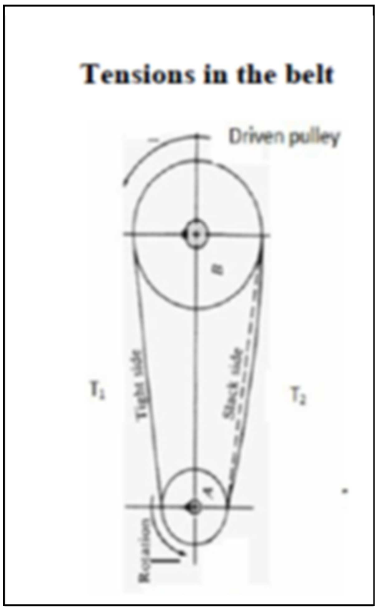


Fig 4.4 tension of belt

Where:- μ- is coefficient of friction between the smaller pulley and v-belt by taking μ= 0.12 from table

Θ - is contact angle on small pulley in radian that is

$= 180^0 = 3.14\mathrm{rad}$

$2.3\log\left(\frac{T1}{T2}\right) = 0.12\mathrm{x}3.14$

$\log\left(\frac{T1}{T2}\right) = \frac{0.12x3.14}{2.3}$

$= 0.164$

$\frac{T1}{T2}$ = 1.45 by taking anti log of 0.164

$T1=1.45T_2$

Therefore by combining the two equations, that is:

$1.45T_2 - T_2=0.645N$

$T_2 =\frac{0.645}{1.45}=$ **0.44 N** in the slack side

4.3.1.3 Design of Shaft

This shaft is a rotating solid part which is used to transmit power from the electric motor through belt and pulleys to the driven shaft by means of key. The power is delivered to the shaft by some tangential force and the resultant torque (or twisting moment) set up with in the shaft permits the power to be transmitted to the driven shaft. The required torque to transmit power to the driver shaft is obtained by using the following relation.

We know that power transmitted (in watts) by the shaft,

$$P= \frac{T}{\omega} \ \omega = \frac{60}{2\pi n} \quad \text{so,} T = \frac{px6c}{2\pi n}$$

Where :- T- is twisting moment in N- m

n- Is speed of shaft in RPM = 750 RPM

P-is power required = 1.9 Kw

$$T =\frac{1.9x1000watt\ x60}{2\pi x750}. = \mathbf{24.19\ N\text{-}m}$$

The members like pulleys, bearing house and bearing mounted on the shaft are exerted forces which cause the shaft to bending and twisting.

The material to be selected for the manufacturing of shaft for the project should meet the following criteria. The desirable properties of the materials for the designed shaft should be;

- It should have Sufficient in strength
- It should have good Machinability
- It should have Impact resistance
- It should have Tough and resist fatigue
- It should have good Heat resistance
- It should have Good heat treatment properties
- It should have high Wear resistance

Table 4.10 Mechanical properties steels used for shafts (Text book of Machine design)

Indian Standard Designation	Ultimate tensile strength in MPa	Yield strength in MPa	Remark
40C8	560-670	200-320	Used for shafts, gears stud bolts, spindle, washer etc. for light stressed
45C8	610-700	220-350	Used for lead screws, feed rods bigger gears, bigger shafts etc…
50C4	640-760	370	
5012	700 minimum	390	

From this mechanical properties of steels used for shafts, we choose **40C8** material because our project is derived with simple mechanism by considering its yield strength of **250 MPa**.

Types of Shafts

The following two types of shafts are important from the subject point of view

1. Transmission shafts. These shafts transmit power between the source and the machines absorbing power. The counter shafts, line shafts, over head shafts and all factory shafts are transmission shafts. Since these shafts carry machine parts such as pulleys, gears etc., therefore they are subjected to bending in addition to twisting.

2. Machine shafts. These shafts form an integral part of the machine itself. The crank shaft is an example of machine shaft.

Stresses on the shafts

The stresses induced in the shaft are:

- Shear stress due to transmission of torque (i.e. due to torsion load)
- Bending stress (tensile or compression) due to forces acting up on the shaft
- Stress due to combined torsion and bending loads

Maximum permissible working stress for transmission shafts

According ASME/America society of mechanical engineers/ code for commercial steel shafts, the maximum permissible shear stress is taken as 40-42 MPa for shafts with key and 55-56 MPa for shafts without key.

For shafts purchased under definite physical specification, the permissible shear stress (allowable shear stress) is 25 % of yield strength but not over 18% of ultimate strength in tension for shafts with key ways.

$$\tau = 0.3\sigma y \text{ or } \tau = 0.18\sigma u$$

Where:- τ- is permissible shear stress

σy - is yield strength

σu - is ultimate tensile strength

For this design the permissible stress is $\tau = 0.30$, σ_y = 0.30 x 250 MPa = **75 MPa**

In designing shafts on the bases of strength, the following cases may be considered.

I - Shafts subjected to twisting moment or torque only

When the shaft is subjected to twisting moment (torque) only, then the diameter of the shaft may be obtained by using the torsion equation.

$$\frac{T}{J} = \frac{\tau}{r}$$

Where: - T = Twisting moment (or torque) acting upon the shaft,

J- Is polar moment of inertia of the shaft about the axis of rotation

τ - is torsional shear stress and

r- is radius of the shaft = d/2

$$J = \frac{\pi}{32} d^4 \quad \text{.......................................Eq. 4.4}$$

For round solid shafts polar moment of inertia,

The torsion equation may now be written as

$$\frac{T}{\frac{\pi}{32} d4} = \frac{\tau}{d/2} \; or \; T = \frac{\pi}{16} \tau d3 \; , \; d = \sqrt[3]{16T/\pi\tau} \text{.................Eq. 4.5}$$

II - Shafts subjected to bending moment only

When the shaft is subjected to a bending moment only, then the maximum stress (tensile or compressive) is given by the bending equation.

We know that

$$\frac{M}{I} = \sigma b/r$$

Where

M - is bending moment acting up on the shaft

I - is moment of inertia of cross sectional area of the shaft about the axis of rotation

σ_b - is bending stress and

r- Is radius of the shaft = d/2

$$I = \frac{\pi}{64} d4 \quad \text{………………………………………...….Eq. 4.6}$$

For round solid shafts moment of inertia,

Substituting these values in bending equation we have

$$\frac{M}{\frac{\pi}{64} d4} = \frac{\sigma b}{d/2} \; or\; M = \frac{\pi}{32} \sigma b d3 \;,\; d = \sqrt[3]{32M/\pi\sigma b} \quad \text{……………………Eq. 4.7}$$

III - Shafts subjected to combined twisting moment (T) and bending moment (M)

When the shaft is subjected to combined twisting moment and bending moment, the shaft must be designed on the bases of the two moments simultaneously. Two types of theories have been subjected to account for the elastic failure of the shaft when it is subjected two various combined stresses. The two types of theories are:

a. Maximum shear stress theories: used for this design because it is used for ductile materials such as mild steel

b. Maximum normal stress theory: used for brittle material such as Cast iron According Maximum shear stress theory, the maximum shear stress in the shaft is given by

$$\tau max = 1/2\sqrt{\sigma b2 + 4\tau 2}$$

Substituting the values of τ and σb from torsion equation and bending equation, we have

$$\tau max = \sqrt[3]{\left(\frac{32M}{\pi d3}\right)2 + 4\left(\frac{16T}{\pi d3}\right)2} \quad \sqrt{M2 + T2} \quad \frac{\pi}{16}\tau \max d3$$ ....Eq. 4.8

The expression $\sqrt{M2 + T2}$ is known as equivalent twisting moment and is denoted by T_e.

