ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

School of Mechanical, Chemical and Materials Engineering

IMPROVED ELECTRIC WOOD LATHE MACHINE

A project submitted in partial fulfillment of the requirement

for the award of the degree of

Master of Science

In

Manufacturing Technology Teachers Education

By

1. Asres Wolde....... ……. (GSR/5255/06)
2. Hana Getachew......... … (GSR/5268/06))
3. Hiwot Asnake………… (GSR/5269/06))
4. Meseret W/mariam…... (GSR/5274/06)
5. Nesru Mudesir……. … (GSR/5276/06)

Advisor: - Dr. Habtamu Beri

Department of Mechanical and Vehicle Engineering

Jun, 2015

Adama, Ethiopia

DECLARATION

We hereby declare that the work which is being presented in this project entitle **"IMPROVED ELECTRIC WOOD LATHE MACHINE",** is our original work and has not been presented for a diploma / degree of any other Institution/University and all the materials used for the project have been duly acknowledged.

Candidate	**Signature**	**Date**
1. Asres Wolde	__________________	_______________________
2. Hana Getachew	__________________	_______________________
3. Hiwot Asnake	__________________	_______________________
4. Meseret W/mariam	__________________	_______________________
5. Nesru Mudesir	__________________	_______________________

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 Date

(Advisor)

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________________________	_________________	_____________
Chairman, Dep't Graduate Committee	Signature	Date
________________________	_________________	_____________
Advisor	Signature	Date
________________________	_________________	_____________
Internal Examiner	Signature	Date
________________________	_________________	_____________
External Examiner	Signature	Date

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ABBREVIATIONS AND ACRONYMS

SMEs	Small and Micro Enterprises
ASTU	Adama Science and Technology University
NC	Numerical Control
CNC	Computerized Numerical Control
TVET	Technical and Vocational Education Training
US	Ultimate strength
YS	Yield strength
CS	Compressive yield Strength
SS	Shear yield Strength
FP	Fatigue Properties
E	Modulus of elasticity
CR	Creep Rate
HD	Hardness
CE	Coefficient of Expansion
IS	International Standard
ASTM	American society of Testing Materials
ASME	American Society of Mechanical Engineers
RHS	Rectangular Hollow Steel
HSS	Hardened Stainless Steel
PPE	Personal Protective Equipment
AISI	American Iron and Steel Institute

ABSTRACT

The overall aim of this thesis project is to show an alternate direction how possible to design and manufacture cost competent electrical wood lathe machine equipped with safety cover and having 1200mm center distance and diameter that can be accommodate wood stock up to 400mm. The machine is fabricated from locally sourced materials, which makes it cheap and easily to maintain. Wood turning machine is known to have a wide use within the wood working industry and SME (Small and Micro Enterprise). Most engineering firms have therefore capitalized on this and developed technologically advanced machines. A visit to local dealer of these machines, it proved that the imported wood lathe machines can somewhat be expensive in our country. Based on the data analyzed, a wood lathe machine is designed and manufactured to improve the efficiency of the users.

Looking at the current economic situation in Ethiopia, an artisan (SME) who wants to own one of this cannot have enough money. With this picture in mind that design and manufacture in a very competitive or viable price by reverse engineering (redesigning). This would allow a low income earner to access the machine. Based on the low cost project, the availability of components and ease of assembly, this machine can be much needed to produce different wood products in length and diameters. The equipment designed is portable, affordable and easy to maintain. Evaluation and test was carried out, thus having result for days of the testing of straight turning, drilling and boring the wood work-pieces.

Overall, this project involves processes like design, fabrication and assembling of different components.

*Key words:-**Reverse engineering, enterprise, Small and micro enterprises***

CHAPTER ONE

INTRODUCTION

1.1 Backgrounds

All over the world there is a constant effort that is geared towards improvement of life in all aspects. People are seen to continuously engage themselves in income generating activities and thus the springing up of businesses all over.

Developing countries including Ethiopia need to improve productivity throughout the economy in an era of rapid economic and technological change to compete successfully. This requires not only capital investment but also a workforce that has the flexibility to acquire and change occupation. The level of competence of a country's skilled workers and technicians is very important to the flexibility and productivity of its labor force.

Currently, Ethiopian government has embarked on a campaign that is aimed at improving the lives of citizen. The campaign to make Ethiopia globally competitive and prosperous dubbed vision 2020 encompasses a great deal of development oriented project, one of which is to ensure that 90% of the country is covered by electricity.

Another area where the Government is improving by making financial services accessible to small and medium enterprises (SME).Right from passing legislation that allows banks to offer loans which require minimal security and have low interest rates to the lately famous.

Constituency Development Fund and other financial support systems, the government has ensured that any person with a business idea that is viable can access funds to realize the idea.

It is with these reasons in mind that embarked on the task of designing a wood lathe of good quality and very competitive pricing. This means the design a wood lathe that will run on electricity as a source of power and that will be competitive in price while maintaining high quality of work output as compared to the already existing machines of its kind in the marketplace. This opens up the wood turning business venture to as many entrepreneurs as possible both of high and low capital investment.

1.2. Statement of the problem

There is a high risk of accident from the use of locally manufactured wood lathe machines due to less improved rotating part covers. Research problems are not only focusing the safety conditions but also stressing the ease of using machine and its price. Nowadays imported machine costs are highly increased and observe the following problems:

- The workers are exposed to series injures during working.
- The SMEs cannot be easily purchase the imported wood lathe machine due to its price.
- An appropriate technology should be conducted in saving human power or energy and time.
- The quantity and quality of production are very low.

1.3 Objective of the project

1.3.1 General objective

The general objectives of this project is to design and manufacture wood lathe machine with a minimum cost and optimum performance.

1.3.2 Specific objectives

The specific objectives of this project are;

- To design and manufacture the machine with 1200mm center distance, swivel headstock and face plate compare to locally manufacture wood lathe machines.
- Increase the rate of productivity of the enterprise and minimize foreign currency by producing wood lathe machine with simple production techniques
- To produce different wood product.
- Provide safe working conditions by use of guards.
- To minimize maintains cost

1.4 Scope of the project

The design and manufacturing of wood lathe machine covers a very broad area. This area encompasses the design, design considerations, construction, and assembly, working conditions and mathematical equations. The design gives in depth details of the construction and fabrication of the apparatus. The wood lathe machine is fabricated from locally marketed material and resources as well as reducing machining process.

1.5 Significance of the project

- Develop designing and manufacturing skill.
- Users of the machine can get optimum efficiency with minimum cost.
- Learn collaboration skills and encourage technology transfer in Ethiopia.
- Increase productivity.

1.6 Limitations of the project

- There is time and financial constraint to accomplish some features of machine, example the swivel headstock of the machine and indexing.
- Long lead time for purchase and deliver required raw materials.
- Lack of willingness by warehouse to provide tools and equipment's as per required.
- There is a limitation of an accurate and precise machine that brings the required tolerance and surface finish value as expected during manufacturing.

CHAPTER TWO

LITRETURE REVIEW

2.1 Introduction

Wood lathe machine is one of the most important machines in wood work shop. This machine is work shaping a rotating piece of wood by the application of sharp tool. The machine that holds and rotating the wood is a lathe. The wood lathe machine is a single work shop tool that can greatly expand your wood working horizon. It is made up of different steel, motor and belt used to make different house and office furniture. This chapter will present the over all of wood lathe machine, use of machine, history of machine, the existing and newly designed wood lathe machine.

2.2 History of wood lathe machine

The lathe is an ancient tool, dating at least to ancient Egypt and known and used in Assyria, ancient Greece, and the Roman. Lathes have been in existence for thousands of years. On the wall of the tomb of Pet Osiris in Egypt, carved in stone, is the earliest illustration of a lathe that is known to exist, dating from approximately 300 B.C**[1].**

The origin of turning dates back to around 1300 BC when the Egyptians first developed a two person lathe. One person would turn the wood work piece with a rope while the other used a sharp tool to cut shapes in the wood. The Romans improved the Egyptian design with the addition of a turning bow. Early bow lathes were also developed and used in Germany, France and Britain. In the middle Ages a pedal replaced hand-operated turning, freeing both the craftsman's hands to hold the woodturning tools. The pedal was usually connected to a pole, often a straight-grained sapling. The system today is called the "spring pole" lathe. Spring pole lathes were in common use into the early 20th century. A two-person lathe, called a "great lathe", Allowed a piece to turn continuously (like today's power lathes). A master would cut the wood while an apprentice turned the crank. The history of turning goes back much farther than that. The art of plain turning is known to have been practiced for at least 3500 years, with gradually increasing improvement from simple woodturning devices to modern engineering. 1500 years before the birth of Christ, Egyptians were using simple lathes. The wood lathe is without question the oldest machine. Interestingly the lathe is also the only machine capable of reproducing itself, although modern computers are beginning to approach that capability. The lathe made possible the production of the required precision parts used in steam engines and later, electric motors. Without the invention of the lathe, no Industrial Revolution could have occurred. Others may argue that certain other mechanical contrivances were equally as important to mankind's progress, but most of those contrivances were probably made in whole or in part on a lathe. Egyptian tombs contain turned artifacts, and some turners in today's third- world countries still turn wood using the techniques supposed to be used back in the dim dawn on woodturning history. This technique is essentially pulling a cord wrapped around work (supported between two fixed centers) back and forth, thereby rotating the work so a sharp-edged cutter could be applied. This was often a two-man operation. From Egypt, woodturning spread to other Mediterranean countries, especially Greece and Rome. In Greece and Rome, the geometric symmetry of turned work was truly appealing, and examples abound extent today. From these great civilizations, the art of turning spread to other European countries, and somewhere along the line the turners tired of sitting on the ground to get their work done. They decided to raise the work off the ground so that they could stand as they turned as in the standing position leaves both hands free to control the cutter. Before 1700, pole lathes and tree lathes were in use throughout Europe.

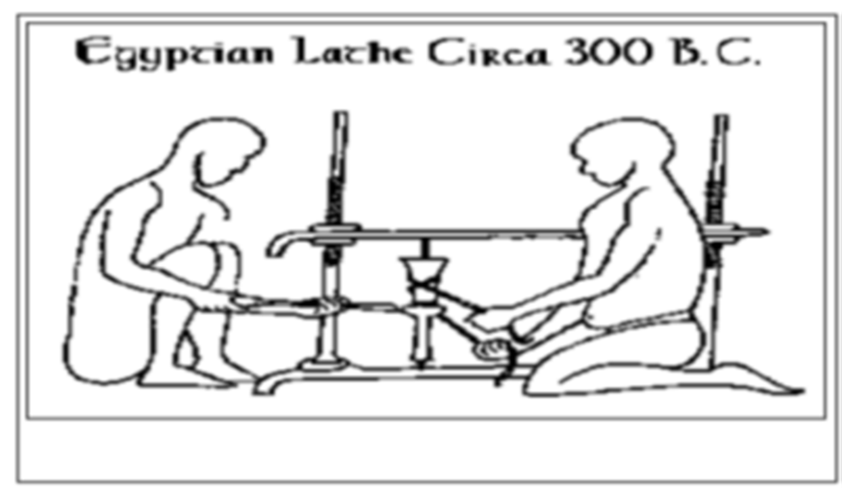


Fig.2. 1 Egyptian lathes in 300BC

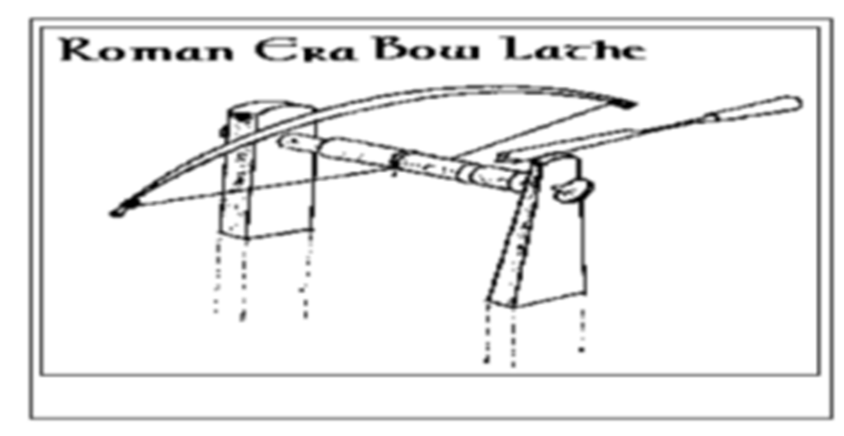


Fig. 2.2 Early Roman lathes [2] and [3] for wood turning

2.3 Wood lathe machine and its uses

Wood lathe turning is the art of shaping a rotating piece of wood by the application of sharp tools. The machine that holds and rotates the wood is a lathe. The wood turning lathe is a simple workshop tool that can greatly expand your woodworking horizon. If you want to shape table legs, chair spindles, and bedposts or add embellishments to your furniture in the form of drawer pulls, cabinet knobs, and finials, then you need a lathe. And if you want to make bowls, plates, stool seats, tabletops, and lidded boxes, a lathe is an indispensable machine. In spindle turning, the grain of the wood being turned runs between the centers of the lathe, that is, parallel to the axis of the lathe .You would spindle-turn table legs, porch columns, and chair rungs. In faceplate turning, however, the grain of the work runs at right angles to the axis of the lathe. You would faceplate-turn large drawer pulls and bowls most lathes are supplied with basic chucks-a set of centers and a faceplate. Some people mistakenly think the type of turning is dictated by the type of chuck used to hold the work. For example, many woodworkers associate turning between centers with spindle turning, but it's possible to hold work between centers and yet be faceplate turning. Similarly, it's possible to spindle-turn while having a piece screwed onto a faceplate. (The screws in this case would be into the end grain of the wood.) The important thing to remember is that the orientation of the grain, not how the work is held, dictates whet her you are spindle or faceplate turning. It is imperative to understand this distinction because each type of work requires different tools and turning techniques.

2.4 Survey on wood lathe machine in Adama

There are different wood lathe machine found on the market imported from outside the country and locally manufactured. According to our survey there are 20 wood workshops in Adama area. From this workshop 8 of them are micro and small enterprises and the rest are private and governmental sectors. Among thus only 5 wood workshops are used the wood lathe machine, all the small and micro enterprises have no wood lathe machine because of the cost. From the above 5 wood workshop 2 of them use imported wood lathe machine, these are ASTU and Adama polytechnic collage and the rest are used locally manufactured wood lathe machines.

2.4.1 Previously Imported wood lathe machine in Adama

There are different wood lathe machine which are imported to inside the country by private and governmental supplier. In Adama governmental sector ASTU and Adama polytechnic collage uses the imported wood lathe, its design structure was made from cast iron, physically so heavy and high cost, the height of machine is too short so it has no ergonomic comfort for the workers and the distance between headstock and tailstock or between center is only one meter long so it is difficult to produce a wood product which is greater than 1meter long. Also it is difficult for maintenance. Because of this reason the design need improvement to solve the problems.

Figur.2.3 Imported wood lathe machine in ASTU

2.4.2 Locally manufactured wood lathe machine in Adama

There are different private sectors which manufacture locally wood lathe machine. Zerihun and Samuel private wood work shop use locally manufactured wood lathe. The machine design structure made from fabricated steel. It is physically heavy, but less cost than imported one, and the rotating device have no safety guard. They do not have operating and maintenance manuals. The head stock is fixed, just like the imported wood lathe machine; the height of the machine is too short; so workers lead to ergonomically problem. Among this problem the machine need more improvement.

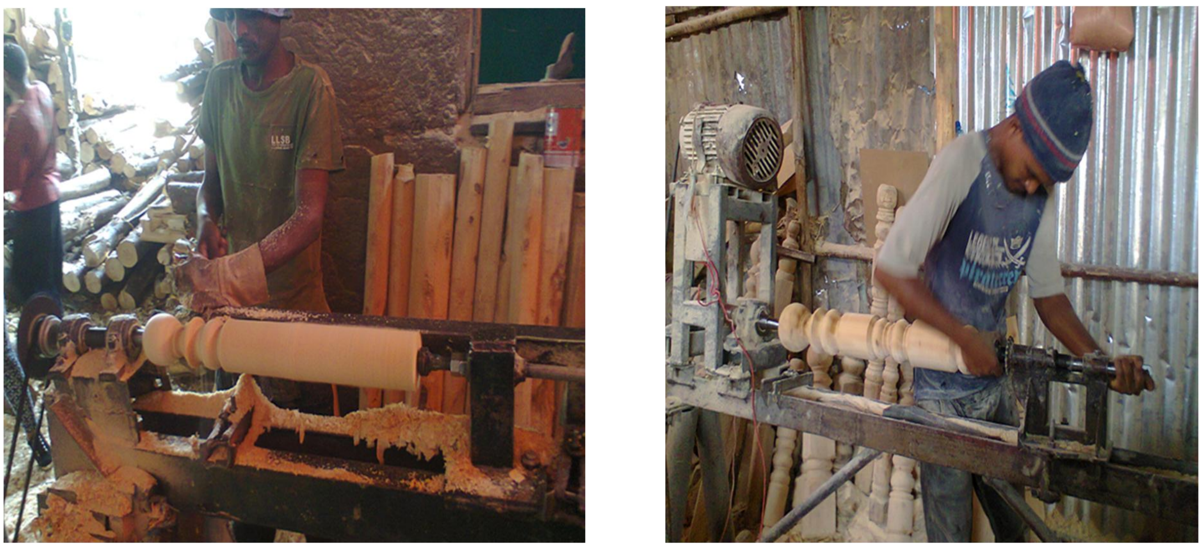


Figure 2.4 locally manufactured wood lathe machine

Figure 2.5 wood lathe bed

2.5 Specification of existing machines in market and improved electric wood lathe Machine

Table 2.1 Comparison of model the new existing wood lathe and improved wood lathe machine

Item No.	Models of the existing machine		Improved electric wood lathe machine
	Wood Lathe 1 Meter - Starter Kit	Wood Lathe Model W1758	
Spindle Speeds	4	Variable	2
Speed Range	850-2510rpm	600-2400rpm	450-2380
Distance Between Centers	1000mm	1168.4mm	1200mm
Turning Capacity Diameter	350mm	406.4mm	400mm
Motor	0.5 hp	2hp	2hp
Construction materials - Bed - Leg - Headstock - Tool rest - Tailstock	Cast iron	Cast iron	Locally Fabricated - Mild steel RHS - Mild steel plate - Mild steel Solid rod - GI pipe - Mild steel angle bar

Figure 2.6 Wood Lathe 1 Meter - Starter Kit

Figure 2.7 Wood Lathe Model W1758

2.6 Improved Electric wood lathe machine

With the bases of the above survey decide to improve imported and locally manufactured wood lathe machine. The idea of developing the machine is generated due to different problems identified with the imported and locally existing machine.

