ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

SCHOOL OF MECHANICAL, CHEMICAL AND MATERIAL ENGINEERING

A Project thesis

On

DESIGNING AND MANUFACTURING OF COBBLE STONE CUTTING MACHINE

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

Masters of Science

in

Manufacturing Technology Teachers Education

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External Examiner	**Signature**	**Date**

DECLARATION

We hereby declare that the work which is being presented in this project entitle "**COBBLE STONE CUTTING MACHINE** ", is developers original work and has not been presented for a diploma / degree of any other Institution/University and we have acknowledged and referenced all materials used in this work.

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

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ABSTRACT

Nowadays in Ethiopia and most third world (developing) country cobble stone is the most preferable construction material for road construction and house building. Currently the cobble manufacturing is almost in traditional way, using hand hammer and cutting tools (chisels) which results, wastage, occupational accidents (ergonomic problem), less aesthetic value, improper utilization of human labor resources are the basic determinant problems, thus better way of cobble stone manufacturing method should be scarded for. The general objective of the project is to design and manufacture /provide/ portable and less cost cobble stone cutting and shaping machine which increase the production rate as compared to traditional method replacing the labor force by means of motor power driven machine and demonstrate the working principle of the cobblestone cutting machine. *There are a number of basic problems in using the existing (commercial available) cobble stone cutting machine. The problems with this are its size or (huge), Costly, due to its size it is not portable (cannot be easily moved from place to place), and then the manufacturers (micro and small enterprise) or contractors do not like to purchase this machine.* This project enables to Increase productivity, develop designing and manufacturing skill, Increase income for micro and small enterprise those who works in cobble stone production activities, Reduce cost by using local available materials, Substitute other import machines. This is beneficial to save foreign exchange currency. *Generally the aim of our project is to solve and minimize the described problems by clearly identifying the problems gathering information in different methods such as questioner, interview and observation. The information gathered is analyzed and used as an input for the design of the cobble stone cutting machine and it will solve the problems within the existing cobble stone cutting machine, protects workers who are engaged in the production of cobble stone using hand hammers, it creates an environment of easily accessible machine in low cost, portable and ergonomically suited cobble stone cutting machine in the market for both small and micro inter prices and for TVET institutions.*

KEY WORDS:-TVET-Technical and vocational education training.

-MSE- Micro and Small Enterprise

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ACRONYMS

IS………………………………..Indian Standard

ASTU……………………………Adama Science and Technology University

WF……………………………....Weight factor

AC……………………………….Alternative Current

RPM……………………………...Revolution per Minute

TVET…………………………….Technical Vocational Education and Training

ASTM…………………………….American Society of Testing Method and Material

CHAPTER- ONE

INTRODUCTION

1.1 Background

Since the beginning of civilization, man has felt the need to travel. Civilizations around the world constructed roads, paved with varied materials. Cobblestones have been a popular choice for streets and sidewalks for centuries. Cobblestones are small to medium-sized stones used as paving material for streets and walkways. Walls and buildings have also been built of cobblestone, and are often found in areas that had access to large smoothed stones from river beds or coastal areas.

Cobblestones are made from highly durable stones, usually granite or basalt. They were usually dug from nearby areas and then cobbled, or roughly shaped into the size needed. The cobblestones were then set in sand or mortar. Sand allows the road to gently give to traffic, preventing the cracking associated with pavement or asphalt. Streets paved with cobblestones have proven their durability and longevity by showing up through worn out sections of paved roads throughout the world. The term cobble is a geological term used to describe a stone of a particular size, which is approximately two and a half to ten inches (.64 to 256 millimeters). Colors range from gray to black to purple, depending on the origin of the stone. Patterns in cobblestone streets depend on the creativity of the workers who designed the streets and installed the cobblestones.

Many European cities, towns and villages never quite got on board with the asphalt revolution, and to this day maintain beautiful and unique cobblestone streets and sidewalks, much to the delight of tourists and locals. In fact, a tourist would be hard pressed to find a city or town in Europe that doesn't have surviving cobblestone roads or sidewalks. [1]

Walking on cobblestone is the fastest way of traveling on foot (up to 17.3Km/h on a flat tile). Cobblestone can only be removed or terra formed by a player with 20 Body Strength and 10 Digging.

If aesthetics and durability were not enough, there has been a recent study supporting cobblestone streets for another reason. The study found that walking on cobblestone-simulated mats improved participants' physical performances and balance due to the uneven surface. This led to an improvement in blood pressure, as well as other health benefits. Cobblestone is easier to create than stone slabs, which has an identical travel speed. For these reasons, cobblestone is widely used when making permanent roads, paths, or courtyards. [2]

1.2 Statement of Problem

Nowadays in Ethiopia and most third world country cobblestone is the most preferable construction material for road construction, and house building. But, since the commercially available cobble cutting machine is costly, huge to move from place to place and minimum supply in the market, the cobble manufacturing method in general is traditional way; using the hand hammer and cutting tool cobblestone workers shape and cut the coble stone. This way of coble stone manufacturing system causes

- Increasing wastage of raw material/stone
- Less production quality
- Less aesthetics value
- The block efficiency varies due to the cutting method
- Occupational accidents are occurring
- Improper utilization of human labor/human labor wastage
- Low production rate and time wastage.