The equivalent twisting moment T_e may be defined as the twisting moment, which when acting alone produces the same shear stress (τ) as the actual twisting moment. By limiting the maximum shear stress (τ_{max}) equals to the allowable shear stress (τ) for the shaft material equation 4.8 can be written as:

$$Te = \frac{\pi}{16}\tau d3$$ Eq.4.9

Bending moment

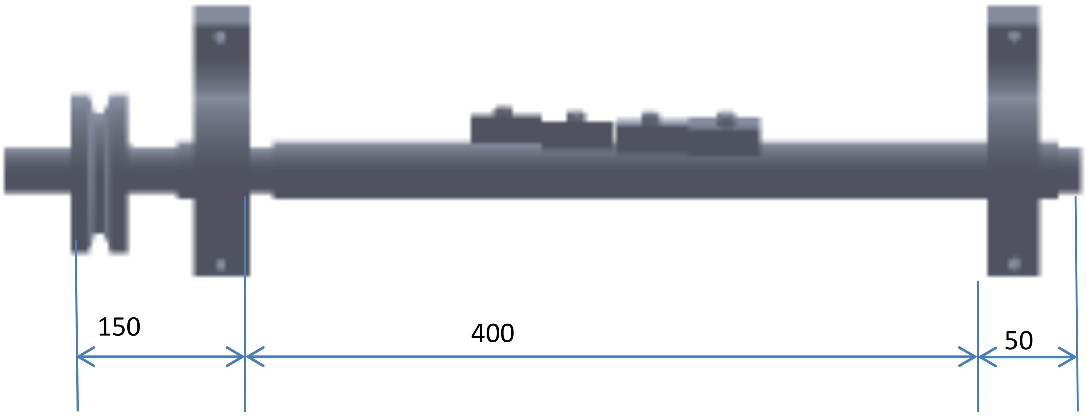


Figure 4.5 Bending moment of driver shaft

A little consideration will show that the maximum bending moment acts on the pulley. A groove angle (α) of pulley ranges from 34-38^o. For this design we take α = 36^o

The twisting moment, T= **24.19 N-m**

Therefore, tangential force (F_t) on the pulley is given by

F_t = 2T/D where, D- is diameter of pulley = 75mm

= 2x24.19 N-m/0.075m

= **645.1 N**

The normal load (W) acting on the groove of pulley is given by

$W = Ft/\cos\alpha$

$= \mathbf{645.1\ N} / \cos 36^{o}$

$= \mathbf{764\ N}$

Here from the above figure, the critical part of the shaft this is exposed to maximum bending moment is at the point where the pulley is mounted.

Bending moment M is given by normal load (W) x Perpendicular distance (L)

M = W x L where, L= 15+5+40=60mm = 0.06m

= **764 N** x 0.06m

= **45.8 N-m**

From equivalent twisting moment equation we know that

$$T_e = \sqrt{M2 + T}^{2} = \sqrt{(45.8)2 + 24{,}19}^{2}$$

= 51.8N-m

= **51.8 x10^{3}N-mm**

The equivalent twisting moment is given by

$$Te = \frac{\pi}{16}\tau d^{3}$$

Where, τ is permissible stress =***62.5*** *MPa* for shaft diameter (d) to be design.

By re-arranging this equation yields $d^{3}=16Te/\pi\tau$

$$d = 3\sqrt{16Te/\pi\tau} = 3\sqrt{16x51.8\ x1000/\pi x62.5}$$

= 21.65mm

Therefore to have better strength and more safe, the driver shaft diameter d is designed by rounding off this value to **25.00mm**

4.3.1.4 Design of key

A key is a piece of mild steel 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. A keyway is a slot or recess in a shaft and hub of the pulley to accommodate a key. The most widely used method of torque transfer is by the use of keys.

A longitudinal groove called a keyway is machined into the shaft and a corresponding groove into the bore of the hub. The key fits simultaneously into both grooves, locking them together.

A square key is provided half in the key way of the shaft and half of its part in the key way of the hub or boss of the pulley. A square key is that its width and thickness are equal, i.e., b=h

a. **Design of Square sunk Key**

Sunk keys are provided half in the keyway of the shaft and half in the keyway of the hub or boss of the pulley. A square sunk key is that its width and thickness are equal,

I.e. $\boldsymbol{w = t = d / 4}$

Design specification of the key is selected from **Appendix-C** based on shaft diameter as follows:

- ❖ Diameter of the shaft = 25 mm.
- ❖ Width of the key, w = 6 mm
- ❖ Thickness of key, t = 6 mm
- ❖ The shear stress of the material is 40Mpa = 40N/mm^2
- ❖ The crushing stress of the key material = 70N/mm^2

b. Design Analysis

A key has two failure mechanisms:

1) It can be sheared off, and
2) It can be crushed due to the compressive bearing forces.

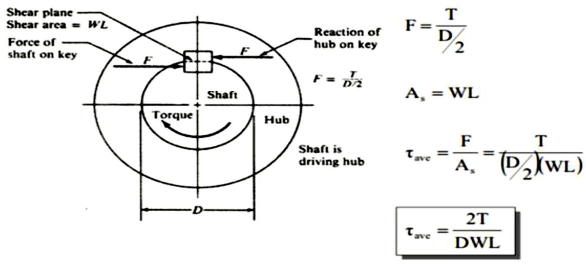


Figure 4.6 Forces exerted on the key

The length of the key is obtained by considering the key in shearing and crushing.

Shearing of key

Let L = Length of key. Considering shearing of the key, developers know that shear strength or torque transmitted of the key,

Shear force F = Area of resisting shear **x** shear stress

$F = L \times w \times \tau$ ………………………………………………….…Eq. 4.10

T= F x d/2,

T = L x w x τ x d/ **51.8x10^{3}N-mm**

= Lx6x40 N/mm^{2}x20/2

L = **51.8**Nx10^{3}/10x6x40

L = **21.5 mm**

Crushing of key

Shear force F = Area of resisting crushing x crushing stress

$F = L \times t/2 \times \sigma_c$……………………………………… Eq. 4.11

We know that T= F x d/2

$T = L \times t/2 \times \sigma_c \times d/2$ ………………………………. …Eq. 4.12

60x10^{3} N-mm = Lx3x70 N/mm^{2} x20/2

L = **51.8** Nx10^{3}/10x3x70 = **24.7 mm**

Taking the larger of the two values, developers have length of key.

L = 24.7 mm say **25 mm.**

4.3.1.5 Design of spring

Stresses in Helical Springs of Circular Wire

Consider a helical compression spring made of circular wire and subjected to an axial load W, as shown in Fig. 4.7 (a).

Let D = Mean diameter of the spring coil,

d = Diameter of the spring wire,

n = Number of active coils,

G = Modulus of rigidity for the spring material,

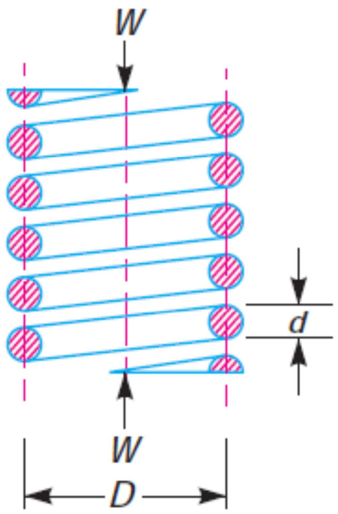
W = Axial load on the spring

τ= Maximum shear stress induced in the wire,

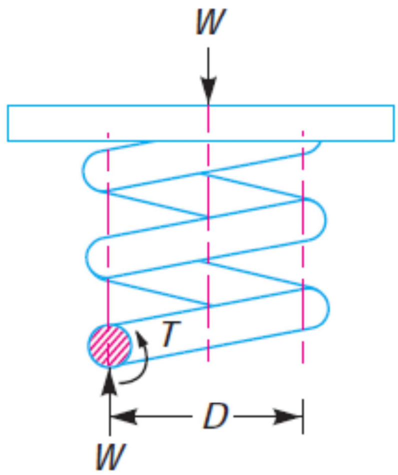
C = spring index = D/d,

p = Pitch of the coils, and

δ= Deflection of the spring, as a result of an axial load W.



(a) Axially loaded helical spring.



(b) Free body diagram showing that wire is subjected to torsional shear and a direct shear.

Fig. 4.7(a) little consideration will show that part of the spring, as shown in above

(b) Is in equilibrium under the action of two forces W and the twisting moment T.

We know that the twisting moment,

$$T = W \times \frac{D}{2} = \frac{\pi}{16} \times \tau_1 \times d^3$$

$$\tau_1 = \frac{8\,W.D}{\pi\, d^3}$$

We know that direct shear stress due to the load W,

$$\tau_2 = \frac{\text{Load}}{\text{Cross-sectional area of the wire}}$$

$$= \frac{W}{\frac{\pi}{4} \times d^2} = \frac{4\,W}{\pi\, d^2}$$

We know that the resultant shear stress induced in the wire,

$$\tau = \tau_1 \pm \tau_2 = \frac{8W.D}{\pi d^3} \pm \frac{4W}{\pi d^2}$$

The **positive** sign is used for the inner edge of the wire and **negative** sign is used for the outer edge of the wire. Since the stress is maximum at the inner edge of the wire, therefore

Maximum shear stress induced in the wire,

= Torsional shear stress + Direct shear stress

$$= \frac{8W.D}{\pi d^3} + \frac{4W}{\pi d^2} = \frac{8W.D}{\pi d^3}\left(1 + \frac{d}{2D}\right)$$

$$= \frac{8\,W.D}{\pi d^3}\left(1 + \frac{1}{2C}\right) = K_S \times \frac{8\,W.D}{\pi d^3}$$

$$K_S = \text{Shear stress factor} = 1 + \frac{1}{2C}$$

The max load of the cement tile vibrator machine is as follow:-

6.1kg x 16 +10kg = 107.6kg

The mean diameter of spring is D = 0.04m.