The improved parts are as mentioned as the following:-

- The high initial cost of machine to purchase create difficulties for small and micro enterprises to their business so we intended to minimize machine cost by:
  - Substituting the heavy casted machine parts like head stock, tail stock, bed, tool rest by fabricated locally available material
- Increase the height of machine to solve ergonomic problems
- Manufacture wood lathe with optimum center distance.
- As a result the intended to design the machine to improve some of the problems through improving and changing some specification of material and manufacturing method as follow:-

Improved design specification of wood lathe machine

- ✓ Total length of the machine ---------------------------------2020mm
- ✓ Total height of the machine ---------------------------------1200mm
- ✓ Maximum distance between centers -------------------------1200mm
- ✓ Width of machine bed--250mm
- ✓ Single phase motor--------------------------------------2HP, 1430rpm
- ✓ The space between the bed rails ----------------------------- 130mm
- ✓ Diameter of headstock pulley --------------------------75 and 125mm
- ✓ Headstock shaft diameter--------------------------------------- 25mm
- ✓ Diameter of motor pulley-------------------------------125 and 75mm
- ✓ V- Belt--- A-32
- ✓ Maximum diameter of work pieces------------------------------400mm

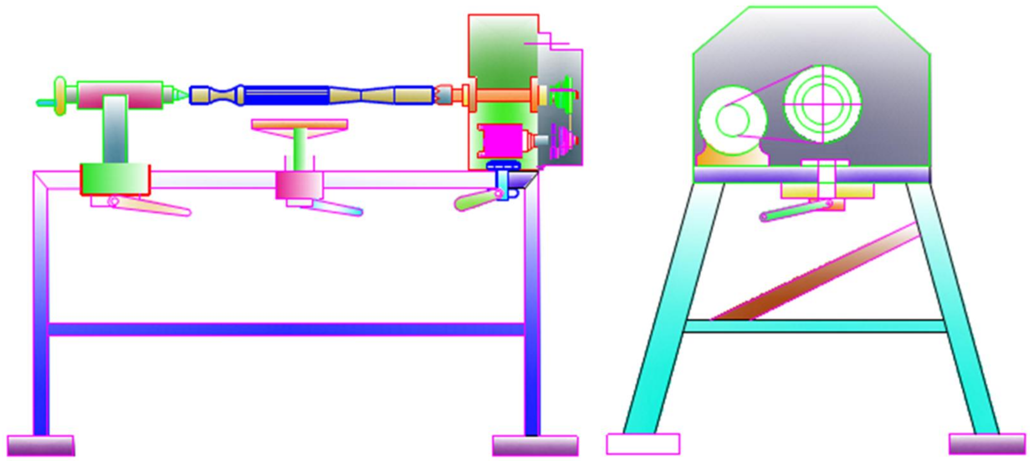


Figure 2.8 Front and side view of proposed wood lathe machine.

2.7 Technological advancement of wood lathe machine

As centuries passed, wood lathes evolved into machines that were wheel driven. The earliest pictures of a wheel driven lathe date is from the1400s. The following century saw a great technological change. Sketches made by Leonardo Da Vinci, circa 1480, showed early treadle wheel lathes. The sketches clearly showed an assembly of a crank, treadle and a flywheel. Wood turners and inventors continued developing the foot-powered lathe as they also perfected wood lathes run by water wheels and water turbines. By the late 1800s wood working lathes were run by steam engines followed later by engines powered by oil, and finally electricity. During the Industrial Revolution, mechanized power generated by water wheels or steam engines was transmitted to the lathe via line shafting, allowing faster and easier work. The design of lathes diverged between woodworking and metalworking to a greater extent than in previous centuries. Between the late 19th and mid-20th centuries, individual electric motors at each lathe replaced line shafting as the power source **[1].**

Beginning in the 1950s, servomechanisms were applied to the control of lathes and other machine tools via numerical control (NC), which often was coupled with computers to yield computerized numerical control (CNC). Today manually controlled and the CNC lathes co-exist in the manufacturing industries.

2.8 Technology transfer effort in Ethiopia

In Ethiopia, TVET institutions are mainly expected to replicate new and selected technologies and transfer the same to the relevant industry in order to increase the competitiveness of the sector according to international standards. It's also needed that these technologies focus on creative capacity building and greatly contribute to the economic development of the country.

TVET institutions having accumulated technology capabilities, and using this potential to promote technology transfer, contribute to the enhancement of productivity and the competitiveness of industries. Moreover, the institutions are expected to relevantly transfer the technologies to micro and small enterprise (MSE) sector in order to increase their productivity, improve the quality of products and services and facilitate creation of new business.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter present research methods used during the thesis work to solve the problems i.e. how to determine the problams,how to collect data and methodes of analyzing those data and conduct the inquire in an unbiased will be discussed. This methodology include sample selection,data collecting methode and analysis to achieve the thesis objective.

3.2 over view of research

The aim of this research is to solve a problem through practical investigation of problems related with wood lathe machine.

Considering previous back ground of the machines designing the research methods to identify problems and way to collect data. Among the existing problems, the first is high cost of machine to purchase. So the study is intended to minimize machine cost by substituting heavy casted machine bed and stands with fabricated materials and by increasing center distance, sizes parts and also by improving their mechanisms. in order to develop these ideas further using different screening methods such as preparing questionnaires to gather the views of customer and practical observations was used. Besides, market assessment was made to know the cost of the existing machine and its availability. Finally, results of the investigation gave clear picture of the existing practical problems related with, assisted in identifying the major shortcomings and limitations of the machine under consideration, it intended to propose the improvement.

3.3 Study Approach and the Research Instrument

The study approach used to collect information's about wood lathe product activity of the existing production system around Adama City and analyze quantitatively. Both primary and secondary data related to wood machine technology has been also usedThis method is believed to be useful because it allows collecting data from a wide range of respondents. Additionally, the need for proving the existence of the problem, methodological approach for collecting, analyzing and interpreting data are under consideration.

The Research instruments used for gathering data:-

- ✓ Questionnaire
- ✓ Structured interview and
- ✓ Direct observations

3.3.1. Questionnaire

A questionnaire was used in the study which includes a number of questions emphasizing individual details, type of wood lathe machine, for how long they used machine, availability of spare parts for maintenance, ergonomic factors to use the machine, etc. to investigate the problem the faced to use the machine at work place. After explaining the aim of the study in a simple term, each subject was approached and the questionnaire was performed individually and collected on the spot on the same day. Open and closed ended questionnaires were designed to collect relevant information.

3.3.2 Structured Interview

A set of interview questions were prepared for different small scale enterprises and private sectors in Adama. Structured interview is conducted with different wood lathe workers /wood traditional turning and shaping workers and wood product users.

3.3.3 Direct Observation

In direct observation data gathering technique, visit of sample wood work shops were made to take measurement of the height and width of the existing machine. Problems faced during maintenance on imported wood lathe machine made up of cast iron. Also visited some wood products made by traditional methods due to economic difficulties to have wood lathe machine

3.4 Questionnaire Design

The questionnaire is designed in a way that enables to get more and brief information from those who use the wood lathe machine based on the problems identified during various workshop visits. Basically, the questions were closed and opened type questions. Furthermore, in view of obtaining as much information as possible, participants were encouraged to give additional information or comments on the open spaces provided under the question.

3.5 Sample Selection

In the present investigation or research sample selection, types of population are different groups of small scale enterprises, governmental and private sectors. From the population of 40wood workers totally 20 in number randomly had been selected. From this workshop 8 of them are micro and small enterprises 2 governmental and the rest are private sectors. To avoid selection bias, all the small scale enterprises and private sectors which don't have the machine and right users of wood lathe machine models were selected randomly from different Kebeles of Adama town. In our random selection, we did not find any enterprises and private sectors that had less than half a year experience. Random Sampling techniques selected due to save time & effort required, to save costs in terms of money & man power. The sampling is selected by using systematic random sampling method. The sample ratio can give sufficient information because it is taken 50% out of total population.

3.6 Data analysis and interpretation

Thus in order to develop these ideas further used different screening methods such as preparing questionnaires to gather the views of customer and through observations. Besides, we assessed the market to know the cost of the existing machine and its availability.

According to data gathered the customer provided the following feedback for the existing machine;

We take around 20 users of wood lathe machines from approximately 40 of available wood work shop.

- The machine does not equip with safety covers
- The existing wood lathe does not allow accommodating wood longer than 1000mm in length.
- The components like bearing and bolt frequently liable to failure.
- The headstock part is not swivel
- The imported lathe machine cost is made in china from 60,000 up to 65,000 and made in Germany 80,000 up to 90,000.

- According to maintenance problem most of the parts of the machine need to repair, due to less quality of materials and stability it needs more maintenance cost. Maintenance cost of the machine is more than the Quality cost
- The availability of the machine is less in the market.

As a result, we intended to design the machine to improve some of the problems through improving and altering some features or components, specifications of materials, mechanisms and manufacturing methods so as to make it more feasible.

3.7 Problems in Data Collection

- ✓ It is time taking to fill a questionnaire because of the participants or small scale enterprises are found in separate places which results a number of appointment dates to give a correct information,
- ✓ Indirect or direct refusal of respondents by providing partial or no information to the survey questions (unwillingness).
- ✓ Some enterprises try to hide their real information and they don't want to demonstrate the machines.

3.8 Method of Analysis

The descriptive statistics is a method of analysis which provides a general overview of results. Frequency distribution, which shows the frequency of observation of each response to each variable under investigation, is used to analyze the result of some questions. Rating scale is one of the most common formats for questioning respondents on their views or opinions of an event or attribute.

In this regard, participants were asked to indicate the importance or level of influence of factors (research variables) by rating them on a four point scale, (O= Not important 1 = fairly important 2 = important and 3 = very important). This statistical technique is intended to establish the importance of the factors. Each of the factors has been assigned an important index, to help rank them according to their importance, as follows.

$$\boxed{Importance\ index\ =\ (\sum i = 0\ wi\ x\ fxi)\ x\ 100/3n}$$

Where wi =weight given to i^t response; I = 1, 2, 3,

fxi = Response frequency

n = total no of responses (--- responses)

For example the importance index of the first factor is "the overall cost of the new machine" is calculated as shown in Table 1.1.

Table 3.1 the importance index of the machine

Level of importance	$Weight\ (Wi)$	$Response\ frequency\ (fx$	$(wi\ x\ fxi)$
very important	3	8	24
Important	2	4	8
fairly important	1	3	3
Not important	0	0	0
Sum		15	35
Note:- Importance Index = 35x100/(15x3) = **77.78%**			

The ranking format was used for analyzing question in which respondents were asked to place a set of attitudes in ranking order, indicating their importance priories or preferences.

3.9 Demand Assessment

We take the sample of 20 enterprises of Small and Medium Scale Enterprises found in Adama town and those are cooperate in wood working enterprises. For each enterprise we distributed questionnaires for them, and the total numbers of questionnaires are totally 20.

The numbers of questionnaires respond from the wood lathe machine:-

- those are complain for cost of the machine = 18
- those are responses to the shortage spare parts = 12
- those are wants to improve the head stock mechanism = 20
- those are desires to assemble safety cover and guide fence = 20
- those are refuses to response our questionnaires= 1

Table 3.2 The respondent response in percentage

S.No	Types of response from respondent	Percentage(number)	Remark
1.	The overall cost of the machine	90%(18)	
2.	Availability of spare parts	60%(12)	
3.	Failure of chain mechanism	100%(20)	
4.	Desire of safety cover and guide fence	100%(20)	
5.	Refuses to response	5%(1)	

Finally we understood that those small scale enterprises provide attentions or desire to modify the existing wood lathe machines and also explain their interest to purchase or to produce other new products.

3.10 How the product developments are accomplished?

Locally manufactured wood lathe machine existing in some governmental and private limited shops. The cost of this locally manufactured wood lathe is comparatively less as compared to the imported wood lathe machines. However, there are a number of practical problems while using these machines. So we proposed to provide comfortable and fair prices by means of redesign and improving or adding some features of that machine. Then the following important parts are redesigned to satisfy the customers and produce parts based on our status or the purchasing power of the enterprises.

- ✓ Redesigning most of the mechanisms, systems and height of head stock: - the head stock components are easy to assemble or disassemble quickly and manufacture different shapes, designs different parts. So we intended to redesign most parts.
- ✓ By adding some features to improve the capacity and performance of the machine:- We intended to add such important components like faceplate extension tool rust, safety guards or covers,
- ✓ By substituting materials of some machine parts: Especially the head stock, tail stock, bead of the machine, and the base or stand of the machine replaced by mild steel materials.

CHAPTER FOUR

DESIGN AND MATERIAL SELECTION

4.1 Introductions to design

To design is either to formulate a plan for the satisfaction of a specified need or to solve a specific problem. If the plan results in the creation of something having a physical reality, then the product must be functional, safe, reliable, competitive, usable, manufacturable, and marketable. Design is an innovative and highly iterative process. It is also a decision-making process. Decisions sometimes have to be made with too little information, occasion-ally with just the right amount of information, or with an excess of partially contradictory in formation. Decisions are sometimes made tentatively, with the right reserved to adjust as more becomes known. The point is that the engineering designer has to be personally comfortable with a decision-making, problem-solving role.

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

A designer's personal resources of creativeness, communicative ability, and problem-solving skill are intertwined with the knowledge of technology and first principles.

Engineering tools (such as mathematics, statistics, computers, graphics, and languages)are combined to produce a plan that, when carried out, produces a product that is functional, safe, reliable, competitive, usable, manufacturable and marketable, regardless of who builds it or who uses it**[6].**

4.2 General considerations in design

There are many factors to be considered while attacking a design problem. In many cases these are a common sense approach to solving a problem. Some of these factors are as follows:

(a) What device or mechanism to be used? This would decide the relative arrangement of the constituent elements.

(b) Material

(c) Forces on the elements

(d) Size, shape and space requirements. The final weight of the product is also a major concern.

(e) The method of manufacturing the components and their assembly.

(f) How will it operate?

(g) Reliability and safety aspects

(h) Inspect ability

(i) Maintenance, cost and aesthetics of the designed product

The designer must be careful to consider every important factor which should rightfully influence his design. In general, the most important things to be considered can be listed as follows:

A. proper functioning

B. cost

C. lubrication

D. ease of manufacture and assembly

E. strength and rigidity of parts

F. wear of parts

G. ease of service and replacing parts

H. proportion of parts

4.3 Material selections

The selection of a material for machine part or structural member is one of the most important decisions the engineering designer has to make. Poor material choice can lead to failure of a part or system or to unnecessary cost. The process of materials selection is difficult one and typically involves multiple conflicting material characteristics as well as large number of constraints.

A good material selection process considers the limiting factors for a particular design exercise which include material properties, material processing, material cost, and material availability. Through systematic and optimizing approach, one can list all the limiting factors associated with the design e.g. strength, hardness, cost and availability.

Weighting measure can be used to prioritize on what materials are more important than others after which all available materials are listed and ranked.

For ranking purposes, indices like cost and availability of the various materials are computed. After this task a list of the materials meeting the limiting requirements is produced, in which the materials are ranked from the one with the highest composite index to the one with the least. In this case, the material with the highest composite index based on cost and availability is taken as the best for the application. Materials for other engineering applications can be selected in the same way. With the advent of the internet, utilization of an online material selection process is a major advancement in the selection of a material for a particular product. The process gives accurate information at fast speeds thus saving time and money during design. The computer can play a major role in storing information (database) on materials properties. In addition a computer code is created using PHP (recursive acronym for hypertext preprocessor) in which the information in the database can be accessed and retrieved. Thus entering the machine part specifications in the program, the computer searches for the qualified materials in the database and displays them to the user **[7].**

4.3.1 Key considerations in material selection

Selecting materials usually begins in the preliminary design stage. The problem of material selection usually involves the selection of materials for a new product or new design, and re-evaluation of an existing product or design to reduce cost, increase Reliability and improve performance.

In selecting the appropriate material one must consider:

1. Material properties, which affects the part performance.
2. Material processing which affects manufacturing costs and therefore the final Part cost.
3. Material cost.
4. Availability. Is the material available in desired quantity and time frame?
5. Regulatory properties; Code acceptance and reparability

The relative importance of the above factors depends on the applications. For example

In military and aerospace applications, pushing the materials properties to the limits takes precedence over cost. For consumer products, lowering cost typically plays the leading role. For an engineering project on a tight schedule, material availability is Important**[7].**

In general, the most important things to be considered can be listed as follows:

A. proper functioning

B. cost

C. lubrication

D. ease of manufacture and assembly

E. strength and rigidity of parts

F. wear of parts

G. ease of service and replacing parts

H. proportion of parts

4.2.2 Materials selection process

Usually, a problem of material selection involves either selection of materials for new Product or design; or re-evaluation of an existing design/product to increase reliability, Reduce cost and improve performance. Materials selection process, being a problem Solving process, is achieved through the following steps

1. Determination of required critical properties from the design operating conditions and environment.

Table 4.1: Adapted from Engineering Design by MadaraOgot.,Gul Kremer

Mode of failure	**US**	**YS**	**CS**	**SS**	**FP**	**E**	**CR**	**HD**	**CE**
Fatigue(high cycle)	•				•				
Fatigue(low cycle)		•			•	•			
yielding				•					
buckling			•			•			
wear								•	
Thermal fatigue							•		•
creep							•		
Gross deformation						•			

KEY

US-Ultimate strength
YS-Yield strength
CS-Compressive yield strength
SS-Shear yield strength
FP-Fatigue properties
E- Modulus of elasticity
CR-Creep rate
HD-Hardness
CE-Coefficient of expansion

2. Screening of large material database for candidate materials that meet the critical material properties is determined in steps

3. Selecting the final material based on a trade-off of discriminating parameters.

4.2.3 Factors influencing materials selection

There are several important factors that need to be considered during material selection. These are commercial properties (Cost and Availability), material Properties (mechanical, physical, and environmental resistance), material processing, And regulatory properties.

Mechanical properties

-Strength, Rigidity, Resistance to fatigue, Ductility, Resilience, Toughness Hardness, damping capacity, Friction, Formability [**7**].

4.3 Design aspects of wood lathe

Wood machining is a cutting technique converting wooden parts in size and shapes. To optimize the wood machining, not only the cutting parameters defining the workability of the material are considered, but also and, necessarily, the technical parameters concerning data acquisition and processing. One of the wood machining modes that consume the most power is turning and particularly the roughing (rough turning). Rough woodturning is an operation consisting to produce functional surfaces which need subsequent finish machining (finishing). Therefore, the smoothness will not be required, but the shaping of the part involves a consequent material removal which requires a significant processing time and as a result further energy consumption. The energy consumption during machining is an important factor for production costs and environmental aspect. Unsuitable cutting parameters are not only sources of energy spending, but cause excessive material consumption as well as premature wear of functional components of the machine. Otherwise, optimal cutting parameters can ensure low energy consumption, secure longer machine and tool life and provide good machinability. Since cutting performance and efficiency are essential requirements in the wood industry, the optimization of cutting parameters is necessary and appropriate for cost-effective and accurate machining**.[9].**

4.4 Material selection and design of pulley and belt

The belts or ropes are used to transmit power from one shaft to another by means of pulleys which rotate at the same speed or at different speeds. The amount of power transmitted depends upon the following factors:

1. The velocity of the belt.
2. The tension under which the belt is placed on the pulleys.
3. The arc of contact between the belt and the smaller pulley.
4. The conditions under which the belt is used.

It may be noted that

(a) The shafts should be properly in line to insure uniform tension across the belt section.

(b) The pulleys should not be too close together, in order that the arc of contact on the smaller pulley may be large as possible.

c) The pulleys should not be so far apart as to cause the belt to weigh heavily on the shafts, thus increasing the friction load on the bearings.

(d) A long belt tends to swing from side to side, causing the belt to run out of the pulleys, which in turn develops crooked spots in the belt.

(e) The tight side of the belt should be at the bottom, so that whatever sags is present on the loose side will increase the arc of contact at the pulleys.

(f) In order to obtain good results with flat belts, the maximum distance between the shafts should not exceed 10 meters and the minimum should not be less than 3.5 times the diameter of the larger pulley.

4.4.1 Selection of a Belt Drive

Following are the various important factors upon which the selection of a belt drive depends:

1. Speed of the driving and driven shafts,
2. Speed reduction ratio,
3. Power to be transmitted,
4. Centre distance between the shafts,
5. Positive drive requirements, 6. Shafts layout,
7. Space available, and 8.Service conditions.

4.4.2 Material used for Belts

The material used for belts and ropes must be strong, flexible, and durable. It must have a high Coefficient of friction. The belts, according to the material used, are classified as follows:

1. Leather belts
2. Cotton or fabric belts.
3. Rubber belt.
4. Balata belts.

4.4.3. Material selection 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 /high density material/.
- ✓ It possesses moderate specific heat capacity.
- ✓ Coefficient of linear expansion of the material should lie at range of minimal value

Total number of decision/N/

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

where n=5

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

$$N = 10$$

Table 4.2 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			0.2
Yield strength		0			0				0	1	0.1
Density	1	1	1				0				0.3
Specific heat capacity			0		1	0		0			0.1
Coefficient of linear expansion				1			1		1	0	0.3

Table 4.3 Properties of candidate materials for pulley

Materials	Tensile strength $/Mpa$	Yield strength $/Mpa$	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
AITM20	152	152	7.20	0.34	11.00
ASTM25	197	197	7.35	0.46	10.00

Table 4.4 Normalized outcomes for pulley

Materials	Normalized Tensile strength /Mpa	Normalized Yield strength /Mpa	Normalized Density	Normalized Specific heat capacity	Normalized Coefficient of linear expansion
AISI1010	67	65	100	72	82
AISI1035	100	100	100	71	87
AITM20	27	33	92	100	91
ASTM25	32	39	95	74	100

Table 4.5 Value outcomes and overall satisfaction of parts for pulley

Materials	**Normalized Tensile strength /Mpa x0.2**	**Normalized Yield strength /Mpax0.1**	**Normalized Density /x0.3**	**Normalized Specific heat capacity x x 0.2**	**Normalized Coefficient of linear expansion x0.3**
AISI1010	13.4	6.5	30	7.2	24.6
AISI1035	20	10	30	7.1	26.1
AITM20	5.4	3.3	27.6	10	27.3
ASTM25	6.4	3.9	28.5	7.4	30

Table 4.6 Overall Satisfaction of parts and ranking

Materials	**Overall satisfaction**	**Ranking**
AISI1010	81.7	2
AISI1035	93.2	1
AITM20	73.6	4

4.5 Design of pulley

In ac motor of power 2HP speed 750rpm

Take the minimum pulley diameter N1=75mm take from table 20.1 and the machine operating time =8hr/day

Design Horsepower = Rated Horsepower × Service Factor ------------------------ (4.2)

= 2Hp × 1.1= **2.2hp**

Horsepower (Hp) converted into kilowatts = ($Hp\ x\ 0.746$) kW

Horsepower rating = 2Hp = **1.492 kW**

Actual design power rating = Rated Horsepower × Service Factor × 0.746 = 2× 1.1 × 0.746

=1.64 kW

P =**1641w**

The minimum pulley diameters recommended for standard V-belt are shown in table

Table 4.7 Dimensions of standard V-belts according to IS: 2494 – 1974**[10].**

Type of belt	Power ranges	Minimum pitch	Top width (b)	Thickness (t)	Weight per
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**	**------**

Note : The smaller the pulley diameter, the less the belt life Do not use the pulleys which are below the minimum recommended.

1. Calculate the design horsepower

$$\boldsymbol{Pd = (Pt)(Fs) - - - - - - - - - - - - - - - (4.3)}$$

v belt cross-section type=service factor of in 8hr working take from **table 4.7**

Service $\boldsymbol{Factors\ (Fs)}$

The selection of a V- belt drive for any application should be based on the nature of the load and the type of driving unit. Service factors for different kinds of driven machines combined with different types of driving unite are shown in **table 4.7**

Table 4.8 Suggested Service Factors for V-belt Drives

	Types of Driving Units				
	AC Motors : Normal Torque, Squirrel Cage,Synchronous and Split Phase.DC Motors : Shunt Wound, Multiple Cylinder Internal Combustion Engines.			AC Motors : High Torque, High Slip, RepulsionInduction, Single Phase Series Wound and SlipRing.DC Motors : Series Wound and Compound Wound, Single Cylinder Internal Combustion Engines, Line Shafts, Clutches.	
	Intermittent Service(3-5 Hours Daily of Seasonal)	Normal Service(8-10 Hours Daily)	Continuous Service(16-24 Hours Daily)	Intermittent Service(3-5Hours Daily of Seasonal)	Normal Service(8-10 Hours Daily)
Agitators for LiquidsBlowers and ExhaustersCentrifugal Pumps and CompressorsFans up to 10 HPLight Duty Conveyors	1.0	1.1	1.2	1.1	1.2
Belt Conveyors for Sand, Grain, etc. Dough MixersFans Over 10 HPGeneratorsLine ShaftsLaundry MachineryMachine ToolsPunches-PresseShearsPrinting MachineryPositive Displacement Rotary PumpsRevolving and Vibrating Screens	1.1	1.2	1.3	1.2	1.3
Brick MachineryBucket ElevatorsExcitersPiston CompressorsConveyors(Drag-Pan-Screw)Hammer MillsPaper Mill BeatersPiston Pumps Positive Displacement BlowersPulverizers Saw Mill and Woodworking MachineryTextile Machinery	1.2	1.3	1.4	1.4	1.5
Crushers(Gyratory-Jaw-Roll)Mills(Ball-Rod-Tube)HoistsRubber Calenders-Extruders-Mills	1.3	1.4	1.5	1.5	1.6

$$Fs = 1.1$$

$$\boldsymbol{Pd = (Pt)(Fs) -----------------(4.4)}$$

Design horsepower it will be

Design horsepower= (2hp) (1.1)

Design horsepower=2.2hp

2. V belt cross-section type selection

After calculating the design horse power cross Section Selection frome the chart Use the chart **(Figure 4.1)** as guide to the V- belt cross section to use for any combination of design horsepower and speed of faster shaft. When the intersection of the design horse power and speed of faster shaft falls near a line between two areas on the chart, it is always desirable to investigate the possibilities in both areas.

From the designed **horse power =2.2kw**and**N= 750 rpm** of faster shaft selection of v belt cross-section **type A** will be selected

Thane Select the minimum pulley diameter from the standard **table 4.7**and the minimum diameter =75mm

3. Velocity Ratio of Belt Drive Rs

It is the ratio between the velocities of the driver and the follower or driven. It may be expressed, mathematically, as discussed below

$$Where: d1 = Diameter\ of\ the\ driver,$$

$$d2 = Diameter\ of\ the\ follower,$$

N1=speed of driver in r.p.m.

N2=speed of the follower in r.p.m.

$$\boldsymbol{Rs} = \frac{\boldsymbol{N1}}{\boldsymbol{N2}} ------------------- (4.6)$$

Length of the belt that passes over the driver, in one minute

$$= \boldsymbol{\pi\, d1\, N1} ----------------- (4.7)$$

Similarly, length of the belt that passes over the follower, in one minute

$$= \boldsymbol{\pi\, d2N2} ----------------- (4.8)$$

$$Rs = \frac{N1}{N2} = \frac{750rpm}{450rpm}$$

Rs= 1.66

4. Calculate the pitch diameter of large pulley(Dp)

$$Dp = diameter\ of\ smaller\ pulley$$

$$\boldsymbol{Dp = Rs\ x\ ds\ Rs} ----------------- \mathbf{(4.9)}$$

Dp = (1.66hp) (75mm)

Dp = 124.5mm

$$Dp \cong 125mm$$

5.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 [**10**].

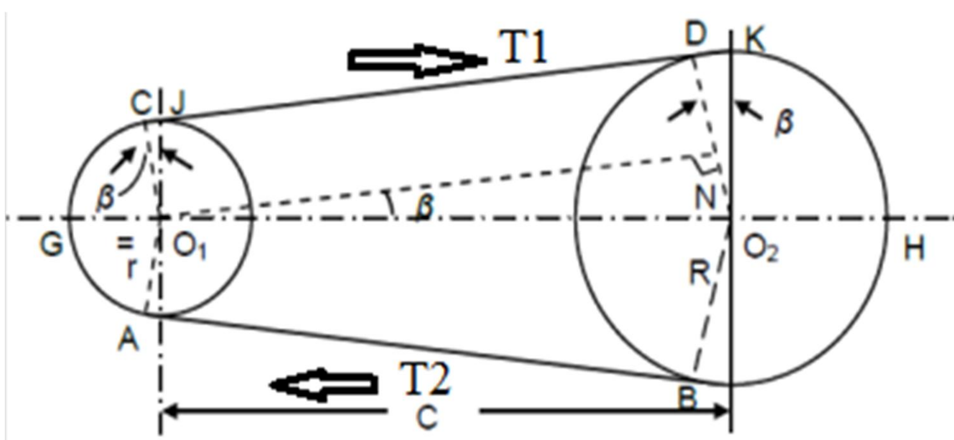


Figure 4.1 the center distance of shaft

- ✓ Before calculated the length Determine the center distance of the shaft by

$$\boldsymbol{Dp} < c < (Dp + ds) ------------------- (4.9)$$

$$\mathbf{125mm} < C < 3(125 + 75)$$

$$\mathbf{125mm} < C < 600\mathbf{mm}$$

Therefore the center distances of the pulley in between 125mm and 600mm and then takes from the available space of the design=**250mm**

- ✓ **Calculate the Pitch Lengths of V-belts**

According to IS:2494-1974, the pitch length is defined as the circumferential length of the belt at the pitch width (i.e. the width at the neutral axis) of the belt. The value of the pitch width remains constant for each type of belt irrespective of the groove angle. The pitch lengths are obtained by adding to inside length:

36 mm for type A,
43 mm for type B,
56 mm for type C,
79 mm for type D and
92mmfor type E.

The following table shows the standard pitch lengths for the various types of belt.

Table 4.9 Standard pitch lengths of V-belts according to IS: 2494-1974**[10].**

type of belt	Standard pitch lengths of V-belts in mm
A	645, 696, 747, 823, 848, 925, 950, 1001, 1026, 1051, 1102,1128, 1204, 1255, 1331, 1433, 1458, 1509, 1560, 1636, 1661,1687, 1763, 1814, 1941, 2017, 2068, 2093, 2195, 2322, 2474,2703, 2880, 3084, 3287, 3693.
B	932, 1008, 1059, 1110, 1212, 1262, 1339, 1415, 1440, 1466, 1567, 1694, 1770, 1821, 1948, 2024, 2101, 2202, 2329, 2507, 2583, 2710, 2888, 3091, 3294, 3701, 4056, 4158, 4437, 4615,4996, 5377.
C	1275, 1351, 1453, 1580, 1681, 1783, 1834, 1961, 2088, 2113, 2215, 2342, 2494, 2723, 2901, 3104, 3205, 3307, 3459, 3713, 4069, 4171, 4450, 4628, 5009, 5390, 6101, 6863,7625, 8387, 9149.
D	3127, 3330, 3736, 4092, 4194, 4473, 4651, 5032, 5413, 6124, 6886, 7648, 8410, 9172, 9934, 10 696, 12 220, 13 744, 15 268, 16 792.
E	5426, 6137, 6899, 7661, 8423, 9185, 9947, 10 709, 12 233, 13 757, 15 283, 16 805.

✓ **Pitch Lengths of V-belts**

$$\boldsymbol{Lp = 2C + 1.57(Dp \ + dP) + \frac{(Dp - dp)^2}{4C}} ----------(\mathbf{4.10})$$

$\boldsymbol{Where}$; C = center distance

Dp = diameter of largest pulley

dp = diameter of smaller pulley

$$Lp = 2(250\text{mm}) + 1.57\ (125\text{mm} + 75\ \text{mm}) + \frac{(125-75)^2}{4(250mm)}$$

Lp = 500mm +314mm + 2.5mm

Lp = 816.5mm

According to IS: 2494-1974The pitch lengths are obtained by adding to inside length: **36 mm for type A,**

$$L = 816.5mm - 36 = 780.5mm$$

According to IS: 2494 – 1974, the nearest standard inside length of V-belt is 787 mm

Lp = 787mm +36

Lp =823mm

Select the nearest standard length from table 4.7

From the above table 4.7 in A cross-section the nearest length =823mm A32

6.Calculate the exact center distance of the pulley after the belt length has been determined

$$\mathbf{b = Lp - 1.57(Dp + dp)} -------------- (\mathbf{4.11})$$

b= 823mm -1.57(125mm + 75mm)

b=509mm

✓ **calculate the new center distance**

$$\boldsymbol{C = \frac{b + \sqrt{b^2 - 2(\mathbf{Dp - dp})}}{4}} ---------------(\mathbf{4.12})$$

$$C = \frac{509\text{mm} + \sqrt{509\text{mm})^2 - 2(125\text{mm} - 75\text{mm})2}}{4}$$

$$C = \frac{509\text{mm}mm + \sqrt{244001}}{4}$$

$$C = 253.29\text{mm}$$

The center distance it is in between **125mm < C < 600 mm**

7. Angle of contact of the belt on each pulley

The angle of smaller pulley or driving pulley

$$\theta_1 = 180 - 2\sin^{-1}[\frac{D-d}{2C}] \text{-- (4.13)}$$

$\theta_1 = 180 - 2\sin^{-1}(\frac{125-75}{2(253.26)})$

$\theta_1 = 180 - 2\sin^{-1}(0.0987)$

$\theta_1 = 168.67^0$

$\theta_1 = 2.94\text{rad}$

The angle of larger pulley (driven)

$$\theta_2 = 180 + 2\mathrm{Sin}^{-1}[\frac{D-d}{2C} \text{ - - - - - - - - - - - - - - - - - (4.14)}$$

$= 180 + 2\mathrm{Sin}^{-1}\frac{125-75}{2(253.26)})$

$= 180 + 2\mathrm{Sin}^{-1}\ (0.0987)$

$= \underline{191.33^0}$

$\theta_2 = \underline{3.34\text{ rad}}$

$$\sin\alpha = \frac{O_2M}{O_1O_2} = \frac{r_2 - r_1}{X} = \frac{d_2 - d_1}{2X} \text{--------------------------------------- (4.15)}$$

=125-75/2(407.74)

$\sin\alpha$ =3.49deg

Table 4.10 effective coefficient of friction

Angle of groove,2β degree	Effective coefficient of friction,μ_e
26	0.578
30	0.502
32	0.471
34	0.445
36	0.421
38	0.339
40	0.380

Table 4.11: Properties of v-belts for industrial purposes

Cross Section of belt symbol	Area of cross section mm^2	Maximum working load1,N	Power range KW	Minimum groove pulley diameter, mm	Weight perimeter N	Density of belt material kg/m^3	Maximum pulley grooves
A	80.7	200	Upto3.42	75	0.882	1115	6
B	143	300	0.5-6.61	137	1.628	1160.8	9
C	236.7	750	0.8-13	229	2.962	1275.8	14
D	476.6	1400	1.65-32.2	330	5.923	1267.3	14
E	681.4	1800	3.48-51.8	533	8.885	1329.6	20

With the same center distance and length of belt for our stepped pulley

$$N1 = 750rpm N2 = ?$$
$$D1 = 125mm$$
$$D2 = 75mm$$
$$\frac{\mathbf{N1}}{\mathbf{N2}} = \frac{\mathbf{D2}}{\mathbf{D1}} ---------------------- \mathbf{(4.16)}$$
$$750rpm * 125mm/75mm$$
$$N2 = 1250rpm$$

And the velocity of the belt

$$\boldsymbol{V} = \frac{\boldsymbol{\pi d1N1}}{\mathbf{60}} -------------------- \mathbf{(4.17)}$$
$$V = \frac{\pi(0.125 * 450)}{60}$$

V=2.94m/s
V=176.62m/min
Therefore, in both case velocity of belt is the same which is 176.62m/min

8. Tensions in the belt

We have two loads on the shaft due to the belt tensions T_1 and T_2. Note that the power that can be transmitted to the belt is a function of the tension on the low side of the belt, the coefficient of friction and the wrap angle.