For the sake of convenience, the unit of force adopted is such that it produces unit acceleration to a body of unit mass.

∴F = m * a = Mass × Acceleration

In S.I. system of units, the unit of force is called newton (briefly written as N). A newton may be defined as the force, while acting upon a mass of one kg, produces an acceleration of 1 m/s2 in the direction in which it acts. Thus

1kgf = 1kg × 9.81 m/s2 = 9.81 kg-m/s2 = 9.81 N ... (Q 1N = 1kg-m/s2) (A Textbook of Machine Design page 25)

So the load of spring =107.6kg x 9.81kg/m^2

= **1055.556 Nm**

$$\tau_2 = \frac{\text{Load}}{\text{Cross-sectional area of the wire}}$$

$$= \frac{W}{\frac{\pi}{4} \times d^2} = \frac{4\,W}{\pi\, d^2}$$

$$d^2 = \frac{4w}{\tau\pi} = x = \frac{\sqrt{4 \text{ x } 1055.556}}{3.14 \text{ x} 420}$$

$$= 3.789\text{mm}$$

According to the standard size of the spring wire from table should be 4.064 mm (Appendix D)

4.4 Ergonomics considerations

Human aspects play an important role in the ergonomic considerations. An effort has been made to understand the muscular problems faced by the workers while Automatic and manual hydraulics cement tile machine.

Optimum metrics were obtained for operators of different heights and a customizable design of our machine is proposed to enhance the ergonomics of the machine. All design decisions were made based on anthropometric data of an average person.

The cement tile vibrator machine is mainly aimed to solve the problems such as musculoskeletal injuries that come due to the awkward postures of the manual hydraulics cement tile machine. The main ergonomics feature in this design is the presence of a comfortable driving mechanism that suits for medium age and any sex groups of people.

CHAPTER FIVE

MANUFACTURING PROCESS

This chapter addresses the process and Operation sheet for critical components of the project.

Manufacturing process is the part of the production process which is directly concerned with the change of shape or dimensions of the part being produced. It 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. Each part or component of a product must be designed so that it is not only meets design requirements and specifications, but also can be manufactured economically and with relative cost.

The broad categories of processing methods for materials are:

- Casting (expansion mold and permanent mold)
- Forming and Shaping (rolling, extrusion, drawing, sheet forming, powder metallurgy, and molding)
- Machining (turning, boring, drilling, milling, and so on)
- Joining (welding, brazing, soldering, diffusion bonding, adhesive bonding and mechanical joining)
- Finishing operations (polishing, burnishing, honing, surface treating, coating, and painting)

Selection of a particular manufacturing process depends not only on the shape to be produced but also on a large number of other factors.

General steps to manufacture components of the machine:-

- Take the material for the component according to the design consideration.
- check the selected diameter (dimension) to assure by proper measuring tool
- Mark the selected material to the recommended dimensions.(Layout)
- Select the appropriate machine or tool for cutting the material to prepare the rough dimension.
- Hold the selected material in the selected machine or tool to make the rough dimensions.
- Perform the operation within the recommended and measured dimension on the marked line with allowance.
- Perform the joining operation (welding, bolt & nut, …)

- Finishing operation to the recommended exact dimension.

5.1 Manufacturing operation

It is series of operation in which components are manufactured in their sequential order. 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 separate work-parts, but certain processing operations are also applicable to assembled items (e.g., painting a spot-welded car body). Processing operation is done by using operation sheet which is the best & simplest way of showing how the part is manufacture through different steps to complete the work. Therefore process operation of our project is explained by using operation sheet.

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 (e.g., a welded assembly is called a weldment).

5.3 **Operation sheet for critical parts**

5. 2.1 Operation sheet for shaft

It is a machine element used to transmit power from the larger pulley to driven shaft through key and pulley. It is also used to vibrate the table to compact cement tile mixture.

Material------------SAE1020

Blank size---------Ø30x 62 mm

Quantity------------01

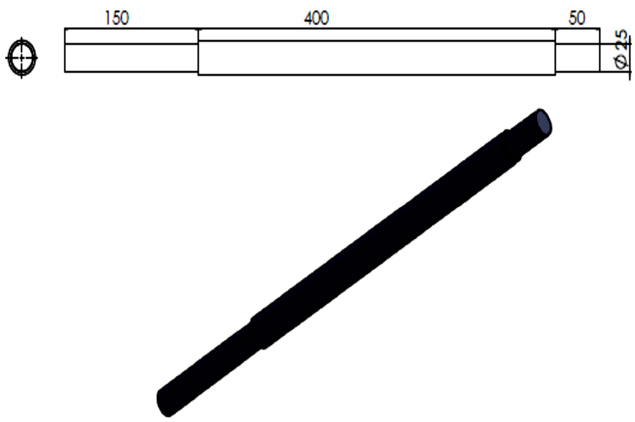


Figure 5.1 shaft

Table 5.1 Operation sheet for driver shaft

No	**Operation**	**Machine used**	**Tools & Equipment's used**	**Time in minute**
1	Measuring & cutting to size	Power hacksaw	Venire caliper, Steel rule	**40**
2	Facing on one side	Lathe machine	Carbide cutter & V. caliper	**5**
3	Turning the step and chamfering	Lathe machine	Carbide cutter & V. caliper	30
4	Facing on the other side	Lathe machine	Carbide cutter & V. caliper	5
5	Turning and chamfering the other step	Lathe machine	Carbide cutter & V. caliper	15
6	Milling a key way	Milling machine	End mill	20
7	checking		v. caliper	10

5.2.2 Operation sheet for pulley

It is one of the machine element used to transmit motion from the prime mover to the larger pulley through V-belt. Since its size is smaller than larger pulley, it has an advantage of reducing speed of rotation of AC motor by one-fourth to have less speed on the larger pulley. It is manufactured from aluminum by using machining process.

Material------------ AISI 1035

Blank size---------Ø90x40 mm

Quantity----------- 02

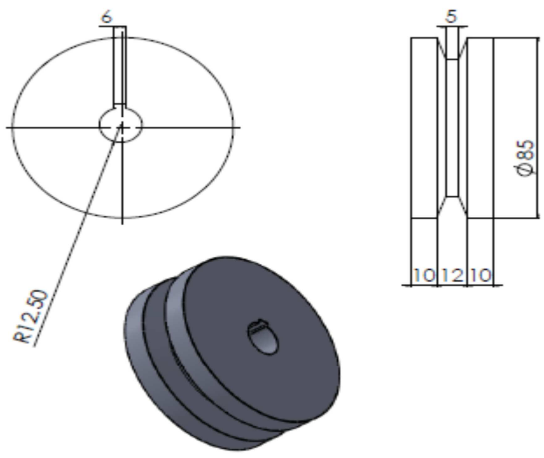


Figure 5.2 pulley

Table 5.2 Operation sheet for pulley

No	Operation	Machine used	Tools & Equipment's used	Time in minute
1	Measuring & cutting to size	Power hacksaw	Venire caliper & steel rule	40
2	Facing on one side	Lathe machine	carbide cutter & V. caliper	5
3	Turning and chamfering	Lathe machine	Carbide cutter V. Caliper	30
4	Facing on the other side	Lathe machine	Carbide cutter V. Caliper	5
5	Turning a hub and Chamfering	Lathe machine	Carbide cutter V. Caliper	40
6	Drilling	Lathe machine	Center drill, Drill bit & V. Caliper	10
7	Milling a key way	Milling machine	Slotting attachment with HSS cutter	50

5.2.3 Operation sheet for base

This is used to carry the machine element and motor parts to facilitate the proper operation. Base can be constructing from square pipe 40mm x40mm x 2mm raw material and the height of the base table is 800mm and 800mm width.