We know that the mass of the belt per meter length,

$$\boldsymbol{m = Area \times length \times density} ------------ \mathbf{(4.18)}$$

$\boldsymbol{Where}$; Density=1115kg/m^3 for belt

Length =823mm

Area=80.7mm^2

Service factor =1.1 from table 4

m=1115kg/m^3 x 0. 823m x80.7$x10^{-6}$m^2

m=0.074kg/m or,

m = 74.05gm/m

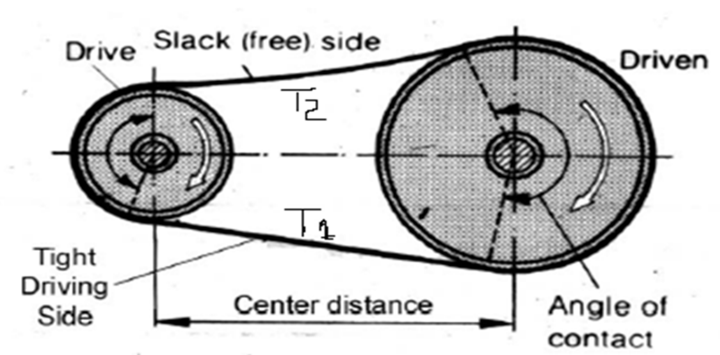


Figure 4.2 Belt tension

From the above table 4.9 mass of the belt per meter length=0.074kg

- ✓ **And the velocity of the belt**

Case – 1

$$V1 = \frac{\pi d1N1}{60}$$

$$= \frac{3.14X0.075X750}{60}$$

$$= \mathbf{2.94}\ \boldsymbol{m/s}$$

Case – 2

$$V2 = \frac{\pi d1N1}{60}$$

$$\frac{3.14X0.125X450}{60}$$

$$= \mathbf{2.94}\boldsymbol{m/s}$$

The velocity of the driven pulley is the same

Take V=2.94m/s,

- ✓ **Working Stresses in Belts**

The ultimate strength of leather belt varies from 21 to 35 MPa and a factor of safety may be taken as 8 to 10. However, the wear life of a belt is more important than actual strength. It has been shown by experience that under average conditions an allowable stress of 2.8 MPa or less will give a reasonable belt life. An allowable stress of 1.75 MPa may be expected to give a belt life of about 15 years

∴ $\boldsymbol{Tc}$**= Centrifugal tension**

$$\boldsymbol{Tc = mv^2} ------------------- (\mathbf{4.16})$$

$$Tc = (\frac{0.074kg}{m})(2.94m/s)^2$$

$$\boldsymbol{Tc = 0.64N}$$

- ✓ maximum tension in the belt,

$$\mathbf{T = \sigma \times a} --------------------(\mathbf{4.16})$$

For A type v-belt area=80.7 mm^2

Allowable tensile stress σ= 1.75 MPs

$$T = (1.75\ MPa)\ (80.7\ mm2)$$

$$\boldsymbol{T = 141.23N}$$

- ✓ Tension in the tight side of the belt,

$$\boldsymbol{T1 = T - TC} ------------------ (\mathbf{4.17})$$

$$T1 = 141.23 - 0.64N$$

$$T1 = 140.59N$$

$\boldsymbol{Where}$; T1= Tension in the tight side of the belt, and

T2= Tension in the slack side of the belt.

- ✓ The angle β varies from 32^0 to 38^0 for A and B types of belts.
- ✓ The angle β varies from 34^0 to 38^0 for C and D types of belts.

Assume the groove angle of the pulley, **2β = 34°or β = 17°.**We know that, μ_e = **0.445 from table4.11**

Table 4.12 coefficient of friction between belt and pulley

Belt material	Pulley material						
	Cast iron, steel			Wood	Compressed paper	Lather face	Rubber face
	dray	wet	greasy				
1. Leather oak tanned	0.25	0.2	0.15	0.3	0.33	0.38	0.40
2. Leather chrome tanned	0.35	0.32	0.22	0.4	0.45	0.48	0.50
3. Convass-stitche	0.20	0.15	0.12	0.23	0.25	0.27	0.30
4. Cotton woven	0.22	0.15	0.12	0.25	0.28	0.27	0.30
5. Rubber	0.30	0.18	----	0.32	0.35	0.40	0.42
6. Balata	0.32	0.20	----	0.35	0.38	0.40	0.42

Table 4.13 Effective coefficient of friction for various pulley groove angles

Angle of groove,2β degree	Effective coefficient of friction,μ_e
2	0.578
3	0.502
3	0.471
3	**0.445**
3	0.421
3	0.339
4	0.380

$\mu e \ = \ 0.445,$

$2\beta \ = \ 340 \ ,$

β =$17^0 \theta \ = \ 168.5$ = 2.94rad

$$\mathbf{2.3\log\left(\frac{T1}{T2}\right) = \mu\theta cosec\beta -------------(4.18)}$$

$$2.3\log(\frac{T1}{T2}) = (0.445)(2.94)(cosec17)$$

$$cosec\ 170 = 1/sin\ 17^0 = 3.42$$

$$2.3 \log(\frac{T1}{T2}) = 4.47$$

$$log(\frac{T1}{T2}) = 4.47/2.3$$

$$log(\frac{T1}{T2}) = 1.94$$

$$(\frac{\boldsymbol{T1}}{\boldsymbol{T2}}) = 87.1$$

$$T2 = \frac{\boldsymbol{T1}}{\boldsymbol{87.1}}$$

T_2=140.59/87.1

T_2=1.62N

Therefore, the tension in the belt

The tension in the belt in tensioned sideT_1=140.59N

The tension in the belt in the slack sideT_2=1.62N

Centrifugal tension TC=0.64N

The tension in the belt T=141.23N

✓ **Calculate the power transmitted per belt**

$$\boldsymbol{P = (T1 - T2)V ---------------(4.19)}$$

$$P = (140.59N - 1.62N)\ 2.94$$

$$P = 408.57W$$

Since the over load factor is 1.1, therefore the belt is to be designed for **2.2hp**

$$\boldsymbol{Total\ power\ transmitted = 2.2X1.1 = 2.2hp ----------(4.20)}$$

Horsepower (Hp) converted into kilowatts $= (Hp\ x\ 0.746)kW$

$$Hp = 2.2\ x\ 0.746Hp = 1.64kw$$

In the case of belt drive the twisting moment (T) is given by

$$\boldsymbol{T = (T1 - T2)R ----------------(4.21)}$$

$\boldsymbol{Where}$;T1= Tension in the tight side of the belt, and

T2= Tension in the slack side of the belt.

R= rides of pulleys/2

4.6 Material selection and design of shaft

A shaft is a rotating machine element which is used to transmit power from one place to another. The power is delivered to the shaft by some tangential force and the resultant torque (or twisting moment) set up within the shaft permits the power to be transferred to various machines linked up to the shaft. In order to transfer the power from one shaft to another, the various members such as pulleys, gears etc., are mounted on it. These members along with the forces exerted upon them causes the shaft to bending. In other words, we may say that a shaft is used for the transmission of torque and bending moment. The various members are mounted on the shaft by means of keys or splines.

Notes: 1. the shafts are usually cylindrical, but may be square or cross-shaped in section. They are solid in cross-section but sometimes hollow shafts are also used.

2. An axle, though similar in shape to the shaft, is a stationary machine element and is used for the transmission of bending moment only. It simply acts as a support for some rotating body such as hoisting drum, a car wheel or a rope sheave.

3. A spindle is a short shaft that imparts motion either to a cutting tool (e.g. drill press spindles) or to a work piece (e.g. lathe spindles).

4.6.1 Material Used for Shafts

The material used for shafts should have the following properties:

1. It should have high strength.
2. It should have good machinability.
3. It should have low notch sensitivity factor.
4. It should have good heat treatment properties.
5. It should have high wear resistant properties.

Material requirement for shaft

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

- Yield strength and tensile strength.
- Wear resistance
- Machinablity

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

Weight factor (Wf) = positive decision x Total No. decision

Table 4.14 application of digital logic with different decision

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
machinability			0			1		1		0	0.2

Table 4.15.Candidate material requirements for shaft

No	**Materials**	yield strength	tensile strength	wear resistance	machinability
1	40C8	667	324	4	4
2	45C8	618	353	3	3
3	50C8	647	392	2	2
4	50C12	706	372	1	1

Table 4.16 Normalized value of shaft

No.	Material	yield strength	tensile strength	wear resistance	machinability
1	40C8	80.5	49	100	100
2	45C8	87.5	50	50	75
3	50C8	91.6	100	25	50
4	50C12	100	52.8	75	25

Table 4.17 performance index (value out comes)

No.	Material	Yield strength x 0.3	Tensile strength x 0.2	Wear resistance x 0.1	machineability x 0.2	Rank
1	40C8	28.32	9.8	10	20	**1**
2	45C8	26.25	10	7.5	10	**4**
3	50C8	27.48	20	5	5	**3**
4	50C12	30	10.56	2.5	15	**2**

From the above result of material selection shows that 40C8 is the material for the shafts so mostly shafts are made of low -to- medium carbon steel one of these materials is mild-steel.

4.6.2 Design of Shafts

The shafts maybe designed based on

1. Strength,
2. Rigidity and stiffness.

1. Strength,

1. In designing shafts based on strength, the following cases may be considered:

(a) Shafts subjected to twisting moment or torque only,

(b) Shafts subjected to bending moment only,

(c) Shafts subjected to combined twisting and bending moments, and

(d) Shafts subjected to axial loads in addition to combined torsional and bending loads.

- ✓ **Maximum Permissible Working Stresses for Transmission Shafts**

According to American Society of Mechanical Engineers (ASME) code for the design of transmission shafts, the maximum permissible working stresses in tension or compression may be taken as [**10**].

(a) 112 MPa for shafts without allowance for keyways.

(b) 84 MPa for shafts with allowance for keyways.

For shafts purchased under definite physical specifications, the permissible tensile stress (σt)may be taken as 60 per cent of the elastic limit in tension (σel), but not more than 36 per cent of the ultimate tensile strength (σu). In other words, the permissible tensile stress, σt = 0.6 σelOr 0.36 σu, which ever is less.

The maximum permissible shear stress may be taken as

(a) 56 MPa for shafts without allowance for key ways.

(b) 42 MPa for shafts with allowance for keyways.

For shafts purchased under definite physical specifications, the permissible shear stress (τ) may be taken as 30 per cent of the elastic limit in tension (σel) but not more than 18 per cent of the ultimate tensile strength (σu). In other words, the permissible shear stress, $\tau = 0.3\ \sigma el$ or 0.18 σu, whichever is less

- ✓ **Standard Sizes of Transmission Shafts**

The standard sizes of transmission shafts are:

25 mm to 60 mm with 5 mm steps; 60 mm to 110 mm with 10 mm steps ; 110 mm to 140 mm With 15mm steps; and 140mm to 500mm with 20mm steps.

The standard lengths of the shafts are 5 m, 6 m and 7 m.

Table.4.18 Allowable shear stress for shafts

Service condition	τ_sMpa
Heavily loaded short shafts carrying no axial load	48-106
Multiple bearing long shafts carrying no axial load	13-22
Axially loaded shafts (bevel gear drives ,or helical gear drive	8-10
Shafts working under heavy overloads (stone crushers, etc.)	4.5-5.3

Table 4.19 Mechanical properties of steels used for shafts

Designation	Tensile strength (N/mm^2)	Yield stress (N/mm^2)	Typical uses of carbon steels
40C8	569-667	324	Steel for crank shafts, spindle, Automobile axle beams ,pushrods, connecting rods, studs bolts, slightly stressed gears ,etc.
45C8	618-696	353	Steel for spindle of machine tools, bigger gears, bolt sand shafts.
50C8	647-765	373	Steel for making keys, shafts, cylinders, machine components required for moderate power resistance .Hardened steel is used for large pitch worms and gears.
50C12	706 Minimum	392	Rail steel. Also used for making spike bolt, gear shafts, rocking levers and cylinders lines.

Table.4.20 Mechanical properties of steel for shaft

Indian standard designation	Ultimate tensile strength, Mpa	Yield strength, Mpa
40C8	560-670	320
45C8	610-700	350
50C4	640-760	370
50C12	700min	390

The following parameters are used to calculate the diameter of the shaft

$\boldsymbol{Where}$;The diameter pulley $D1 = 75mm$

The diameter of large pulley $D2 = 125mm$

Rpm$N1 = 750rpm$

Rpm $N2 = 450RPM$

Shaft material 40C8, from table

Ultimate tensile strength $\sigma u = 700Mpa$

Yield strength =353Mpa

$$\sigma t = 0.6\,\sigma el$$

$$or\ 0.36\,\sigma u$$

Coefficient of friction $\mu = 0.3$

Factor of safety's =4

T1= Tension in the tight side of the belt, $\boldsymbol{T1 = 139.45N}$

T2= Tension in the slack side of the belt, $\boldsymbol{T2 = 1.6N}$

$$\boldsymbol{\sigma} = \frac{\boldsymbol{\sigma u}}{Fs}$$

$$\boldsymbol{\sigma} = \frac{650Mpa}{4} = 162.5Mpa$$

$$\tau a = \frac{\tau u}{Fs}$$

$$\tau a = \frac{353Mpa}{4} = 88.25Mpa$$

Allowable shear stress τ_a

- ✓ **Shafts Subjected to Twisting Moment Only**

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

- ✓ **The torque($\boldsymbol{Tsh}$) transmitted by the driven pulley of shaft,**

$$\boldsymbol{Tsh = \frac{PX60}{2\pi N}} -------------------(\mathbf{4.22})$$

$$Tsh = 1.64X\ 10^3 X\ 60/2X3.14x450$$

$$=1.64X\ 10^3 X\ 60/2X3.14x450$$

$$=98.4\ x\ 10^3/2826$$

$$Tsh = 34.82\ Nm$$

- ✓ **Total vertical load on the pulley**

$$\boldsymbol{Wt = T1 + T2 + 2TC} --------------(\mathbf{4.23})$$

$$Wt = 139.45N + 1.6N + 2(1.78N)$$

$$Wt = 144.61N$$

Assuming that the torque on the mounted wood is same as that of the shaft, therefore the tangential force acting vertically upward on the wood

$$Ft = \frac{Tsh}{Rw} ---------------------- (4.24)$$

$$\boldsymbol{Where};\ Dw(diameter\ of\ wood\ work - piece$$

$$Rw\ (radius\ of\ the\ work - piece$$

$$Rw = \ 200mm \ = \ 0.2m$$

Tangential force $\mathrm{Ft} = \frac{34.8\ \ 2\mathrm{Nm}}{0.2\mathrm{m}}$

$$Ft = 1160.5$$

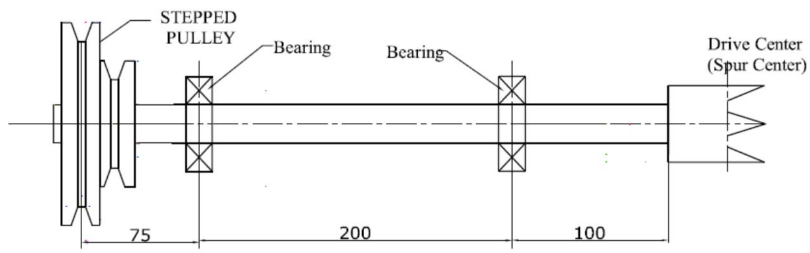
$$Rb = Ft - Ww$$

$$= 1160.5\ - 530.81$$

$$Rb = 629.69N$$

- ✓ **bending moment acting on the shaft**

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 But in actual practice, the shafts are subjected to fluctuating torque and bending moments. In order to design such shafts like line shafts and counter shafts, the combined shock and fatigue factors must be taken in to account for the computed twisting moment (Mt) and bending moment (Mb). Thus for a shaft subjected to combined bending and torsion Since the driven pulley is overhung and the distance of the center from the nearest bearing is 75 mm, therefore,



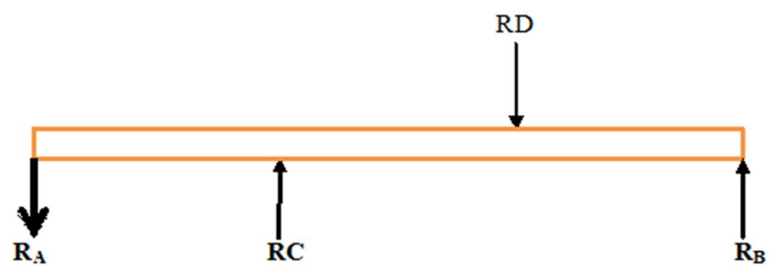


Figure 4.3 The forces acting on the driven shaft (spindle).

$\boldsymbol{Where}$; Mc = banding moment at c

Rc = reaction force at c

RA = reaction force at A

$RB = reaction\ force\ at\ B$

$$\mathbf{M\,c = (T1\ +\ T2\ +\ 2TC)L -------------(4.25)}$$

$$= (139.45N\ + 1.6N\ + 2(1.78))75mm$$

$$= (144.61N)75mm$$

$$\boldsymbol{Mc = 10845.75N - mm}$$

Now let us find the reactions at the bearings C and D. Let RC and RD be the reactions at C and D respectively. A little consideration will show that the reaction RC will act upward while the reaction RD act downward as shown in taking the moment at D

$$\mathbf{Rc(200) = (RA\,)(L\,) +\ RB\,L ------------(4.26)}$$

$$\mathrm{Rc} = 144..61)(275)\ + 629.69)(100)$$

$$\mathrm{RC\ =\ 513.68N}$$

For the equilibrium of shaft

$$\mathrm{RD} + 144.61 = \mathrm{RC} + 629.69$$

$$\mathrm{RD} = 998.76$$

The bending moment at A and C are = 0

- ✓ **Bending moment at C**

$$\mathbf{BMC = RA\ L} ------------------- (\mathbf{4.27})$$

$$\mathrm{BMC} = (144.69)\ (75\mathrm{mm})$$

$$\mathrm{BMC10845.75N}$$

$$\mathrm{BMC} = 10.8 \text{ x } 10^3\ \mathrm{N-mm}$$

- ✓ **Bending moment at D**

$$\mathbf{BMD = RD\ x\ L} --------------- (\mathbf{4.28})$$

$$\mathrm{BMD} = (629.69)(100\mathrm{mm})$$

$$\mathrm{BMD} = 62969\mathrm{N-mm}$$

$$\mathrm{BMD} = 62.97 \text{ x } 10^3\ \mathrm{N-mm}$$

Therefore, the maximum bending moment at D

M=62.97x $\mathbf{10^3}$ N-mm =62969.N-mm

Shafts Subjected to Combined Twisting Moment and Bending Moment

When the shaft is subjected to combine twisting moment and bending moment, then the shaft must be designed based on the two moments simultaneously. Various theories have been suggested to account for the elastic failure of the materials when they are subjected to various types of combined stresses. The following two theories are important from the subject point of view:[10]

1. Maximum shear stress theory or Guest's theory. It is used for ductile materials such as mild steel.
2. Maximum normal stress theory or Rankin's theory. It is used for brittle materials such as Cast iron.

- **the equilibrium twisting moment ($\boldsymbol{Te}$),**

$$\mathrm{Te} = \sqrt{\mathrm{T}^2 + \mathrm{M}^2} -------------------(4.29)$$

$$\mathrm{Te} = \sqrt{(34820)^2 + (62969)^2}$$

$$\mathrm{Te} = 71955.04\mathrm{N} - \mathrm{mm}$$

- **The equvalent bending moment(Me)**

$$Me = \frac{1}{2}(M + Te)$$

$$Me = \frac{1}{2}(62969 + 71955.04)$$

$$Me = 67462.01N - mm$$

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

- **According to the maximum shear stress theory**

$$\tau = 88.25Mpa$$

$$\boldsymbol{Te = \frac{\pi}{16}\tau d^3 --------------------- (4.30)}$$

$$Te = \frac{\pi}{16}(88.25mpa\ )d^3$$

$$\boldsymbol{Te = 17.319Mpad^3 ----------------(4.31)}$$

From the above equation

71955.04N-mm=17.319$mpad^3$

$$d^3 = 4154.68$$

$$d = \sqrt[3]{4154.68}$$

$$d \geq 16.07mm$$

- **According to maximum normal stress$\boldsymbol{\sigma}$=162.5mm**

$$d^3 = \frac{32Me}{\pi\sigma}$$

$$d^3 = \frac{32(67462.01N - mm)}{\pi(162.5mpa)}$$

$$d^3 = 4230.84$$

$$d = 16.17mm$$

Assuming for rotating shafts with gradually applied loads

$$\boldsymbol{Km} = \mathbf{1.5}$$

$$\boldsymbol{and\ Kt} = \mathbf{1}$$

Km= Combined shock and fatigue factor for bending, and

Kt= Combined shock and fatigue factor for torsion.

Table 4.21 recommended values for Km and Kt

Nature of load		Km	Kt
1. Stationary shafts	(a) Gradually applied load	1.0	1.0
	(b) Suddenly applied load	1.5 to 2.0	1.5 to 2.0
2.Rotating shafts	Gradually applied orsteady load	1.5	1.0
	Suddenly applide loade with minor shock only	1.5 to 2.0	1.5 to 2.0
	Suddenly applide load with heavy shocks	2.0 to 3.0	1.5 to 3.0

$\boldsymbol{Where}$; Km $= 1.5$and Kt $= 1$from the tabel 4.16

M=maximum bending moment=62969N-mm

T=23210N

- ✓ **the equivalent twisting moment of the shaft**

$$\mathbf{Te} = \sqrt{(\mathbf{Km\ xM})^2 + (\mathbf{Kt} + \mathbf{T})^2} - - - - - - - - - - - - - - - -(\mathbf{4.32})$$

Te=$\sqrt{(1.5x62969)^{2+}}(34820\ x1)^{\ 2}$

Te=$\sqrt{94453.5)2 + 34820)2}$

$$Te = 100667.25N - mm$$

- ✓ **The equivalent bending moment (Me)**

$$\text{Me} = \frac{1}{2}(Km\ M + \sqrt{(\text{Km xM})^2 + (\text{Kt} + \text{T})^2}$$

$$\text{Me} = \frac{1}{2}(1.5(62969 + \sqrt{(1.5\ \text{x}62969)^2 + (34820 + 1)^2}$$

Me=97560.38N-mm

- ✓ **According to the maximum shear stress indused in material of shaft[10]**

  Te =17.31(d^3)

100667.25=17.31(d^3)

$$d^3 = 100667.25/17.31$$

$$d^3 = 5815.55mm$$

$$d \geq 17.98mm$$

- ✓ **According to maximum normal stress (tensile or comperasive)**

$$\mathrm{Me} = \frac{\pi}{32}\sigma \mathrm{d}^3$$

$$\mathrm{Me} = \frac{\pi}{32}(162.5\mathrm{Mpa})\mathrm{d}^3$$

$$\mathrm{Me} = \frac{\pi}{32}\sigma \mathrm{d}^3$$

$$97560.38\mathrm{N} - \mathrm{mm} = 15.94\mathrm{Nd}^3$$

$$\mathrm{d}^3 = 6120.48$$

$$\mathrm{d} \geq 18.29\mathrm{mm}$$

Acording to the standard of shaft size take 30mm of diameter for maximum shaft life.

Wood turning parameters

Wood turning is a manufacturing mechanical process involving single edge tools which cut (removes material) from the surface of a work piece animated by a rotational movement (cutting action), which is the principal movement of the process. The tool is moved in an additional translation (linear or not) called feed movement, allowing to define the profile of the work piece. The combination of these two movements, as well as the shape of the active part of the tool is used to obtain the machining shape of revolution: cylinders, planes, cones or complex shapes of revolution . Straight turning provides the work-piece a cylindrical shape. In woodturning, parts have initially sharp edges and need to be round and roughly shaped. Rough wood turning is the most dominating and consuming electric energy among other turning operations

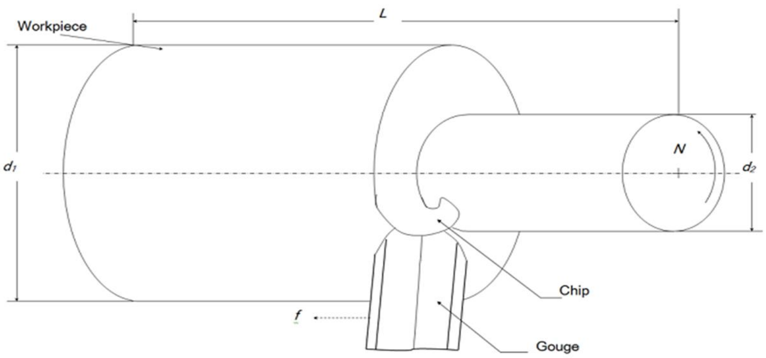


Figure 4.4 Schema of the turning operation.

The cutting parameters for straight turning are:

$$ap = \text{depth of cut}$$

$$Vc = \text{cuting speed}$$

$$Vf = feed\ rate$$

$$Fc = \text{Cutting force}$$

$$MRR = material\ removal\ rate$$

i) The depth of cut $ap(mm)$ which is

$ap = \frac{d1-d2}{2}$, Where:- d1 is the dimeter of unmachined round surface and d2 is the diameter of machined round surface.

ii) The cutting speed

$$\mathbf{N = \frac{60\ x\ 1000\ \ Vc}{\pi\ x\ d1},------------------(4.34)}$$

iii) The feed rate $vf\ (m\ /min)$, which is define

$$\boldsymbol{Vf = f\ X\ \mathrm{N} ------------------(4.35)}$$

iv)The required cutting power W(Watt) can be estimated using the following formula

$$\boldsymbol{W = Fc\ X\ Vc --------------(4.36)}$$

v)where Fc is the cutting force (N).The material removal rate (MRR) $(cm3/min)$ represents the ratio of the amount (volume) of material cut (removed) to the cutting time and is defined as

$$\mathrm{MRR} = \mathrm{a_{px}fxV_C} ------------(4.37)$$

Combining these two equations yields This equation describes the power needed to perform a cut per the material removal, thus the specific energy. The required cutting powers W must be compared to the available power on the machine, taking into account the machine's efficiency and characteristics.

$$W = \frac{Fc}{apxf} MRR ----------------- (4.38)$$

These safety factors are based on yield strength.

1. SF=1.25 to 1.5 for exceptionally reliable materials used under controllable conditions and subjected to loads and stresses that can be determined with certainty—used almost invariably where low weight is a particularly important consideration.
2. SF=1.5 to 2 for well-known materials, under reasonably constant environmental conditions, subjected to loads and stresses that can be determined readily.
3. SF=2 to 2.5 for average materials operated in ordinary environments and subjected to loads and stresses that can be determined.
4. SF=2.5 to 3 for less tried materials or for brittle materials under average conditions of environment, load, and stress.
5. SF=3 to 4 for untried materials used under average conditions of environment, load, and stress.
6.SF=3 to 4 should also be used with better known materials that are to be used in uncertain environments or subjected to uncertain stresses.
7. Repeated loads: The factors established in items 1 to 6 are acceptable but must be applied to the endurance limit rather than to the yield strength of the material.
8. Impact forces: The factors given in items 3 to 6 are acceptable, but an impact factor should be included.
9. Brittle materials: Where the ultimate strength is used as the theoretical maximum, the factors presented in items 1 to 6 should be approximately doubled.
10. Where higher factors might appear desirable, a more thorough analysis of the problem should be undertaken before deciding on their use

4.7 Material selection and design of key

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

4.7.1 Design of key

A key is a piece of mild steel inserted between the shaft and hub or boss of the pulley to connect this together in order to prevent relative motion between them. It is always inserted parallel to the axis of the shaft. Keys are used as temporary fastenings and are subjected to consider-able crushing and shearing stresses. A keyway is a slot or recess in a shaft and hub of the pulley to accommodate key.

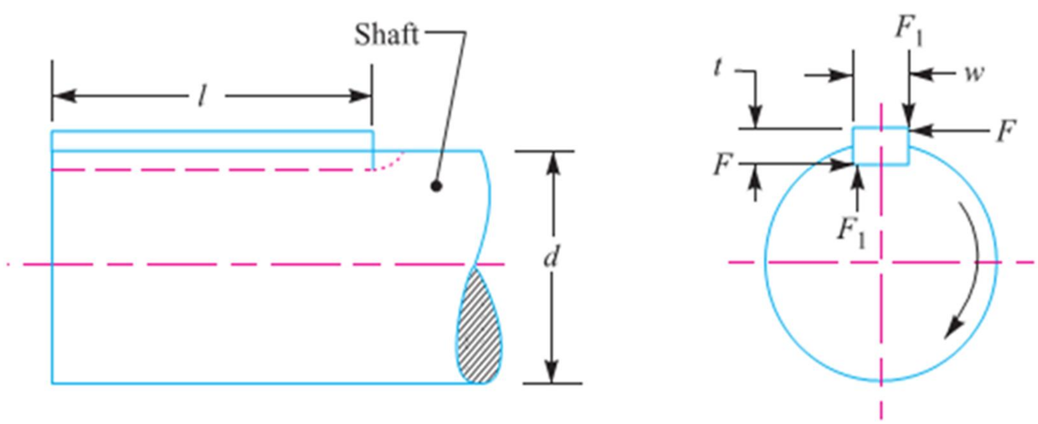


Figure 4.5 Forces acting on a sunk key.

A key connecting the shaft Figure 4.6

Let $T =$ Torque transmitted by the shaft

$F =$ Tangential force acting at the circumference of the shaft,

$d =$ Diameter of shaft

$l = Length\ of\ key.$

$w = Width\ of\ key.$

$t =$ Thickness of key, and

$$\tau and\ \sigma c = \ Shear\ and\ crushing\ stresses\ for\ the\ material\ of\ key.$$

A little consideration will show that due to the power transmitted by the shaft, the key may fail due to shearing or crushing.

- ✓ **Torque transmitted by shaft**

$$\boldsymbol{T = \frac{2.2X10^3X\ 60}{2\pi X450}} - - - - - - - - - - - - - - - -(\mathbf{4.39})$$

$$Transmit\ a\ torque = 46.69N.mm$$

- ✓ **Design the rectangular key for a shaft**

The diameter of the shaft d=22mm

Conceder the material of key mild steel 45C8

Shear stress ($\boldsymbol{\tau}$) =40Mpa

Crush stress (σ) =80Mpa

From Table 4.16, we find that for a shaft of 22 mm diameter,

Width of key, w= 8 mm Ans.

And thickness of key, t = 7mm Ans.

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

Let L= Length of key.

- ✓ **The shearing strength (or torque transmitted) of the key,** considering shearing of the key.

$$\mathbf{T = \frac{(L)(w)(\ \tau\ )d}{2}} - - - - - - - - - - - - - - - - - - -(\mathbf{4.40})$$

$$\boldsymbol{Where}; L = \ Length\ of\ key.$$

$$W = Width\ of\ key$$

$$T = torque$$

$$\boldsymbol{\tau}\ = \ \ Shear\ stress$$

$$T = L\ x\ 8mm\ (40Mpa)\ 25/2$$

$$T = L(3520N - mm)$$

$$L = 1.57d\ (\frac{\boldsymbol{\tau}}{\sigma})$$

$$L = 1.57(22)\ (40/80)$$

$$L = 17.28mm$$

$$T = 17.281(3520)$$

$$T = 60826.12N - mm$$

- **Torsional shearing strength (or torque transmitted) of the shaft,**

$$\mathbf{Te = \frac{\pi}{16}\tau(d)^3 -----------------(4.41)}$$

$$Te = \frac{\pi}{16} 40Mpax22^3$$

$$Ts = 83.58\ x\ 10^3 N - mm$$

- **Now considering crushing of the key.**

We know that shearing strength (or torque transmitted) of the key,

$$\mathbf{Tk = L\left(\frac{\boldsymbol{t}}{2}\right)(\boldsymbol{\sigma})\left(\frac{\boldsymbol{d}}{2}\right) -----------------(4.42)}$$

$$Tk = (L)7/2(80)22/2$$

$$Tk = 3080L$$

From shearing strengthTs=3769.91 X $10^6 N - mm$

$$Ts = Tk$$

$$3769.9110^6 N - mm = 80L$$

L= $83.58x10^3 N/3080$

$$L = 27.13mm$$

Taking the largest value of length L= 27.13mm

4.8 Material selection and design of bearing

- **Bearing**

A bearing is a machine element which supports another moving machine element (known as journal). It permits a relative motion between the contact surfaces of the members, while carrying the load. A little consideration will show that due to the relative motion between the contact surfaces, a certain amount of power is wasted in overcoming frictional resistance and if the rubbing surfaces are in direct contact, there will be rapid wear. In order to reduce frictional resistance and wear and in some cases to carry away the heat generated, a layer of fluid (known as lubricant) may be provided. The lubricant used to separate the journal and bearing is usually a mineral oil refined from petroleum, but vegetable oils, silicon oils, greases etc.,

- ✓ **Standard Dimensions and Designations of Ball Bearings**

The dimensions that have been standardized on an international basis are shown in Figure 4.7. These dimensions are a function of the bearing bore and the series of bearing. The standard dimensions are given in millimeters. There is no standard for the size and Number of steel balls.

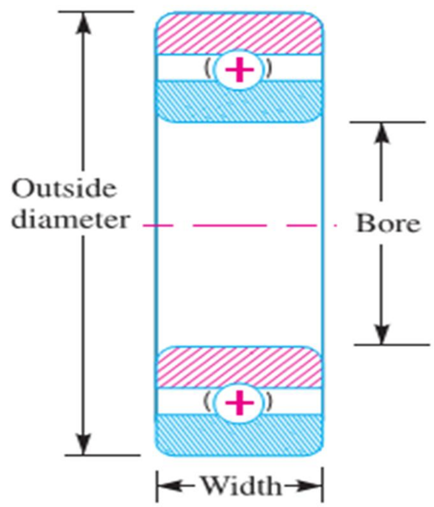


Figure 4.6 Standard designations of ball bearings.

- ✓ **the principles of bearing selection**

Bearing selection is influenced by many factors such as loads, geometry, maintenance, available clearance, displacement, rotation, deflection, availability, policy, designer preference, Construction tolerances and cost. In general, vertical displacements are restrained, rotations are allowed to occur as freely as possible, and horizontal displacements may be either accommodated or restrained. The loads should be distributed among the bearings in accordance with the structure analysis. The operating conditions are an important factor to consider when selecting the bearings to be used. Therefore among the principle factors that need to be considered here are:

1. The dimension of the shaft and bearing assembly including parameters such as clearance, length to diameter ratio, surface finish and bearing thickness

2. The speed of rotation, whether it is constant, varying or oscillating.

3. The magnitude of the load that the bearing is expected to sustain and whether this load is constant or varying in intensity and direction.

4. The lubricant to be used, its viscosity operating temperature, pressure and rate of flow the physical and chemical properties of the journal and bearing materials.

A variety of other factors such as rigidity of shafts, bearing and housing as well as environmental conditions such as presence of dirt and corrosive agents[**10**].

- ✓ **The available types of bearings are:**

1 The slider bearing type.

2 The rolling element types e.g. roller bearing.

The complete bearing selection was made after a full consideration of the particular working conditions.

Material selection for bearing

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

Table 4.22 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.

- ✓ **The following is a guideline we used as to the type of bearings to be used:**

The speed: The spindle speeds are high (1490-2800 rpm). The high speed can be achieved with deep groove ball bearings.

Load: The magnitude of load determines the size of the bearing used. Ball bearings are capable of handling light and moderate loads.

Misalignment: Angular misalignment between shaft and bearing housing results when shaft Bends under operation load or when shafts are supported by bearings in separate housing which are far apart.

Accurate alignment is obtained and maintained between seating's when rigid bearings are used.

- ✓ **Life of a Bearing**

The life of an individual ball (or roller) bearing may be defined as the number of revolutions (or hours at some given constant speed) which the bearing runs before the first evidence of fatigue develops in the material of one of the rings or any of the rolling elements.

The rating life of a group of apparently identical ball or roller bearings is defined as the

Number of revolutions (or hours at some given constant speed) that 90 per cent of a group of bearings will complete or exceed before the first evidence of fatigue develops (i.e. only 10 per cent of a group of bearings fail due to fatigue).

The term minimum life is also used to denote the rating life. It has been found that the life, which 50 per cent of a group of bearings will complete or exceed, is approximately 5 times the life which 90 per cent of the bearings will complete or exceed. In other words, we may say that the average life of a bearing is 5 times the rating life (or minimum life). It may be noted that the longest life of a single bearing is seldom longer than the 4 times the average life and the maximum life of a single bearing is about 30 to 50 times the minimum life[**10**].

The life of bearings for various types of machines is given in the following table.

- ✓ **Load on radial bearing**

In order to select a most suitable ball bearing, first of all, the basic dynamic radial load is calculated. It is then multiplied by the service factor (KS) to get the design basic dynamic radial load capacity. The service factor for the ball bearings is shown in the following table.