Material------------Mild steel

Blank size---------800mm x 800mm

Quantity --------- 1

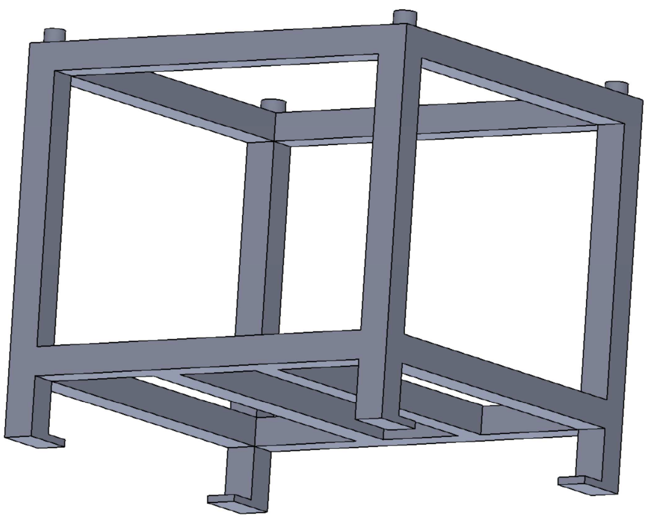


Figure 5.3 Base

Table 5.3 Operation sheet for base

No	Operation	Machine used	Tools & Equipment's used	Time In minute
1	Measuring & cutting to size	Power hacksaw	Venire caliper, Tape rule	240
2	Fit the align position and Check the angle	-	Try square & tape rule	**60**
3	Welding set up part and avoid the slag	Welding machine	Chipping hammer	240
4	finishing	Grinder machine	grinder disk	50

5. 2.4 Operation sheet for vibrating table

This is used to hold the mold material at the top of the plate and shaft, pulley, bearing house are join together with at the back of vibrating table. Therefore the table is constructing for 91cmx91cmx2mm angle iron and 87cmx87cmx 1.5mm mild steel sheet.

Material------------mild steel

Blank size---------910mm x 910 mm

Quantity --------- 01

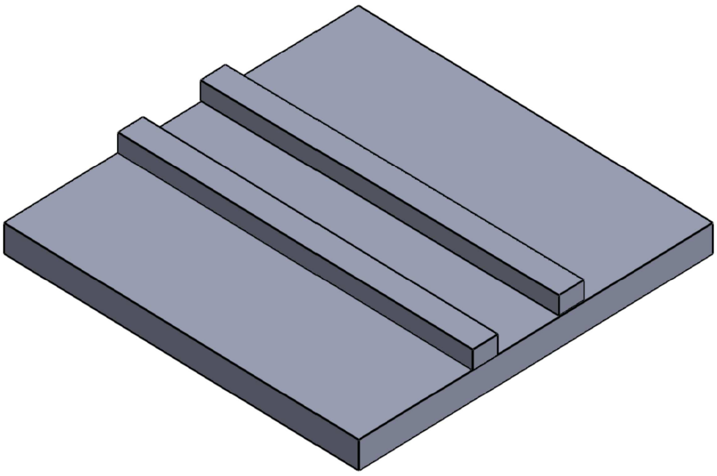


Figure 5.4 vibrating table

Table 5.4 Operation sheet for vibrating table

No	Operation	Machine used	Tools & Equipment's used	Time in minute
1	Measuring & cutting to size	Power hacksaw	Venire caliper, Steel rule	40
2	align the angle iron in to the position and Check the angle	-	Try square & tape rule	**5**
3	welding the correct angle	Welding machine	Try square	15
4	Fit the plate in to the top frame		Try square	5
5	welding the plate in to the angle iron	Welding machine	Chipping hammer	15
6	Finishing	Grinder machine	grinder disk	10

5. 2.5 Operation sheet for key

This is used to fasten the pulley in to the shaft key way. Therefore the pulley is cannot be loosen used to insert the press fit to collaborate the shaft keyway. Key can be constructing from 60mm x60mm x 30mm mild steel.

Material------------mild steel

Blank size---------60mm x 60mm

Quantity --------- 1

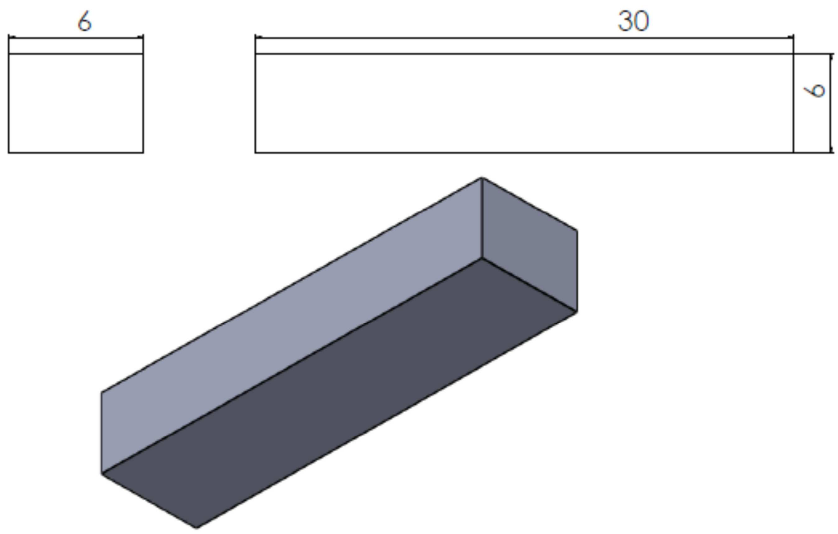


Fig. 5.5 key operation

Table. 5. 5 Operation sheet for key

No	Operation	Machine used	Tools & Equipment's used	Time
1	Measuring & cutting to size	hacksaw	Venire caliper, Steel rule	30 min
2	Filing on all side	Flat file	V. caliper	**15 min**
3	finishing	Grinder ,Sand paper	-	10 min

CHAPTER SIX

ASSEMBLY AND MAINTENANCE

6.1 Procedures of assembling components

Now all the parts needed for making our project are manufactured and prepared as necessary. Then the next step is assembling of manufactured components in their correct place for making the project functional.