- ✓ **Equivalent load on bearing**

$$\mathbf{P = f \text{ x } T ------------------(4.43)}$$

$$\mathrm{T = T1 + T2 + Wt.}$$

$$\textbf{Total load on the v belt} ---------- (\mathbf{4.44})$$

$$T = 67812.5$$

$$P = (2.2)\ (67812.5N)$$

$$P = 149187.5N$$

$$Radial\ load\ (WR.) = 435.81N$$

$$Constant\ axial\ or\ thrust\ load\ (WA) = 186.76N$$

Sservice factor (Ks) for moderat shock load=2

N=450r.p.m

The life of baring also take from table 27-3 =from25, 000

Average life of bearing 5 year and 8hr working hour per day

$$Lh = 25000$$

Life of the bearing in revolutions

$$\boldsymbol{L = 60\,N \times LH} ---------------- \mathbf{(4.45)}$$

$$L = 60(450)25000$$

$$L = 675\;X10^{6}\text{rev}$$

- ✓ the basic dynamic equivalent radial load

$$\boldsymbol{w = X.V.W_R + YW_A} --------------- \mathbf{(4.46)}$$

V = A rotation factor,

= 1, for all types of bearings when the inner race is rotating,

= 1, for self-aligning bearings when inner race is stationary,

= 1.2, for all types of bearings except self-aligning, when inner race is Stationary.

In order to determine the radial load factor (X) and axial load factor (Y), require WA/ WR and WA/ C0

. Since the value of basic static load capacity (C0) is not known, therefore let us take WA/ C0 = 0.5.

Now from **Table 4.22**, find that the values of X and Y corresponding to WA/ C0= 0.5 and

$$WA/\,WR\; = 186.74/435.81N\; = 0.42$$

Take X=1 Y=0 from **table 4.22**

Since the rotational factor (V) for most of the bearings is 1, therefore basic dynamic equivalent radial load,$\boldsymbol{w = X.V.W_R + YW_A}$ **--------------------------------------- (4.47)**

$$W = (1)(1)(435.81\; + 0(186.74)$$

$$W = 435.81N$$

Table 4.23 Value of service factor, from Table 4.18, for moderate socks load the service factor (KS) for ball bearings is =2

S.no.	Types of service	Service factor (KS) for radial Ball bearing
1	Uniform and steady load	1.0
2	Light shock load	1.5
3	Moderate shock load	2.0
4	Heavy shock load	2.5
5	Extreme shock load	3.0

$$\boldsymbol{C = W(\frac{L}{10^6})^{\frac{1}{K}}} ----------------------\mathbf{4.48}$$

$$C = 435.81\mathrm{N}(\frac{675 \text{ X } 10^6\mathrm{rev}}{10^6})^{\frac{1}{2}}$$

$$C = 308035.63N$$

C=308.03KN

From Table 4.18let us select the bearing No. 202 which has the following basic capacities,

$$\mathrm{C0} = 3.55 \text{ kN} = 3550\mathrm{N}$$

$$\mathrm{C} = 6.11 \text{ kN} = 6110\mathrm{N}$$

$$\text{Now WA/Co} = 186.74/355 \text{ N} = 0.05$$

$$\therefore \text{ From Table 27.4, the values of X and Y are}$$

$$\boldsymbol{X = 1 \quad , \quad Y = 0}$$

4.9 Material selection and design of tail stock spindle and house

The hollow shafts are usually used in marine work. These shafts are stronger per kg of Material and they may be forged on a mandrel, thus making the material more homogeneous than would be possible for a solid shaft. When a hollow shaft is to be made equal in strength to a solid shaft, the twisting moment of both the shafts must be same. In other words, for the same material of both the shafts.

A. For hollow shaft

$$\mathbf{T} = \frac{\pi}{16}\mathbf{X}\left[\frac{\mathbf{do^4 - di^4}}{\mathbf{do}}\right. ------------------(\mathbf{4.49})$$

$$\mathbf{d^3 = do^3 - (k^4)} --------------- (\mathbf{4.50})$$

$$\mathrm{d}^3 = \frac{\mathbf{do^4 - di^4}}{\mathbf{do}} ----------------(\mathbf{4.51})$$

$\mathrm{do} = is$ insidediameteroftheshaft

$di \;=\; is\ out\ side\ diameter\ of\ the\ shaft$

The head stock outer diameter of the shaft and the tail stoke outer diameter of the shaft is equal which is 25

$$\boldsymbol{K} = \frac{\boldsymbol{di}}{\boldsymbol{do}} = \mathbf{0.5} ----------------- (\mathbf{4.52})$$

$$di \;=\; 25X0.5 = 12.5$$

$$di \;= 12.5$$

The twisting and bending moment of the head stock of shaft are equal to the tail sock shaft are the same?

4.10 Material selection and Design of lead screw

A square thread, as shown in Fig 4.3, is adapted for the transmission of power in either direction. This thread results in maximum efficiency and minimum radial or bursting pressure on the nut. It is difficult to cut with taps and dies. It is usually cut on a lathe with a single point tool and it cannot be easily compensated for wear. The square threads are employed in screw jacks, presses and clamping devices.[10]

The standard dimensions for square threads according to IS: 4694 – 1968.[10]

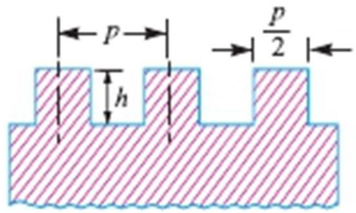


Figure 4.7 The diameter of square thread

$$\boldsymbol{dc = \frac{4w}{\pi\sigma c}} ----------------- (\mathbf{4.53})$$

- The load to be raised or lowered is placed on the head of the square thread rod which is rotated by the application of an effort at the end of leaver for lifting or lowering the load.

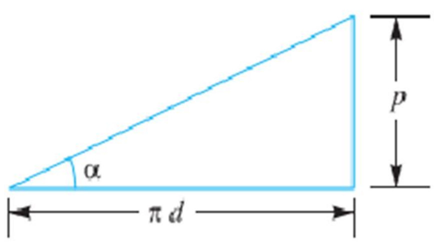


Figure 4.8 (a) Development of screw

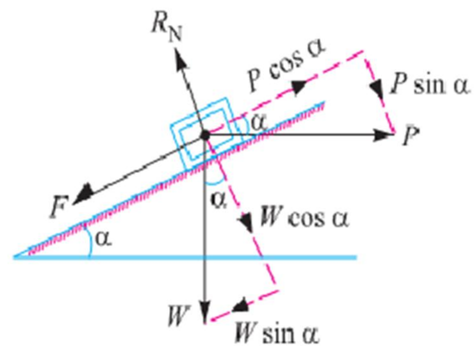


Figure 4.8 (b) Forces acting on the screw

$$Ac\ = \frac{\pi}{4}\ (di2 - do2)$$

$$Ac = \frac{\pi}{4} di2 - do2)$$

$$Ac = \frac{\pi}{4}(252 - 182)$$

Ac=236.29

$$\boldsymbol{\sigma c \frac{W}{A}} ---------------------- (\mathbf{4.54})$$

$$W\ = \sigma c\ x\ A$$

$$W\ = 236.29x297 = 70176.6$$

The diameter of square thread

$$\boldsymbol{dc = \frac{4w}{\pi \sigma c} ------------------- (4.55)}$$

$$dc = \frac{4x70176.6}{\pi x 297}$$

$$dc = 17$$

When the square tread is **M20 X 2**

Basic dimensions for square threads in mm (Fine series) according to IS: 4694 – 1968 from table 17.1 [10] is:

$$\text{Nominal diameter (do)} = 20$$

$$\text{di} = 14$$

$$\text{D} = 20.5$$

$$\text{core diameter(dc)} = 18$$

$$\text{pitch of the screw(p)} = 2$$

$$\text{h} = 1$$

$$\text{H} = 1.25$$

$$\text{Area of core (Ac)} = 254$$

A. The mean diameter of the screw is

When the nominal diameter (*do*) and the core diameter (*dc*) of the screw is given, then

Mean diameter of screw,

$$d = \frac{do + dc}{2}$$

$$d = \frac{20 + 18}{2}$$

$$d = 19$$

B. the helix angle of screw(lead angle)

$$\boldsymbol{\tan \alpha = \frac{p}{\pi d} ------------------- (4.56)}$$

$$\tan\alpha = \frac{2}{\pi x 19}$$

$$\tan\alpha = 2.034$$

C. the coefficient of friction

The coefficient of friction depends upon various factors like material of screw and nut, workmanship in cutting screw, quality of lubrication, unit bearing pressure and the rubbing speeds. The value of coefficient of friction does not vary much with different combination of material, load or rubbing speed, except under starting conditions. The coefficient of friction, with good lubrication and average workmanship, may be assumed between 0.10 and 0.15. The various values for coefficient of friction for steel screw and cast iron or bronze nut, under different conditions are shown in the following table.

Table 4.24 Coefficient of friction under different conditions

$S.N.a$	Condition	Average coefficient of friction	
		starting	running
1	High grade material and workmanship and best running conditions	0.14	0.10
2	Average quality of material and workmanship and best running conditions	0.18	0.13
3	Poor workmanship or very slow and in frequent motion	0.21	0.15

D. the angle of friction

$$\boldsymbol{\mu = \tan\emptyset} ------------------ (\mathbf{4.57})$$

0.14 =tan(0.14)

$$\emptyset = 7.96$$

E. the torque

The torque required to raise a load by means of square threaded screw may be determined by considering a screw jack. The load to be raised or lowered is placed on the head of the square threaded rod which is rotated by the application of an effort at the end of lever for lifting or lowering the load. A little consideration will show that if one complete turn of a screw thread be imagined to be unwound, from the body of the screw and developed, it will form an inclined.

$$\boldsymbol{T1 = Px\frac{d}{2}} ------------------- \mathbf{4.58}$$

$$\boldsymbol{T1 = W\,x\frac{\tan\alpha + \tan\emptyset}{1 - \tan\alpha + \tan\emptyset}x\frac{d}{2}} ----------- \mathbf{4.59}$$

$$\mathrm{T1} = 70176.6 \text{ x } \frac{\tan 1.95 + \tan 7.96}{1 - \tan 1.95 + \tan 7.96} \text{x} \frac{19}{2}$$

$$T1 = 24533.739Nmm$$

- ✓ The load along the plane

$$\boldsymbol{P = Wx\frac{\tan\alpha+\tan\emptyset}{1-\tan\alpha+\tan\emptyset}} --------------- \mathbf{(4.60)}$$

$$\mathrm{p}=70176.6\mathrm{x}\frac{\tan\alpha+\tan\emptyset}{1-\tan\alpha+\tan\emptyset}$$

p=58036.04N

- ✓ Resolving the forces along the plan

$$\mathbf{RN = w\cos\boldsymbol{\alpha} - p\sin\boldsymbol{\alpha}} ----------- \mathbf{(4.61)}$$

$$\mathrm{RN} = 70176\cos 1.95 - 58036\sin 1.95$$

$$RN = 68162.68N$$

$$\boldsymbol{F = \mu RN} ----------------- \mathbf{(4.62)}$$

$$\boldsymbol{Where};\ F = force$$

$$\mu = coffecent\ of\ friction$$

$$RN = normal\ force$$

$$F = 0.1947(68162.68)N$$

$$F = 13271.23N$$

- ✓ Maximum stress(σmax)

$$\boldsymbol{\sigma max = \frac{1}{2}(\sigma c + \sqrt{\sigma c^2 - 4\tau^2})} \text{---------------------------------} \mathbf{(4.63)}$$

$$\sigma c = \frac{4W}{\pi dC^2}$$

$$\boldsymbol{Where}; max = maimum\ stress$$

$$W = wighet$$

$$dc = core\ diameter$$

$$\sigma c = stress$$

$$\tau = shear\ stress$$

$$T1 = torque$$

$$\boldsymbol{\sigma c = \frac{4\,x70176.6}{\pi(18)^2}} - - - - - - - - - - - - - - - \mathbf{(4.64)}$$

$$\sigma c = \frac{1}{2}(275 + \sqrt{}75625\text{-}4335.6\ )$$

$$\sigma c = \frac{1}{2}(542)$$

$$\sigma c = \mathbf{275}$$

$$\sigma max = 271$$

$$\boldsymbol{\tau = \frac{16T1}{\pi dc^3}} - - - - - - - - - - - - - - - \mathbf{(4.65)}$$

$$\tau = \frac{16(24533.739\text{Nmm})}{\pi(18)^3}$$

$$\tau = \frac{221817555.2}{18312.48}$$

$$\tau = 18.312\text{mpa}$$

- ✓ Maximum shear stress τmax

$$\boldsymbol{\tau max = \frac{1}{2}\sqrt{\sigma c^2 4\tau^2}} - - - - - - - - - - \mathbf{(4.66)}$$

$$\tau max = \frac{1}{2}\sqrt{275^2 X4(18.312)^2}$$

$$\tau max = \frac{1}{2}\sqrt{275^2} + 4(18.312)^2$$

$$= \frac{1}{2}\sqrt{}(75625\text{-}4335.6\ )$$

$$\tau max = 133.5Mpa$$

The given $\sigma c = \frac{362}{2}$ Mpa

$$\tau c = \frac{297}{2}$$

$$\tau c = 148mpa$$

F. The efficiency of Square Threaded Screws

The efficiency of square threaded screws may be defined as the ratio between the ideal effort (*i.e*. the effort required to move the load, neglecting friction) to the actual effort (*i.e*. the effort required to move the load taking friction into account).

$$\mu = \frac{\sin \boldsymbol{\alpha}\, \boldsymbol{x} \cos(\boldsymbol{\alpha} + \emptyset)}{\cos \boldsymbol{\alpha x} \sin(\boldsymbol{\alpha} + \emptyset)} ---------------(\mathbf{4.67})$$

$$\mu = \frac{\sin \alpha 1.95\, x \cos(1.95 + 7.96)}{\cos \alpha x \sin(1.96 + 7.96)}$$

$$\mu = \frac{0.034\, x 0.985}{0.999 x 0.172}$$

μ=0.1947

μ=19.47%

4.11 Design and material selection of face plate

Material selection of face plate

Plates are made from low carbon steel which works fine for most operations but is not suitable for large diameter and heavy work.

Bending moment (Mb)

$$\boldsymbol{M_b} = \mathbf{T\, x} \frac{\boldsymbol{d}}{\mathbf{2}} ----------------- (\mathbf{4.68})$$

$$T = \frac{Px60}{2\pi N}$$

T = 34820N.mm

$$M_b = 34820\text{x}\frac{100}{2} =$$

= (34820) (50)

$$M_b = 17410000$$

- ✓ **Twisting moment**

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

$$\tau = 88.5$$

d=100

$$T = \frac{\boldsymbol{\pi}}{\mathbf{16}}(88.5)100^3$$

T= 17319.1KW

4.12 Material selection and design of head stoke body

- ✓ **Torque**

For high strength Material for head stoke body is 10C4

Density of 10C4 =7850Kg.m^3

- **Tangential force**

$$\boldsymbol{\tau = \frac{F_t}{A}} \text{ -- } \mathbf{(4.69)}$$

$$F_t = \frac{T_{sh}}{Rp}$$

$$= \frac{348\ \ 20}{62.5}$$

$$F_t = 557.12$$

$$\tau = \frac{557.12}{1125}$$

τ = 0.495

- ***total*** **Wightof the head stock cover**

$$Tw = w + wm + T$$

$$Tw\ = 435.81\ +\ 28.4$$

$$Tw\ = 464.23$$

$$Tw = 4(464.23)$$

W = mg

= 2.9kg x 9.8

W = 28.42Kg/m

- **Torque**

$$\boldsymbol{T = \frac{Px60}{2\pi N}} - - - - - - - - - - - - - - - - - - \mathbf{(4.70)}$$

T=34820Mpa

- **Normal stress**

$$\boldsymbol{\sigma = \frac{P}{(b-d)h}} - - - - - - - - - - - - - \mathbf{(4.71)}$$

$$= \frac{313.68}{1125}$$

$$\sigma = 0.456$$

$$\boldsymbol{\sigma_{max=}\ \sigma k_t} \text{-----------------------------------} \mathbf{(4.72)}$$

$$k_t = \frac{\sigma max}{\sigma}$$

$$k_t = (1 + \frac{2a}{b})$$

$$k_t = 2.69$$

$$\sigma_{max} = 2.69x0.456$$

=1.23

4.13 Design and Material selection of lathe bed

Material selection

For maximum strength, minimum cost and easily production of lathe bed select mild steel RHS with 100x60x3mm

The dimension of is square pipe 100x60mm

928.46(25-x)=1856.92(x)

23211.5-928.46x=1856.2x

23211.5=2785.38x

X=8.4

Shear stress of bead $\boldsymbol{T = 2Amt(z) - - - - - - - - -}$**(4.73)**

$$\tau = \frac{T}{2Amt}$$

$$= \frac{18\ 56.92}{5046}$$

τ=0.368

- ✓ **Bending moment**

  BM=928.46 x 16.6

  BM =15226.75

- ✓ Bending moment of Mc

$$629.69x = 1856.92(1900)$$

MC=(1856.92)(1900)-629.69x950

=3528148-598205.5

MC=2929942.6KN

MB=(1856.92)950-928.46(950)

=1764074-598205.5

MB=1165868.5

From the above banding moment take the maximum bending moment

$$\tau = \frac{T}{2Amt}$$

$$\tau = 0.368$$

Find the angle of twisting

$$\emptyset = \frac{TL}{GJ} \text{ -- } \mathbf{(4.74)}$$

Where G=3.66

$$J=\frac{2(60)^2(100)^2 2(3)}{3(60+100)}$$

$$J=\frac{432000000}{48\ \ 0}$$

$$J = 900000$$

$$\sigma max = \frac{\sigma}{Fs}$$

$$\sigma = \frac{2929942.5}{21.3x10^3 mm^3}$$

$$\sigma = 137.6N.mm^2$$

Take factor of safety

$$F_{sa} = 4$$

$$\sigma max = \frac{137.6}{4}$$

$$\sigma max = 34.4$$

4.14 Machine performance analysis

- power transmitted through the belt pulley

$$P = (T1 - T2)\ Vb$$

$$\theta = 3.01 rad$$

$$P = (140.59 - 1.62)2.94$$

V=176m/s

- Actual power input

  P=2.2Kw x total efficiency

- Total efficiency

  efficiency of belt x efficiency of bearing

  =0.95 x 0.85

- power input

$$P = 2.2kw \ \ x\, 0.8075$$

P = 1776.5

- power losses in bearing

  P = 0.15 of input power

  = 0.15(1776.5)

  P = 266.475

- power transmitted at shaft

  P = 1776.5-266.475

  P = 1510.025

- The efficiency of the machine

$$ή = \frac{1510.025}{1776.5} \text{ x } 100\%$$

$$ή = 0.85\, x\, 100\%$$

$$ή = \mathbf{85}\%$$

CHAPTER- FIVE

MANUFACTURING PROCESS

5.1 Manufacturing process

A manufacturing process is a designed procedure that results in physical and/or chemical changes to a starting work material with the intention of increasing the value of that material.

A manufacturing process is usually carried out as a unit operation, which means that it is a single step in the sequence of steps required to transform the starting material into a final product.

Manufacturing operations can be divided into two basic types:-

(1) Processing operations and

(2) Assembly operations.

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

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 weldments)[**11**].

5.1.1 Sheet metal the side part of headstock cover

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

Blank size------300x240x5mm

Quantity--------02

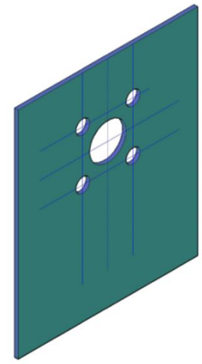


Figure 5.1 Headstock side frame

Table 5.1 manufacturing plan for sheet metal the side parts

Operation No	Descriptions	Feed mm/revolution	Cutting speed m/min	Depth of cut mm	Machine Tool	Tools
001	Measuring and laying out to 300x240x5mm	-	-	-		Scriber, v-caliper, tape rule, center punch, ball-peen hammer
002	Mounting the blank on sheet metal shearing machine	-	-	-	Power shears	-
003	Cutting the blank to the required size	-	-	-	Power shears	-
004	Mounting the work-piece on radial drilling machine	-	-	-	Radial drill machine	vice
005	-Drilling ∅10mm , 5 holes -Enlarge ∅10 to ∅20mm, 1center hole -Enlarge ∅20 to ∅25.5mm, 1 center hole	0.25 0.5 0.5	25 25 25	10 5 2.75	Radial drill machine	Drill bit ∅10mm Drill bit ∅20mm Drill bit ∅25.5mm
006	Mounting the work-piece on bench vice and filling the drilled parts	-	-	-	Bench vice	Vice Files

5.1.2Manufacturing plan for stepped Shaft

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

Blank size------300x250x5mm

Quantity---------01

Figure 5.2 stepped shaft

Table 5.2 Manufacturing plan for stepped Shaft

Operation No	**Descriptions**	**Feed mm/revolution**	**Cutting speed m/min**	**Depth of cut mm**	**Machine Tool**	**Tools**
001	Measuring of the shaft 400mm and Ø30mm	-	-	-		Scriber v-caliper tape rule
002	Mounting and cutting the blank on power hack saw	-	-	-	Power hack saw	Vice
003	Mounting the work piece on lathe machine	-	-	-	Lathe machine	Lathe chuck Tail stock
`004	Facing the work piece Ø30mm, length 3mm on both sides	0.1	30	1.5	Lathe machine	Turing tool
005	Centering the two ends	0.1	30	4	Lathe machine	Centering tool
006	-Turning the work-piece from Ø30mm to Ø25.2mm, length 315mm - Turning the work-piece from Ø25.5mm to Ø25mm, length 315mm	0.2 0.1	30 30	1.5 0.1	Lathe machine	Turing tool
007	Step turning Ø30mm to Ø26.92mm, length 40mm	0.2	30	1.5	Lathe machine	Turing tool
008	Grooving Ø25mm to Ø23.9mm, length 1.2 mm	0.1	30	0.55	Lathe machine	Lathe Cut-off tool
008	Thread cutting on the shaft , length 40, M27 x1.5mm	0.15	30	0.25	Lathe machine	Metric V-threading tool
009	Milling on Ø30mm, length 15mm	0.2	30	3	Horizontal milling machine	End mill Ø15mm

5.1.3 Manufacturing of lathe bed in RHS

Material mild steel

RHS 100X60X3mm

Quantity=1

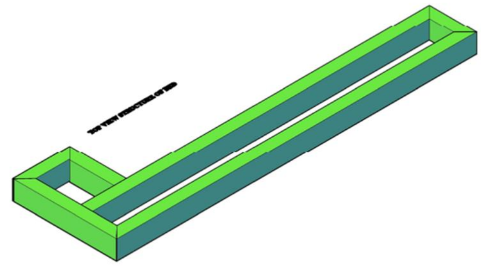


Figure 5.3 lathe bed

Table 5.3 Manufacturing plan of lathe bed

Operation No	Descriptions	Feed mm/revolution	Cutting speed m/min	Depth of cut mm	Machine Tool	Tools
001	Measuring and laying out to RHS100 X $60x3mm$	-	-	-	Scriber v-caliper tape rule	Scriber v-caliper tape rule
002	Mounting the blank on power hack saw	-	-	-	Power hack saw	Vice
003	Sawing the blank to the required size in $45° length =$ 1900mm,544.32mm	-	25	-	Power hack saw	Power hack saw blade
004	Welding of the joint	-	-	-	Welding machine	Welding machine

5.1.4 Manufacturing of lathe stand RHS

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

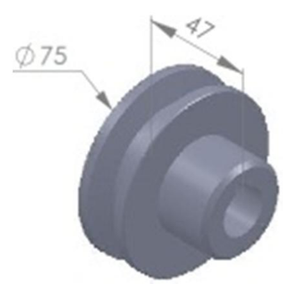
Blank size-------60X60X3mm

Quantity--------5

Figure 5.4 lathe stand

Table 5.4 Manufacturing plan for RHS

Operation No	**Descriptions**	**Feed mm/revolution**	**Cutting speed m/min**	**Depth of cut mm**	**Machine Tool**	**Tools**
001	Measuring and laying out to 60x60x3mm	-	-	-	Scriber v-caliper tape rule	Scriber v-caliper tape rule
002	Mounting the blank on power hack saw	-	-	-	Power hack saw	Vice
003	Sawing the blank to the required size of length	-	-	-	Power hack saw	Power hack saw blade
004	Welding the stand to bed	-	-	-	Welding machine	Welding machine
005	Grind the welding part	-	-	-	Grinding machine	Grinding tool



5.1.5 Manufacturing of stepped pulley

Material aluminum

Blank size-------$\emptyset 75mm\ and 125mm$

Quantity--------2figure

5.5 stepped pulley

Table 5.5 manufacturing plan for stepped pulley

Operation No №	Descriptions	Feed mm/revolution	Cutting speed m/min	Depth of cut mm	Machine Tool	Tools
001	Measuring the blank diameter of aluminum$\emptyset 130mm\ x50mm$	-	-	-	Scriber v-caliper tape rule	Scriber v-caliper tape rule
002	Mounting the blank on lathe	-	-	-	lathe machine	lathe machine
003	Turning, facing and measuring	2.5	25	2.5	lathe machine	lathe machine vernier caliper
004	Make groove in appropriate belt dimension	-	-	-	lathe machine	lathe machine

5.1.6Manufacturing of tool rest stand

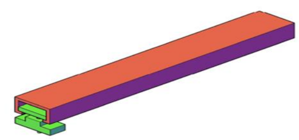


Figure 5.6 tool rest stand

Material mild steel

Blank size-------$U - chanl\ 300mmx2mm$

Quantity-1

Table 5.6 manufacturing plan for tool rest stand

Operation No №	Descriptions	Feed mm/revolution	Cutting speed m/min	Depth of cut mm	Machine Tool	Tools
001	Measure and mark the blank dimension of u-channel	-	-	-		Scriber, v-caliper tape rule
002	Mount the work piece on the power hacksaw	-	-	-	Power hack saw	vice
003	Cutting the u-channel with the dimension of 300mmx2mm	-	-	-	Power hack saw	Power hack saw blade
004	Grinding the cutting age	-	-	-	grinder	Grinder disk

5.1.7Manufacturing of tool rest

Material mild steel
Blank size -------$\emptyset 75mm\ and 125mm$
Quantity----- 1 pcs

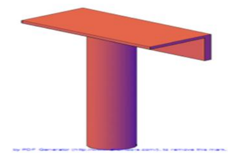


Figure 5.7 tool rest

Table 5.7 manufacturing plan for tool rest

Operation No No	**Descriptions**	**Feed mm/revolution**	**Cutting speed m/min**	**Depth of cut mm**	**Machine Tool**	**Tools**
001	Measure and mark the blank dimension of angle iron and round pipe	-	-	-		
002	Mount the angle iron in the vice	-	-	-	vice	vice
003	Cutting the angle iron 250mm	-		-	Power hacksaw	Power hack saw blade
004	Filing the cutting age	-	-	-	File	File
005	Welding the angle iron on the round pipe	-	-		Welding machine	Welding machine

5.1.8Manufacturing of tail stock support

Material =mild steel

Quantity=2

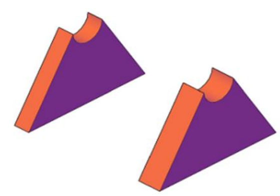


Figure 5.8 tailstock frames

Table 5.8 manufacturing plan for tail stock support

Operation No No	**Descriptions**	**Feed mm/revolution**	**Cutting speed m/min**	**Depth of cut mm**	**Machine Tool**	**Tools**
001	Measure and mark the blank dimension of plate	-	-	-		
002	Mount the plate on the shear	-	-	-	Shear machine	Shear machine tool
003	Cutting the plate with appropriate dimension	-	-	-	Shear machine	Shear machine tool
004	Filing the cutting age	-	-	-	File	File
005	Welding the plate on the tail stock base	-	-	-	Welding machine	Welding machine

CHAPTER SIX

MAINTENANCE AND ASSEMBLING

6.1 Maintenance and inspection

Regular periodic maintenance on your machine will ensure its optimum performance. Make a habit of inspecting your machine each time you use it. Check for the following conditions and repair or replace when necessary:

- ✓ Loose mounting bolts.
- ✓ Worn switch.
- ✓ Worn or damaged cords and plugs.
- ✓ Damaged V-belt.
- ✓ Any other condition that could hamper the safe operation of this machine.

Table 6.1 lathe maintenance schedule**[12].**

Frequency	Task	Reason
Every time you use a Morse-taper accessory	Wipe dust out of the taper socket with your finger and wipe the taper accessory	The biggest cause of spindle damage (head stock and tailstock) is damaged tapers or taper seats due to dirt.
Every turning session	Sweep or vacuum chips from the machine, then wax all unpainted metal parts such as the bed, spindles, and tool rest. Oil plane bearings. If your machine has oil holes or cups, you should apply a few drops of high-viscosity (30 or higher) machine oil. Some older motors also have oil cups, which should be lubricated.	Wood is hygroscopic and even dry wood can promote rusting in the right conditions. If you tum green wood, this action is an absolute must. Plane bearings will run forever if lubricated. They require a film of oil; if they don't have it, they will quickly fail.
Monthly	Grease any fittings. Some older machines may have grease fittings for the head stock bearings and possibly the motor. They should be given one shot of grease. Do not over grease. This should be a habit	Grease is required on a regular basis to keep such bearings healthy.
Annually	Clean all belt pulleys	Dirt and rubber buildup on pulleys causes vibration.
Every one to five years	Check the belt for wear and the bear-ings for endplay and lubrication. On most lathes that are used a reasonable amount, this check should be done more frequently. Since the spindle has to be removed on most lathes to replace the belt, you might as well replace the bearings. On variable-width sheave machines, belt replacement	A worn or loose belt causes vibration and poor power transmission. Dry bearings will soon fail (if they have not already).

	will be required every year or two, so replacing the bearings may not make sense in this case.	
Every decade regardless of use	Replace the belt and bearings	1ime alone will take its toll. Grease in sealed bearings will dry out, and rub-ber in belts gets hard and cracks.

Cleaning

Cleaning the wood working lath is relatively easy. Vacuum excess wood chips and sawdust, and wipe off the remaining dust with a dry cloth. If any resin has built up, use a resin dissolving cleaner to remove it. Remove any debris or oily substances from the inside of the spindle and quill.

Lathe Bed

Protect the lathe bed by wiping it clean after every use—this ensures moisture from wood dust does not remain on the bare metal surfaces. Keep your lathe bed rust-free with regular applications of quality lubricants.

Tailstock

To disassemble the tailstock for cleaning, loosen the set screw above the hand wheel, and then completely unthread the hand wheel from the threads of the quill. Except for the live center, thoroughly clean all of the unpainted parts with mineral spirits and apply a thin coat of light machine oil to these surfaces.

When re-assembling the tailstock, thread the hand wheel back onto the quill, tighten down the set screw that secures it, then back the screw off one full turn so that the hand wheel can freely rotate.

Lubrication

Since all bearings for the machine are sealed and permanently lubricated, simply leave them alone until they need to be replaced. Do not lubricate them.

Wipe a lightly oiled shop rag on the outside of the headstock spindle. DO NOT allow any oil to get on the inside mating surface of the spindle.

Use the quill hand wheel to extend the tailstock quill all the way out, and apply a thin coat of white lithium grease to the outside of the quill. DO NOT allow any lubricant to get on the inside mating surface of the quill.

6.2 Health and safety at work

All lathe operators must be constantly aware of the safety hazards that are associated with using the lathe and must know all safety precautions to avoid accidents and injuries. Carelessness and ignorance are two great menaces to personal safety. Other hazards can be mechanically related to working with the lathe, such as proper machine maintenance and setup.

Some important safety precautions to follow when using lathes are:

- ✓ Correct dress is important, remove rings and watches, and roll sleeves above elbows.
- ✓ Always stop the lathe before making adjustments.
- ✓ Does not change spindle speeds until the lathe comes to a complete stop
- ✓ Handle sharp cutters, centers, and drills with care.
- ✓ Remove chuck keys and wrenches before operating
- ✓ Always wear protective eye protection.
- ✓ Handle heavy chucks with care and protect the lathe ways with a block of wood when installing a chuck.
- ✓ Know where the emergency stop is before operating the lathe.
- ✓ Use pliers or a brush to remove chips and Warf, never your hands.
- ✓ Never lean on the lathe.
- ✓ Never lay tools directly on the lathe ways. If a separate table is not available, use a wide board with a cleat on each side to lay on the ways.
- ✓ Keep tools overhang as short as possible.
- ✓ Never attempt to measure work while it is turning.
- ✓ Never file lathe work unless the file has a handle.
- ✓ File left-handed if possible.
- ✓ Protect the lathe ways when grinding or filing.
- ✓ Use two hands when sanding the work piece. Do not wrap sand paper or emery cloth around the work piece

6.3 General warning and hazards

The purpose of safety symbols is to attract your attention to possible hazardous conditions.

This manual uses a series of symbols and signal words which are intended to convey the level of importance of the safety messages. The progression of symbols is described below.

Remember that safety messages by themselves do not eliminate danger and are not a substitute for proper accident prevention measures.

Indicates an imminently hazardous situation which, if not avoided, WILL result in death or serious injury

Indicates a potentially hazardous situation which, if not avoided, COULD result in death or serious injury

Indicates a potentially hazardous situation which, if not avoided, MAY result in minor or moderate injury. It may also be used to alert against unsafe practices.

This symbol is used to alert the user to useful information about proper operation of the equipment.

The primary hazards of Wood Lathes are contact with and contact at the point of operation.

- ✓ Contact with rotating parts at the point of operation occurs because the operator's hands may become too close to the rotating parts during turning.
- ✓ Work piece may be ejected if incorrectly fixed and inappropriate speeds are used.
- ✓ Wood Lathes produce large amounts of dust particularly during sanding and must be used in conjunction with dust extraction plant[13]

Key Hazards

- ✓ Point of operation – Contact with the tool or cuter head may occur.
- ✓ Contact with moving parts, such as the power transmission, chucks, spindles, and the work piece
- ✓ Getting loose clothes, jewelry, or long hair caught in rotating parts.
    - o Entanglement is a serious hazard on a lathe. Loose clothes or long hair can become entangled around the rotating parts of the lathe pulling the operator into the cutter or rotating stock resulting in significant injury or death.

- ✓ Being struck by flying chips or wood splinters thrown by the cutting action.
- ✓ Being struck by a work piece that has not been adequately secured in the lathe or is oversized.
- ✓ Inhalation of dust and particles.
- ✓ Dropping objects on foot.
- ✓ Electrical shock.

Key Controls

- ✓ Approved and authorized persons ONLY can operate equipment.
  - Training to be done and documented by designated competent instructor.
  - Appropriate department supervisor shall ensure unauthorized persons do not have access to machines.
  - Follow all safety warnings given in the OEM's Operating Manual.
    - Scriber
    - v-caliper
  - Tape rule A visual pre-operation inspection should be done prior to use.
  - Equipment to be operated ONLY with required guarding in place.
  - Remove chuck keys, adjusting wrenches and knockout bars. Form a habit of checking for these before turning on the lathe.
  - Cord should be checked for cracks or worn areas. Remove from operation if cord is damaged or if plug does not have proper grounding (3-prong).
- ✓ Personal Protective Equipment (PPE) shall be worn
- ✓ Machines designed for a fixed location shall be securely anchored to prevent walking or moving.
- ✓ Follow proper Lock out procedures (CFR 1910.147).
  - NOTE: If device is plug in and plug is under exclusive control of the person performing the work, unplugging the machine will suffice. If person performing the work needs to leave the machine before work is complete, proper LOTO procedures are to be followed.
- ✓ Install awareness devices (signage, barriers, etc.) around saw.

- ✓ Instruct operators not to wear loose fitting clothing (short sleeves preferred), jewelry (including rings and watches) or gloves.
- ✓ Instruct operators with long hair to secure in a cap or hair net.

Operating Precautions

- ✓ Do not use stock that has splits, cracks, or knots. Allow glued joints to dry before working on stock.
- ✓ Hold tools firmly in both hands.
- ✓ Keep all cutting tools, blades and cutters sharp for the best performance.
- ✓ Make sure the tool rest is set close to the stock. Work only in the area covered by the tool rest; do not attempt to support the tool with your hands. Adjust the tool rest when the lathe is not running.
- ✓ Check that all locking devices on the tailstock and tool rest assembly (rest and base) are tight before operating the lathe.
- ✓ Make sure the blank is securely fastened.
- ✓ Rotate your work piece by hand to make sure it clears the tool rest and bed before turning the lathe on. Be certain that the work piece turns freely and is firmly mounted.

ALWAYS CHECK THE SPEED OF THE LATHE BEFORE TURNING IT ON. Use slower speeds for larger diameters or rough pieces, and higher speeds for smaller diameters and pieces that are balanced.

Always start a piece at a slower speed until the work piece is balanced. If the lathe is shaking or vibrating, lower the speed. If the work piece vibrates, always stop the machine to check the reason. As a starting point, consult your operator's manual for recommended speeds for a particular lathe. Make sure the lathe speed is compatible with the size of the blank.

Never make any adjustments other than changing speed while the lathe is turning. Never adjust the tool rest or tailstock while the lathe is turning

6.4 Assembling

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 [Appendix C].