1- Assembling of bearing with driver shaft by press fit………………01 sub assembly

Fig- 6.1 shaft, ball bearing with housing

2- Assembling of pulley with shaft by join with key……… 02 sub assembly

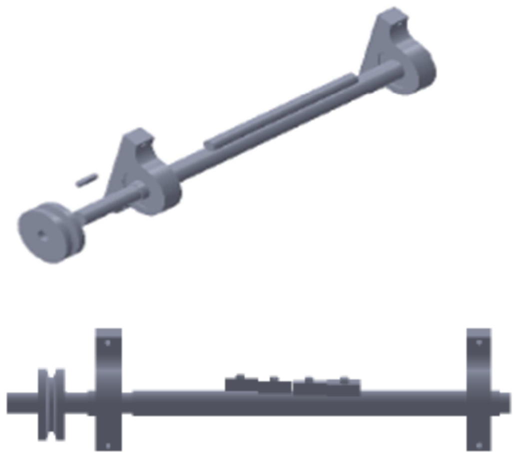


Fig 6.2 pulley, shaft and key

3- Assembling of driver shaft with vibrating machine ……………03 sub assembly

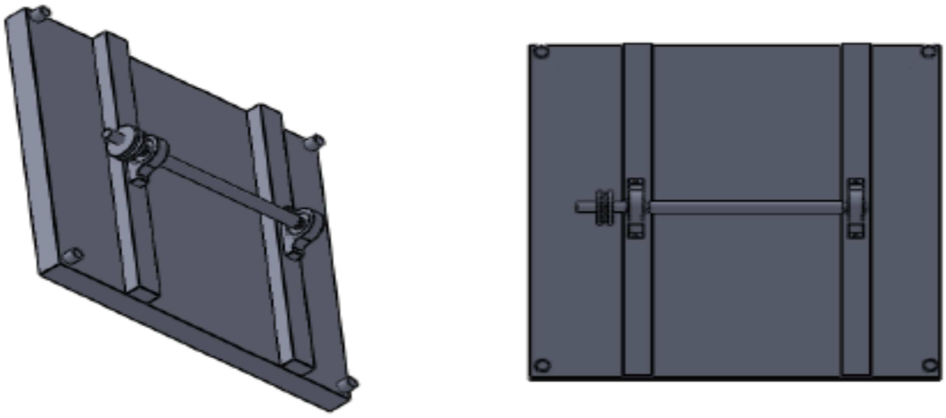


Fig 6.3 vibrating table, driver shaft, pulley and ball bearing with housing

4- Assembling of base with motor …………………………..04 sub assembly

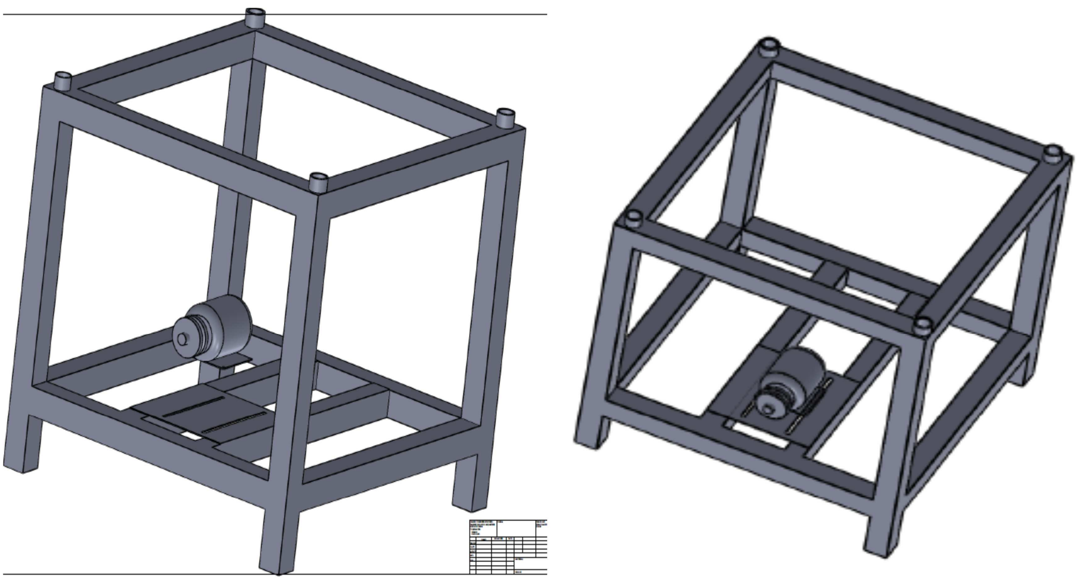


Fig 6.4 base and motor

5- Assembling of base with spring ……………… …… 05 sub assembly

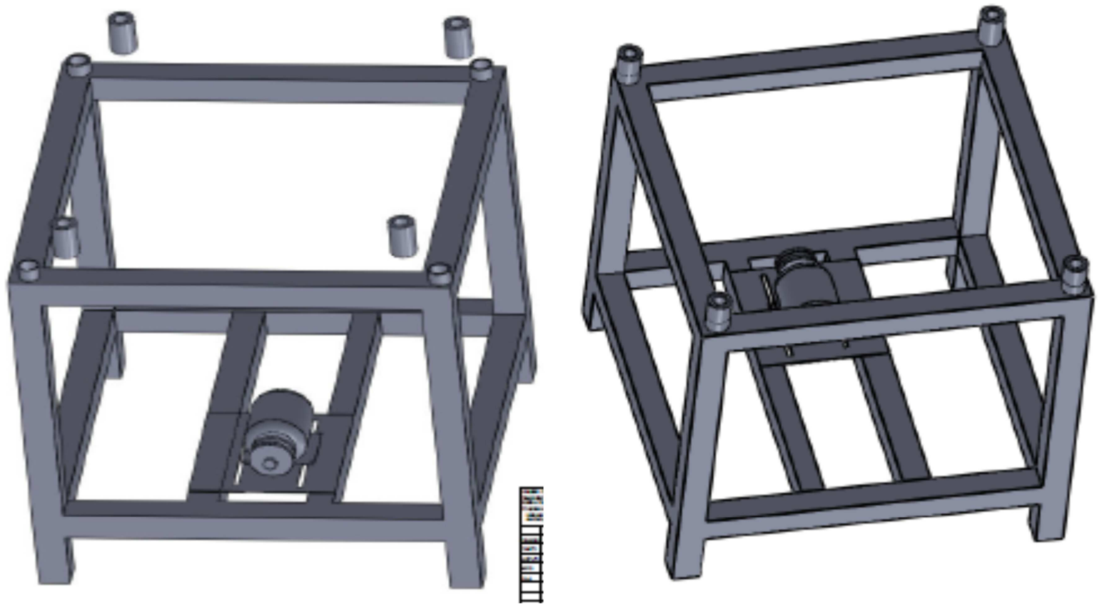


Fig 6.5 base and spring

6- Assembling of base and vibrating table ………………….06 sub assembly

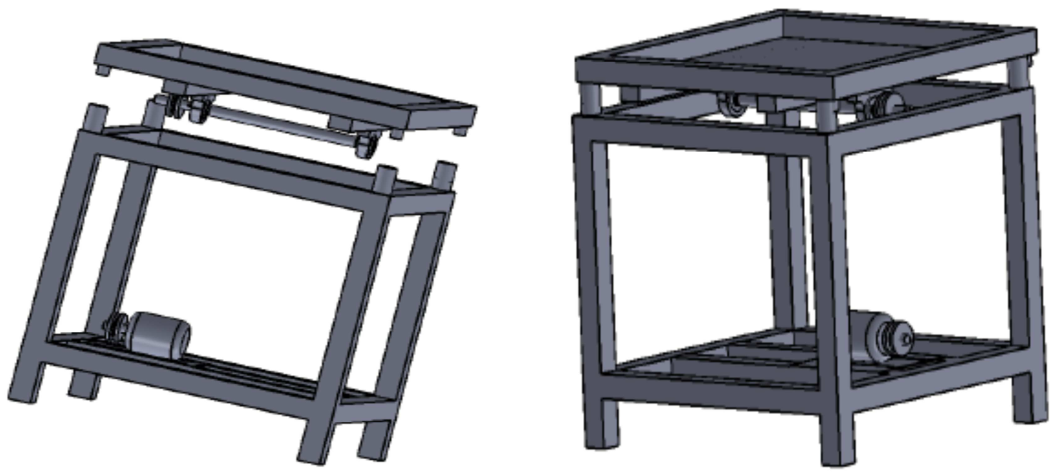


Fig 6.6. Base and vibrating table

7- Assembling of belt…………………………………… 07 sub assembly

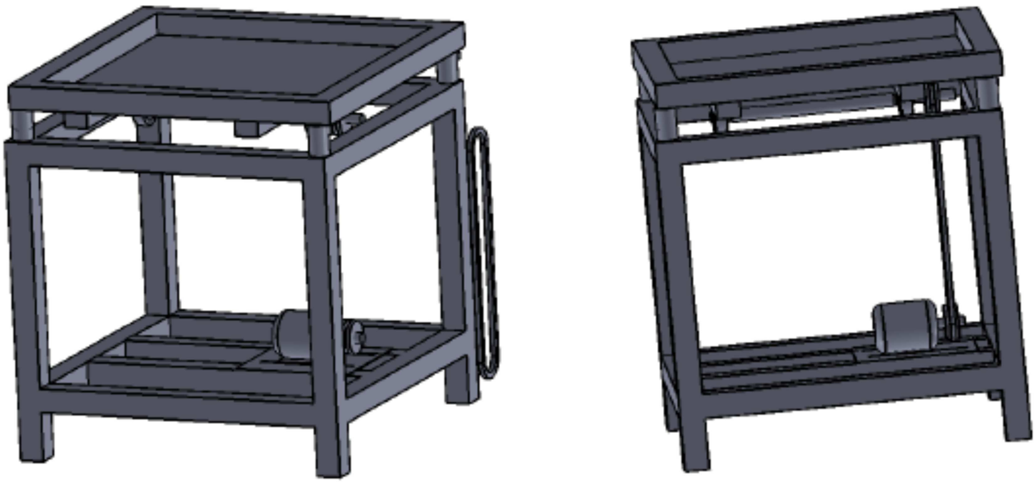


Fig 6.7 belt assembling

8- Assembling of cover ……………………………………..08 Assembly

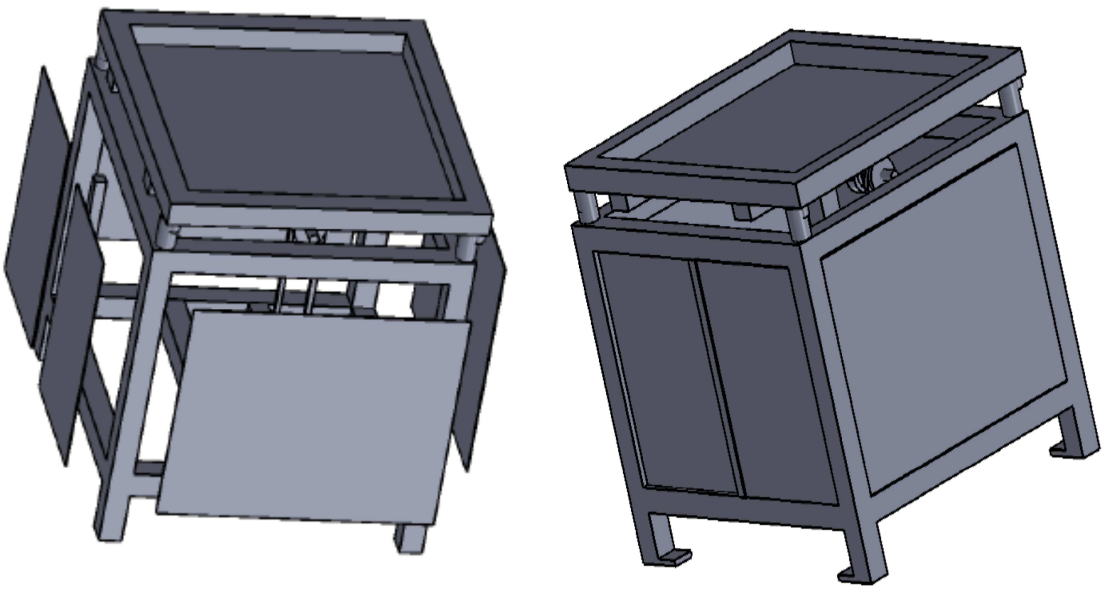


Fig. 6.8 covers assembling

6.2 Maintenance

Before apply a maintenance program for our machine, first realize the following questions.

- What is maintenance and why is it performed?
- What type of maintenance needed to prolong the life of our machines?
- What time interval to maintain the machine?
- Frequently which parts of our machine will be damaged? So what type of maintenance we choose or preferable.
- What are the common tasks of PM maintenance for our machines?

6.2.1 The need for maintenance

Maintenance is "to keep the equipment in specified operational condition or repair to its operational mode." This would imply that maintenance should be actions taken to prevent a device or component from failing.

The need for maintenance is predicated on actual or coming failure – ideally, maintenance is performed to keep equipment and systems running efficiently for at least design life of the component(s). As such, the practical operation of a component is time-based function.

6.2.2 Maintenance strategies or option

The following are the maintenance strategies that are commonly applied in the plants.

- Breakdown Maintenance or Unplanned Maintenance
- Preventive or Scheduled Maintenance
- Predictive or Condition Based Maintenance

Breakdown maintenance is allowed to run until it breaks down and then repairing it and putting back to operation. This strategy is suitable for equipment that are not critical and have spare capacity or redundancy available.

Preventive or scheduled Maintenance, maintenance actions such as inspection, lubrication, cleaning, adjustment and replacement are undertaken at fixed intervals. An effective PM program does help in avoidance of accidents.

Predictive or Condition Based Maintenance monitoring (CM) detects and diagnoses faults and it helps in planned maintenance based on equipment condition. This condition based maintenance strategy or predictive maintenance is preferred for critical systems and for such systems breakdown maintenance is to be avoided. A number of CM techniques such as vibration, temperature, oil analysis, etc. have been developed, which guide the users in planned maintenance

6.2.3 Maintenance and their functions

Some of the important functions of the maintenance programs are as follows:-

1. Inspection or checkups.
2. Lubrication.
3. Planning and Scheduling.
4. Records and analysis.

Inspection or Check-ups

Inspection is an essential function of the maintenance program. There are external and internal inspections. External inspection means to watch for, and detect defects form abnormal sound, Vibration, heat, smoke etc. When machine is in operation; internal inspection means inspection of internal parts, such as bearings, bearing house, and pulley etc.

Frequency of inspection should be decided very carefully, as too less inspection may cause breakdown, as defects could not be traced out and repair immediately; while too much inspection, wastage of machine time and labor productivity. Hence frequency inspection should be decided on the basis of past experiences and scheduled program for inspection.

Lubrication

We use systematic way of lubrication which is applying the right type of lubricant at the right time, at right place and in right quantity. For lubrication, we should be prepared and that should be followed a lubrication schedule strictly.

Planning and Scheduling

Every preventive maintenance work should be pre-planned in detail on the basis of the analysis done on the past records. Thus programmed should be in detail specifying the point requiring daily, weekly, monthly, and half yearly or yearly attention.

Records and Analysis

Good record keeping is essential for good maintenance. With the help of records possible cause for major repetitive failures can be examined and rectified so as not to repeat so early.

6.2.4 The expecting problems in our machine

The main expected problems in the operations of cement tile vibrator machine and the elements that will require maintenance activities are:-

- Bearing parts can be easily worn-out;
- The spring is damaged in the cause of tension and compression.

- The belt parts might be tensioned or it will produce slippage.
- Some parts of the machine might be corroded.
- Misalignment of pulley.

Due to the above problems operator must not work on a cement tile vibrator machine without first taking training and without being informed of the risks, the precautions required and operating instructions for the guards and compulsory safety devices. The maintenance system should be applied during working regularly.

CHAPTER SEVEN

COST ANALYSIS

This chapter computes 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 cement tile vibrator machine and also result and discussion is included.

7.1 Cost Analysis

7.1.1 Elements of cost established selling price

Design and manufacture a product according to a certain specification by minimizing total cost and maximizing efficiency of the product or machine to meet service requirements is only one aspect of production. Based on these the design and manufacture of certain cement tile 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

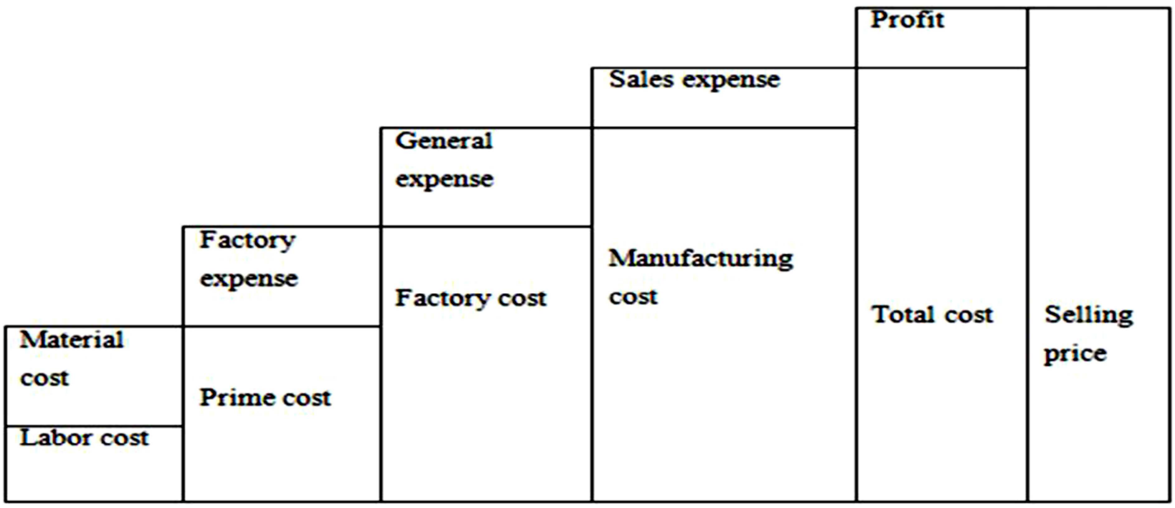


Figure 7.1 Establishing of selling price

The chief cost elements of direct material cost and direct labor cost determines major 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.