CHAPTER- SEVEN

COST ANALYSIS

The cost analysis is used to determine the overall costs of the machine after manufacturing. The total cost the produced machine can be determined by;

1. The costs of raw materials and the cost of standard items.
2. Operation process
3. Costs of power consumption and consumable materials
4. Labor costs
5. Machine depreciation cost.

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

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

The costs of this material are based on data obtained from:-

- ✓ Local market
- ✓ Our experience
- ✓ Purchased cost

It is unrealistic to believe we can design an appropriate wood lathe machine without input and budget. In addition to the activities and materials needed to design, manufacture the prototype, we will be able to travel to some villages and perform realistic user studies, stationary, material costs, printing costs, binding expenses, travel expenses, per dime payments.

Table 7.1 Consumable material cost

S.N	Items Needed	Specification	Unit	Qt	Unit price		Total price		Remark
					Birr	cent	Birr	cent	
1	Mild Steel sheet metal	1000x 1000 x5mm	Pcs	1	2000	00	2000	00	
2	Mild Steel RHS	100x60x6000mmx3mm	Pcs	1	1000	00	1000	00	
3	Mild Steel RHS	60x60x6000mmx3mm	Pcs	2	500	00	1000	00	
4	Aluminum Ingot	Ø150mmx300mm	Pcs	1	1000	00	1000	00	
5	Aluminum Ingot	Ø80mmx300mm	Pcs	1	500	00	500	00	
6	Mild Steel Angle bar	5x50x50mm, length 500mm	Pcs	1	41	67	41	67	
7	Mild Steel round bar	Ø100mm, length 100mm	Pcs	1	700	00	700	00	
8	Mild Steel round bar	Ø60mm, length 250mm	Pcs	1	600	00	600	00	
9	Mild Steel round bar	Ø30mm, length 500mm	Pcs	1	600	00	600	00	
10	Mild Steel round bar	Ø12mm, length 500mm	Pcs	1	100	00	100	00	
11	GI Pipe	Ø1¾", length 250mm	Pcs	1	25	00	25	00	
12	GI Pipe	Ø1½", length 250mm	Pcs	1	20	00	20	00	
13	GI Pipe	Ø1¼", length 250mm	Pcs	1	16	00	16	00	
14	GI Pipe	Ø1", length 250mm	Pcs	1	12	00	12	00	
15	Mild Steel Electrode	Ø3.2mm, MT-12	Pack	1	180	00	180	00	
16	Mild Steel Electrode	Ø2.5mm, MT-12	Pack	2	130	00	260	00	
17	Welding wire	Ø2.5mm	Kg	1	50	00	50	00	
18	Emery cloth	P120	meter	1	20	00	20	00	
19	Anti-rust paint	Mega, gray color	Kg	1	150	00	150	00	
20	Metal paint	Mega, green color	Kg	1	230	00	230	00	
21	Thinner	Abro	Gallon	1	80	00	80	00	
22	Body filer oil	Standard	Kg	1	120	00	120	00	
23	Hair Brush	2"	Pcs	2	15	00	30	00	
					TOTAL		**8734**	**67**	

Table 7.2 Standard item cost

No	Name of material	Size	Unit	Qty	Unit price		Total price	
					Birr	**Cent**	**Birr**	**Cent**
1	Hexagonal bolt and nut	M16x2, length 150mm	pcs	2	25	00	50	00
2	Hexagonal bolt and nut	M12x1.75, length 100mm	pcs	6	20	00	120	00
3	Hexagonal bolt and nut	M10x1.5, Full thread length 70mm	Pcs	10	15	00	150	00
4	Hexagonal bolt and nut	M10x1.5, Full thread length 40mm	Pcs	10	12	00	120	00

5	Hexagonal bolt and nut	M8 x125, Full thread length 40mm	Pcs	10	10	00	100	00
6	Hexagonal bolt and nut	M6x1, Full thread length 100mm	Pcs	10	8	00	80	00
7	Plain washer	For M6	Pcs	10	2	00	20	00
8	Plain washer	For M8	Pcs	10	2	00	20	00
9	Plain washer	For M10	Pcs	20	3	00	60	00
10	Spring washer	For M12	Pcs	12	3	00	36	00
11	Plan washer	For M16	Pcs	12	3	00	36	00
12	Ball bearing	SKF No. 6203	pcs	4	150	00	600	00
13	Ball bearing	SKF No. 6205	pcs	2	175	00	350	00
14	Grinding disk	Ø 180x22x6.5mm	Piece	1	45	00	45	00
15	Grinding disk	Ø 180x22x3mm	Piece	3	45	00	135	00
16	Grinding disk Cutter	Ø 550x22x3mm	Piece	1	80	00	80	00
17	Drill Bit	HSS, Ø6mm	Pcs	3	20	00	60	00
18	Drill Bit	HSS, Ø8mm	Pcs	2	25	00	50	00
19	Drill Bit	HSS, Ø10mm	Pcs	2	30	00	60	00
20	Drill Bit	HSS, Ø12mm	Pcs	2	35	00	70	00
21	V-Belt	A-41	Pcs	1	200	00	200	00
22	Single phase motor	2950rpm, 2HP	pcs	1	4000	00	4000	00
23	On/Off push button	Green and Red	Pcs	1	180	00	180	00
24	Electric cable	Stranded, Single phase,3x2.5mm^2	meter	6	75	00	450	00
							Total cost=7022.00	

7.2 Operation process costs

The operation process costs are the costs of machine which is used to produce overall parts of the universal woodworking machine and it includes:-

- Start and stop time of the machine
- Loading and unloading costs
- Cleaning time costs

Table 7.3 Machine operation time used to produce the components of the machine

No	**Operation**	**Total working hr.**
1	Cutting on power hacksaw	3 hrs.
2	Turning and boring on lathe	4hrs
3	Drilling on radial drill	4hrs
4	Shielded metal arc welding	12hrs
5	Shearing on sheet metal shears	3hrs
6	Grinder on portable grinder	9hrs
	Total	**35hrs**

Table7. 4 Machine cost per hours

No	**Operations**	**Cost of a machine per hour in birr**	
		birr	**Cent**
1	Cutting on power hacksaw	30	00
2	Turning and boring on lathe	50	00
3	Drilling on radial drill	25	00
4	Shielded metal arc welding	20	00
5	Shearing on sheet metal shears	25	00
6	Grinder on portable grinder	15	00

- ✓ **The machine cost of each machine**

1 .Power hack saw/Cp/------------------------------------working hours-6hrs

$$Cp = 3hrs\ x\ 30birr$$
$$Cp\ = 90birr$$

2. Lathe machine /Lmc/------------------------------------working hours-4hrs

$$Cl = 4hrs\ X\ 50birr$$
$$Cl = 200birr$$

3. Column drilling machine/Cdm/-----------------------working hours-6hrs

$$Cd = 4hrs\ X\ 25birr$$
$$Cd = 100birr$$

5. Arc welding machine/Cw/---------------------------working hours-12hrs

$$Cw = 12hrs\ X\ 20birr$$
$$Cw\ \ = 240birr$$

6. Sheet metal shear/CS/-------------------------------------working hours-3hrs

$$CS\ = 3hrs\ X\ 25birr$$
$$Cs = 75birr$$

7. Portable grinder/---working hours-9hrs

$$Cg\ = 9x15birr$$
$$Cg = 135birr$$

Total machine cost is 840birr

7.3 labor cost

Table 7.5 Estimated cost for a person (for machinist or fabricator) machine operation

No	Description	Operation cost of a machine in birr	
		Birr	cents
1.	Labor cost per person/hour	50	00

Table 7.6 The working hours of the improved electric wood lathe machine

No	Types of work	Total time
1.	Layout work	16hrs
2.	Machine work	16hrs
3.	Bench work	15hrs
4.	Assemblies	16hrs
5.	Miscellaneous	10hrs
Total labor hours		**73hrs**

Total Labor Costs are /TLC/ = working hours-13 hrs and 5min

$$Tlc = 73hrs\ X\ 50birr$$

Tlc $= \mathbf{3650birr}$

7.4 Machine depreciation cost

The expected machine depreciation cost in our case is 120Birr

7.5 Sub- Grand Total cost of the machine

= 8734.64 + 7022.00 +3650.00 +840.00 +120.00

= **20366.64** Birr

- ✓ Contingences =15% **x**20366.64 birr = 3054.96
- ✓ Total costs of the machine = 20366.64+3054.96 **= 23421.6Birr**

The Current cost of the wood lathe machine in the market made in china 60,000 – 65000.00Birr and Germany 80000-90000.00Birr.

CHAPTER EIGHT

CONCLUSION AND RECOMMENDATION

8.1 Conclusion

This thesis project tried to search for the possible design and manufacturing method that can be adapted and duplicated by SMEs to full fill their knowledge gap to manufacture it and market demand.

Specifications of existing machines are tabulated and selected Wood Lathe 1 Meter - Starter Kit (40” WOOD LATHE Model No.CWL 1000) and Wood Lathe Model W1758machines as bench mark to make comparison with improved electric wood lathe machine. While designing the machine, materials are selected considering optimum performance, availability, and cost and convince of manufacturing method as well. In engineering analysis, the basic assumption is to ensure whether the selected materials type, size, mechanisms, and weld designs are safe enough in strength to accomplish the intended functions of the machine. Furthermore, the required maintenance for machine is prescribed as per requirement.

The comparison of the cost of the newly prototype machine with the existing; the fabricated machine is cheaper than the imported Wood Lathe Model W1758; as prototype machine costs 23421.6 Eth.Birr and the imported Wood Lathe Machine Model MP-1000WC is 65000.00 birr made in China. Besides, the cost will minimize even more than that when it is produced. Generally, the equipment designed is portable, affordable and easy to maintain. Evaluation and test was carried out, thus having result for days of the testing of straight turning, drilling and boring the wood work-pieces. The reversed wood turning machine is analyzed and manufactured by following the reverse engineering principle and procedures to make long service life, efficient, cost effective and ergonomically convenient. The reverse engineering and manufacturing of this machine is to provide to solve the problem stated in the literature review as a whole and to attain the objectives stated.

The various parts of the machine are easy to manufacture in the workshop. But it requires good technical skills in engineering drawing and machine design. The machine is cheap and does not contain intricate and expense parts. It is therefore easy to construct.

8.2 RECOMMENDATION

From the project, performance test and result analysis been carried out, modification still needs to be done on the machine in order to increase machines efficiency.

The modifications are as follows;

1. A better way of mounting the swivel headstock that can turn greater diameters for boring operation.
2. A better locking device for the tailstock using of cam mechanism.
3. A wood lathe that can turn different diameters of work-pieces at variable speeds.
4. There are flying objects which can lead to injury during operation for operators. Thus, is should be made of plastic safety guard on the front part of the machine.

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APPENDIX: A

Question for data collection

Site of data collection: Adama

Dear participant:

The main aim of this questionnaire is to gather information or data about wood lathe machine for the project work of manufacturing Post Graduate project to design and manufacture the wood lathe machine at Adama Science and Technology University with modifying part of the machine. For the ideas that you will give us genuine information about the demand and importance of this machine, we would like to thank you in advance.

Direction

Tick √ in the given box.

Part I. Personal characteristics (Demography)

1. Sex: Male ☐ Female ☐

2. Age: 15 -20 ☐ 21 – 30 ☐ 31 – 40 ☐ Above 40 ☐

3. Educational qualification level:

- Under graduate (Degree) ☐ Diploma ☐

- Postgraduate (Master) ☐ Certificate ☐ By experience ☐

We prepared Questionnaire for those who use wood lathe Machine in Adama cities. In order to answer the questions easily or to minimize ambiguity that prepared with national language.

Part-II Questionnaires

1. For how long do you this machine?

A. Below one year   C. Up to three years

B. Up to two years   D. Four and above that

2. If there is work for how much time per day did you use this machine?

A. Below three hours   C. form 6 up to 8 hours

B. form 4 up to 6 hours   D. Above 8 hours

3. At first time when you purchase the machine do you get it easily on the market?

A. Yes B. No I can't find it easily on the market

4. Do you get all spare parts easily on the market

A. Yes

B. Most parts dose not found on the market

C. Some parts are available and some are not

5. How often do you maintain the machine? Do you use maintenance program?

A. I don't have maintenance program C. after 2-3 years used

B. After one year service D. I never maintain the machine

6. When you compare total price with the machine service?

A. Very high C. It is medium

B. It is fair D. it is low

7. Is that easy to assemble and disassemble the machine for maintenance

A. Very comfortable C. medium

B. little comfortable D. very difficult

8. When you use the machine, is it ergonomically comfortable, is there any ergonomic factors?

A. Yes C. little discomfort to use it

B. It is medium D. very hard to use it

9. Is there any difference between the method before you use and now on you use the machine?

A. Yes B. there is No difference

10. If your answer is Yes will you explain the difference?

____

11. What are the most problems you face when you use this machine?

____

12. Which part of the machine did most of the time break down?

____

13. How much time per day do you save when you use this machine?

____

14. How do you purchase this machine is it direct from the market or by ordering?

____

15. If you have other opinion which is not mentioned by us

____

Part -III Structured Interviews

The purpose of this questioner is to gather information or data about wood lathe machine for thesis work on design and manufacture in Adama science and Technology University with modifying some parts of the machine

1. For how long do you use this machine and also for what type of wood do you use it (is it for all type of wood)?
2. Have you ever conducted training on the use of this machine or do you use it with only through experience?
3. If it is experience have you ever tray to conduct training?
4. Are you interested to purchase the machine if you get it in low cost from small enterprises?
5. If the machine break down do you have other alternative way to use?
6. When you compare the price to purchase this machine and the use is it balance with the price?
7. If you have other opinions which are not mention by us?

We prepared Questionnaire for those who use wood lathe Machine in Adama City. In order to answer the questions easily or to minimize ambiguity that prepared with national language

ይህንን መጠይቅ ለመሙላት ስለተባበሩን በቅድሚያ ከልብ እናመሰግናለን

የመጠይቁ አላማ ስለ እነጨት ስራ ማሽን የማስተር የመመረቅያ ፕሮጀክት ድዛይን አድርገን ልናመርት ስለሆነ በዚህ ዙርያ ስለማሽኑ ጥቅምና ተፈላጊነት ላይ ያተኮረ ጥናት እያደረግን ስለሆነ የበኩልዎን ለሚሰጠን ትክክለኛ መረጃ በቅድሚያ እናመሰግናለን፡፡

መጠይቁን ሲሞሉ ግልጽ በሆነ መንገድ በማብራራት ቢገልጹና ምርጫ ያለውን መጠይቅ ሲመልሱ መልሱን የያዘውን ፊደል በመክበብ ይሆናል

ክፍል አንድ

የ -√ አምልክት ያድርጉ ፡

1. ጾታ፡ወንድሴት ☐ ☐

የትምህርት ደረጃ ፡ ድግሪ ☐ ዲፕሎ ☐ ሰርትፊከት ሌላ ☐

ክፍል ሁለት

1. ይህንን ማሽን ለምን ያህል ጊዜ ተጠቅመዉታል?

ሀ. ከአንድ ዓመት በታች ለ. እስከ ሁለት ዓመት ሐ. እስከ ሶስት ዓመት

መ. አራትእናከዚያበላይ

2. ሥራአለከተባለማሽኑንበቀንለምንያህልሰዓትይጠቀማሉ?

ሀ. ከሶስት ሰዓት በታች ለ. ከ4-6 ሰዓት ሐ. ከ6-8 ሰዓት መ. ከ 8 ሰዓትበላይ

3. በመጀመሪያ ማሽኑን ሊገዙ ሲወጡ በቀላሉ በገበያ ላይ አግኝተዉት ነበር?

ሀ. አዎን ለ. በቀላሉ ላገኘዉ አልቻልኩም

4. ለማሽኑ የመለዋወጫ ዕቃ (spare part) እንደልብ በገበያ ላይ ይገኛል?

ሀ. አዎን ለ. አብዘሀኛዉን አይገኝም ሐ. አንዳንዱሲገኝአንዳንዱግን አይገኝም

5. የሚያስፈልገዉን ጥገና በምንያህል ጊዜ ያደርጉታል? በፕሮግራምስ ይመራሉ?

ሀ. ፕሮግራም የለኝም ለ. አንድ አመት ካገለገለ በኃላ ሐ. ከ 2-3 ዐመት አገልግሎት ከሠጠ በኃላ

መ. ጥገና አድርጌ አላዉቅም

6. ለማሽኑ የዋለዉ አጠቃላይ ወጪ ከሚሰጠዉ አገልግሎት ጋር ሲነጻጸር የሚሰጠዉ ጥቅም_________________?

ሀ. ከፍተኛነዉ ለ. አጥጋቢነዉ ሐ. መካከለኛነዉ መ. ዝቅተኛነዉ

7. ከጥገና፤በታከመቀየር፤ማሽኑንበቀላሉለመገጣጠምናለመፈታታትእንዲሁምለመጠገንአመችነዉ?

ሀ. በጣምአመቺነዉለ. መካከለኛነዉሐ. ትንሽያስቸግራልመ. በጣምያስቸግራል

8. ማሽኑንለመጠቀምከጥንቃቄናከምቾትአንጻርተስማሚነዉ?(Ergonomics factor)

ሀ. አዎንለ. መካከለኛነዉሐ. ትንሽያስቸግራልመ. በጣምያስቸግራል

9. ከዚህበፊትከሚጠቀሙትማሽንናአሁንበሚሰሩበትመካከልየተለየነገርአግኝተዋል?

ሀ. አዎን   ለ. አላገኘሁም

10. ለ9ኛ ጥያቄ አዎን ከሆነ ያገኙትን ነገር ይግለጹልን?

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11. ለብዙ ጊዜ ማሽኑን በሚጠቀሙበት ሰአት የሚያጋጥምዎት ችግር ምንድንነዉ?

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12. አብዛኛዉን ጊዜ የሚበላሸዉ የትኛዉ የማሽን ክፍል ነዉ?ምን አይነት ጥገና ይጠቀማሉ?

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13.ይህንን ማሽን በመጠቀም በቀን ምነያህል ጊዜ ይቆጥባሉ?

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14. ይህንን ማሽን እንደትነዉ የሚገዙት ቀጥታ ከገባያ ወይንም በትእዛዝነው ቢገልጹልን?

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15. እዚህ ማሽን ላይ ቢጨመር ጥሩነዉ ብለዉ የሚያስቡት ነገር ካለ ቢገልጹልን?

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APPENDIX: B DETAIL DRAWING

APPENDIX: C ASSEMBLING DRAWING