7.1.2. The costs of raw materials and 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.

Table 7.1 the costs of raw materials and the cost of standard items

No	Items Needed	Specification	Unit	Qty	Unit price		Total price		Remark
					Birr	cent	Birr	cent	
1	Mild steel sheet metal	1.5mm thick	Pcs	2	480	00	960	00	
2	Angle iron	2x 40x6000 mm	Pcs	1	250	00	250	00	
3	Square pipe	2x40x40x6000 mm	Pcs	2	450	00	900	00	
4	Square pipe	1x15x15x6000 mm	Pcs	1	120	00	120	00	
5	Round bar	Ø 28x370mm	Pcs	1	200	00	200	00	
6	Aluminum Ingot	Ø70x140 mm	Pcs	1	500	00	500	00	
8	Bolt and nut	M6x60 mm	Pcs	12	5	00	60	00	
9	Single phase motor	1.9 KW	Pcs	1	3000	00	3000	00	
10	Electrical switch	Single phase	Pcs	1	90	00	90	00	
11	V-belt	A43	Pcs	1	200	00	200	00	
12	Ball bearing		Pcs	2	500	00	500	00	
13	Electric cable	Three in one	m	3	40	00	120	00	
14	Mild steel electrode	Ø3.2mm, Mt 12	pac	1/2	90	00	90	00	
15	Mild steel electrode	Ø2.5mm, Mt 12	pac	1/2	80	00	80	00	
16	Paint brush	D/t size	Pcs	2	20	00	40	00	
17	Grinding disc		Pcs	1	30	00	30	00	
18	Cutting disc		Pcs	2	30	00	60	00	
19	Carbide cutter	20x20x100 mm	Pcs	1	150	00	150	00	
20	Drill bit	HSS Ø 1.5-13	set	1	250	00	250	00	
21	Drill bit	Ø 18, 25	Pcs	2	200	00	200	00	

22	End mill cutter	Ø 6	Pcs	1	100	00	100	00	
23	Hack saw blade	18T/inch	Pcs	8	30	00	240	00	
24	Anti-rust		kg	01	55	00	55	00	
25	Paint	Blue	kg	1/2	20	00	30	00	
26	Paint	green15	kg	1/2	30	00	30	00	
27	Thinner		Lit	01	30	00	30	00	
Total material cost = 8285.00									

7.1.3 Labor cost for manufacturing and assembling components

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 7.2 Manufacturing Labor cost

No.	Parts name to be made	Qty	Operation	Working time in minute	Payment per hour	Labor cost price in Birr	Total cost of part in Birr
1	Shafts	01	Measuring & cutting to size	**40**	25.00	16.70	**52.12**
			Facing on one side	**10**	25.00	4.16	
			Turning the step and chamfering	30	25.00	12.50	
			Facing on the other side	10	25.00	4.16	
			Turning and chamfering the other step	15	25.00	6.25	
			Milling a key way	20	25.00	8.35	

2	Pulley	02	Facing on the other side				78.54
			Turning a hub and Chamfering	40	25.00	16.70	
			Drilling	10	25.00	4.14	
			Milling a key way	50	25.00	20.43	
3	Base	01	Measuring & cutting to size	2:40	25.00	66.70	**178.83**
			Fit the align position and Check the angle	**60**	25.00	25.00	
			Welding set up part and avoid the slag	2:40	25.00	66.70	
			finishing	50	25.00	20.43	
4	Vibrating Table	01	Measuring & cutting to size	40	25.00	16.70	**41.62**
			align the angle iron in to the position and Check the angle	**10**	25.00	4.14	
			welding the correct angle	15	25.00	6.25	
			Fit the plate in to the top frame	10	25.00	4.14	
			welding the plate in to the angle iron	15	25.00	6.25	
			Finishing	10	25.00	4.14	
5	Key	02	Measuring & cutting to size	30	25.00	12.5	**22.8**
			Filing on all side	**15**	25.00	6.25	
			Finishing	10	25.00	4.14	
						Total	**374.00**

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 7.3 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	Assembling of bearing with driver shaft	Manual	0:30	25.00	12.5
2	Assembling of pulley with shaft	Manual	0:10	25.00	4.50
3	Assembling of driver shaft with vibrating machine	Bolting	0:30	25.00	12.50
4	Assembling of base with motor	Welding and Bolting	0:20	25.00	10.00
5	Assembling of base with spring	Manual	0:10	25.00	4.50
6	Assembling of base and vibrating table	Manual	0.30	25.00	12.50
7	Assembling of belt with motor and vibrating table	manual	0:30	25.00	12.50
8	Assembling of cover with base	Welding	1:00	25.00	25.00
Total cost					**94.00 Birr**

Total Labor Cost = Labor cost for manufacturing components + Labor cost for assembling components.

= **374.00 Birr** +**94.00 Birr**

Total Labor Cost = **468.00** Birr

7.1.4. 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 KWH. The electrical machines used and time consumed is indicated below:-

Table 7.5 Machines & time consumed/hour

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
1	Shafts	01	0:40	1:05	0:20	0:30			
2	Key	01	0:30		1:10				
3	pulley	02	0:30	5:35	0.30				
4	Base	01	0:40			3:00	0.40	0:30	0.50
5	Vibrating table	01	0:40			3:00			0.50
Total time/hour			**2:20**	**6:40**	**2:00**	**6:30**	**0:40**	**0:30**	**1:40**

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 A power hack saw power rating (p) =0.75KW and working time (t) =2:20hr.

Solution

Energy consumed (E) =?

E=Pxt= (0.75x2) + (0.75x20/60)

E=1.5KWH + 0.250KWH

Energy consumed (E) = **1.75KWH**

Example-2 A lathe machine power rating (p) =2.2KWand working time (t) =6:40H.

Solution

Energy consumed (E) =?

E=Pt= (2.2x6) + (2.2x40/60)

E=13.2 KWH + 1.47 KWH

Energy consumed (E) =**14.7 KWH**

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

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

Table 7.6 Electrical power consumption cost

No	Machine type	Power rating of the machine in KW	Total machining time in hour	Energy consumed in KW	Payment for 1KWH in Birr	Total payment in birr
1	Power hack saw	0.75kw	2:20	1.75	0.70	1.225
2	Lathe machine	2.20kw	6:40	13.2	0.70	9.24
3	Milling machine	1.50kw	2:00	3.00	0.70	2.10
4	Arc welding machine	4.90kw	6:30	31.85	0.70	22.295
5	Oxy-fuel cutting	0.14kw	0:40	0.093	0.70	0.0651
6	Drilling machine	1.30kw	0:30	0.65	0.70	0.445
8	Portable hand grinder	2.00kw	1:40	3.00	0.70	2.10
Total cost						**37.47 Birr**

7.1.5. 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:-

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

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 z hours)'.,

Example: 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

$$D = \frac{40000-12000}{10}$$

= **2800 Birr per year**

In one year we have 12 months, and the depreciation cost for a month,

2800/12 =**233.33**Birr/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 5 working days the depreciation cost per day =58.33/5= **11.67**Birr/day. Further we have 8 working hours in a day so the depreciation cost per hour= 11.67/8= **1.46** Birr/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 thehourly depreciation

Table 7.7 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	5:45	8	40
2	Arc welding machine	5	30,000	00	2	19	19:10	11	30
3	Potable grinder	3	2,000	00	0	24	28:00	0	20
4	Lathe machine	10	150,000	00	5	47	5:10	104	85
5	Drilling machine	10	100,000	00	3	65	1:50	7	30
6	Milling Machine	12	200,000	00	6	08	2:00	170	25
Total Cost								**302**	**30**

7.1.6 Total cost of Cement tile Vibrator Machine

Manufacturing cost:-

- Material cost ----------------------- = 8285.00Birr
- Labor cost -------------------------- = 468.00 Birr
- Electric power consumption cost =37.47Birr
- Machine depreciation cost = 302.30Birr

  Manufacturing cost = 9092.77 Birr

- **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 = $\frac{10\text{x}\mathbf{9092.77}\text{ Birr}}{100}$

  = **909.28 Birr**

- ***Total manufacturing cost*** = Manufacturing cost + Contingency

  = 9092.77 Birr+ 909.28 Birr

  = <u>**10,002.05 Birr**</u>

- ***Profit***: **-** it is usually taken as20% of the total cost.

Profit = D = $\frac{20x10{,}002.05\text{Birr}}{100}$

= **2,000.41 Birr**

- **Selling price** = Profit + Total manufacturing cost

= 2000.41 +10002.05 Birr

= **12,002.46 Birr**

Selling price of existing machine are;-

- Hydraulic press machine = 80,000 birr
- Automatic feeding , mixing and compacting machine = 200,000 birr

So our project (cement tile vibrator machine) is very cheap in price comparing from existing machine.

Return on investment

$$\text{ROI} = \frac{(\text{Amount received} - \text{Amount invested})100}{\text{Amount invested}}$$

$$= \frac{(2000.41-10002.05)x100}{10002.05}$$

$$= \underline{\mathbf{-80\%}}$$

So enterprises return their investment to cement tile vibrator machine through one and half year.

CHAPTER EIGHT
RESULT AND DISCUSSION

8.1. Result and discussion

The machine was fabricated and assembled by local material and machinery. It is designed to compact the cement tiles into the required strength. During testing of the machine, some activities have been made such as:-

- Belt mechanism design for vibrating the table

We have test the belt mechanism for vibrating the table as free-load testing of the motor, load testing of motor with the help of belt and pulley, stability of the machine, amount of vibration applied with different eccentric load on the shaft.

- Appropriate material selection for each machine components

We have test the all the materials of components weather the materials are appropriate or not.

- Electrical mechanism to increase productivity

As we have test the cement tile vibrator machine can produce 16 pieces with 2 minutes or not. so it achieve the objective to increase number of production compared to hydraulic cement tile machine.

- Minimize wastage of time, money and energy

As we have test the cement tile vibrator machine is very fast and it has not require more energy so it minimize time and energy.

- Operating method and cost of machine

As we have test the cement tile vibrator machine is very simple to operate and very cheap (12,002.46 birr) comparing from existing machine.

8.2. Testing of compacting operation

In the first test of vibrating, prepared concretes are mixed manually and fill into plastic mould. The plastic moulds are placed to the vibrating table and adjust the vibration until the required compactness is obtained by using adjustments depending up on the eccentric load.

During testing, we didn't look exaggerated problems comparing the thesis with practical implications except one comment from some Cement tile MSEs representatives said using two motors in the both side of the shaft is better to balance the vibration. Thus, the project is functional as per the design and meets the objective. See the picture at **Appendix E.**

CHAPTER NINE

CONCLUSION AND RECOMMONDATION

9.1 Conclusion

The demand of Cement tile vibrating machine is higher and it is the time to solve the problem of tile manufacturer. It can be improved tile processing tasks in minimum cost, save time and energy. Ethiopia has good resources to produce tiles, but cannot get economic advantages from the resources because they have not enough and balanced cost machine.

So it is better to

- Design belt mechanism for vibrating the table
- To select appropriate material for each machine components.
- Changing hydraulics in to electrical mechanism to increase productivity
- Design machine elements for appropriate operation.
- To minimize wastage of time, money and energy by producing 8-16 pieces in one operation.
- To minimize the cost of machine by using local material.
- Manufacture cement tile vibrator machine in simple operating method.

In our improved cement tile machine will be compact 8-16 tiles at once by changing different size moulds and vibrating cement concrete appropriately. The existing machine is produce one piece of product at one time in the help of hydraulic pressing.

This machine has the following advantages:

- Manufactured from local materials
- Easy to assemble and disassemble.
- It does not need highly skilled man.
- Convenient for transportation.
- Low in cost and easy to maintain.
- Save time and money.
- It can create job opportunity
- It can be easily manufactured and distributed to various areas of our country and easily adapted as technology transfer to SMEs.

9.2 Recommendations

Any person who has interest will try to make this project is successful, what developers want to recommended about the machine as follows:

- If there is vibration during compacting, it should be bolted on the ground;
- The government should initiate SMEs and other investors to work on the cement tile products.
- By increasing the size of motor and table it can be produce more than 16 pieces.

9.3 Future works

The project is feasible and functional as per the design. It should be distributed to all the country especially capital city and sub city car roads are available in order to keep road standards, to improve comfort, to create job for the people and to get government income tax. Thus, all concerned body should work on cement tile products to get advantages from the resources.

Since the design is concerned only on cement tile vibrating machine, it doesn’t include grinding, cutting and washing of tile. So for the future the design can be improved by including grinding, cutting and washing process together in a single unit that can perform electrically. In order to know the required time, the electrical system needs modification with timer.

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APPENDIX A

Table 1 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 (b)mm	Thickness (t)mm	Weight per Meter 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	-

APPENDIX B

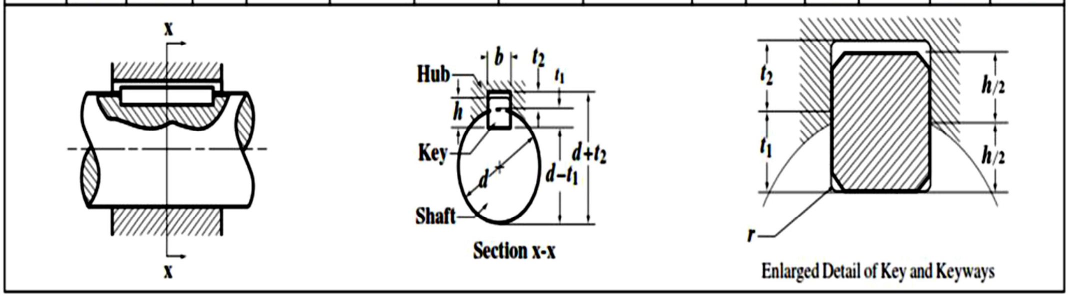
Table 2 Torque f l e x ® v- belt s (ISO standard of Good year's Belt products)

Belt reference	Imperial reference (inch)	Inside length Li (mm)	Datum length Ld (mm)
ZX 53 ½ 53 ½ 1365			1385
ZX 53 ½	53 ½	1365	1385
ZX 54	54	1375	1395
ZX 54 ½	54 ½	1390	1410
ZX 55	**55**	**1400**	**1420**
ZX 56	56	1425	1450
ZX 57	57	1450	1470
ZX 57 ½	57 ½	1465	1485
ZX 58 ¼	58 ¼	1475	1500
ZX 58 ½	58 ½	1490	1510

APPENDIX C

Table 3 British standard metric keyways for square and rectangular parallel keys BS 4235: Part 1972(1986)

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



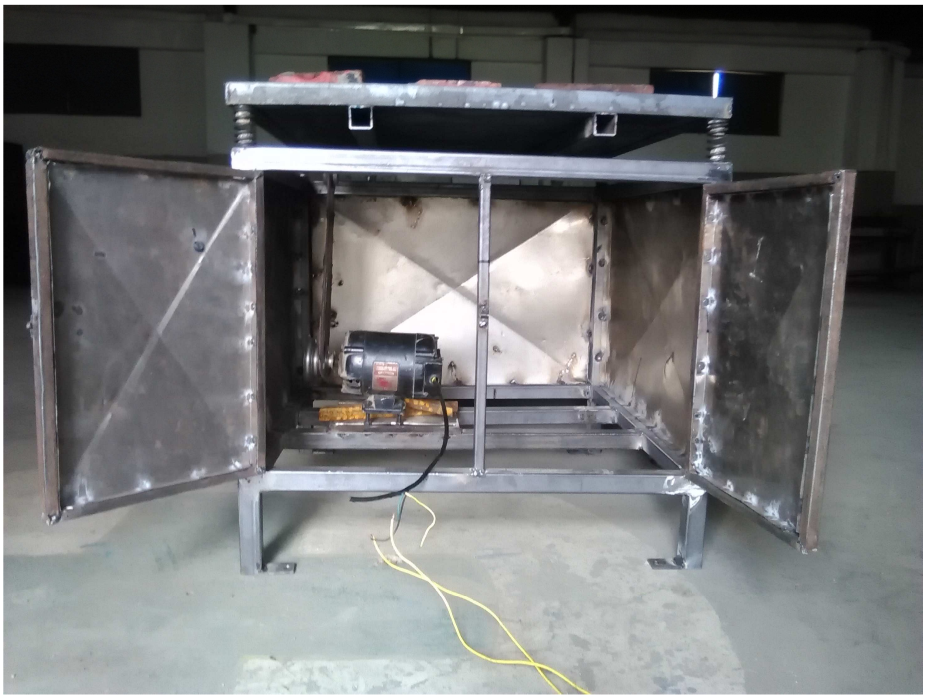
APPENDIX D

Table. 4. Standard wire gauge (SWG) number and corresponding diameter of spring wire.

SWG	*Diameter (mm)*	*SWG*	*Diameter (mm)*	*SWG*	*Diameter (mm)*	*SWG*	*Diameter (mm)*
7/0	12.70	7	4.470	20	0.914	33	0.2540
6/0	11.785	8	4.064	21	0.813	34	0.2337
5/0	10.973	9	3.658	22	0.711	35	0.2134
4/0	10.160	10	3.251	23	0.610	36	0.1930
3/0	9.490	11	2.946	24	0.559	37	0.1727
2/0	8.839	12	2.642	25	0.508	38	0.1524
0	8.229	13	2.337	26	0.457	39	0.1321
1	7.620	14	2.032	27	0.4166	40	0.1219
2	7.010	15	1.829	28	0.3759	41	0.1118
3	6.401	16	1.626	29	0.3454	42	0.1016
4	5.893	17	1.422	30	0.3150	43	0.0914
5	5.385	18	1.219	31	0.2946	44	0.0813
6	4.877	19	1.016	32	0.2743	45	0.0711

Text book of machine design, 1st edition, R.S.KHURMI AND J.K GUPTA, Eurasia publishing house, New Delhi ,2005

APPENDIX E:- Testing and discussion result



APPENDIX F: - Application of cement tiles