Generally the aim of our project is to solve and minimize the described problems above by creating of easily accessible machine in low cost, portable and ergonomically suited cobble stone cutting machine in the market for both small and micro enterprises and for TVET institutions.

1.3 Objectives of the study

1.3.1General objective

The general objective of the project is to design and manufacture /provide/ portable and less cost cobble stone cutting and shaping machine which increase the production rate as compared to traditional method replacing the labor force by means of motor power driven machine and demonstrate the working principle of the cobblestone cutting machine.

1.3.2 Specific objective

- Determining and measuring the property of stone which is used for cobblestone;
- Design and manufacturing of stone cutting and shaping blade;
- Determining the number of motors to be used;
- Designing and adaptation of a stone cutting machine using local material
- Design and selecting of appropriate materials to improve quality of the machine, cost, and size of the machine for its portability.

1.4 Scope of the Project

The project's intention is to design and manufacture cobblestone cutting machine based on the existing machine by minimizing the size and materials in order to make it to be portable and cost effective. Our target groups are micro and small enterprise/MSE/ who are engaged in cobble stone production/manufacturing/, government road construction authority, TVET institutions and individual contractors.

1.5 Methodology

Surveying different literature (journal and book) about the cobblestone cutting machine design consideration study the property of stone that used for cobble in Ethiopia surveying information about the current situation on the coverage cobblestone road in our country Ethiopia and forecast for the future

- Data collection on the current cobblestone manufacturing /production/
- Group discussing with Adama road construction agency and Adama town municipality

- Questioners (customer, currently cobble manufacturing /production/ sectors)
- By using internet and others secondary data collection methods Detail design of our cobblestone cutting and shaping machine

This detail design also include the following main category

1. Geometric analysis /with free hand sketching its 2D drawing of our machine
2. Motor selection and determine the blade path
3. Determining the power transmission mechanism
4. Material selection for each component based on the geometric analysis and the property of the stone
5. Stress analysis that are occurred on each components
    - Shearing and crushing stress on the table
    - Tensile and bending stress on the shaft
    - Crushing stress on the blade
6. Part drawing for each component
7. Manufacturing method and lubrication system
8. Cost analysis
9. Method of Assembly drawing
10. Material and software to be used for our work

1.6 Significance of the project

Nowadays, in Ethiopia and most third world (developing) country cobble stone is the most preferable construction material for road construction and house building. Currently the cobble manufacturing is almost in traditional way, using hand hammer and cutting tools(chisels) which results, wastage, occupational accidents(ergonomic problem),less aesthetic value, improper utilization of human labor resources are the basic determinant problems in this way of cobble stone manufacturing method.

Though the possible solution for this is using appropriate cobble stone cutting machine and there are basic problems in using the existing (commercial available) machine. The problems with this are it is huge and it is Costly due to its size it is not portable (cannot be easily transport from place to place)

In general, SMEs can duplicate the machine and sel to the market and users of the machine can get optimum efficiency with minimum cost.

This project enables to:

- Increase productivity
- Develop designing and manufacturing skill
- Increase income for micro and small enterprise those who works in cobble stone production activities
- Reduce cost by using local available materials
- Substitute other import machines. This is beneficial to save foreign exchange currency.

1.7 Limitations of the project

The improved machine has some limitations as:

- Limited budget and time constraint;
- Shortage of accurate machineries;
- There is no enough research works and materials on cobble stone cutting machine;
- The depth of cut that the cutter can perform at one path is limited to maximally 15cm
- The transversal movement of stone is manual.
- The coolant system doesn't circulate.

1.8 Organization of the Project

This thesis is composed of eight chapters. The first chapter presents introduction of the thesis, back ground, problem statement, objectives, scope and significance of the project. Chapter two discusses related literature review of the project. The third chapter presents the research methodology employed to achieve the thesis objective including instrument development, sample selection, data collection and analysis. Chapter four introduces design analysis and material selection of critical components. Chapter five addressed manufacturing process for critical components and maintenance of the project. The sixth chapter computes the total cost by adding costs of raw materials and standard items, labor cost for manufacturing and assembling components, electrical power consumption cost and machine depreciation cost to manufactured parts required for fabricating the project procedures of assembling components. Chapter seven covers result and discussion. Chapter eight give a short recommendation and conclusions.

CHAPTER- TWO

LITERATURE REVIEW

2.1 Definition of cobble stone

Cobble stone means a naturally rounded stone larger than a pebble and smaller than a boulder, formerly used in paving.

Cobble stone are stones that were frequently used in the pavement of early streets. "Cobble", the diminutive of the archaic English word "cob", meaning "rounded lump", originally referred to any small stone rounded by the flow of water; essentially, a large pebble. It was these smooth "cobbles", gathered from stream beds that paved the first "cobblestone" streets. In England, it was commonplace since ancient times for flat stones with a flat narrow edge to be set on edge to provide an even paved surface. This was known as a 'pitched' surface and was common all over Britain, as it did not require rounded pebbles. Pitched surfaces predate the use of regularly-sized granite setts by more than a thousand years. Such pitched paving is quite distinct from that formed from rounded stones - although both forms are commonly referred to as 'cobbled' surfaces. Most surviving genuinely old 'cobbled' areas are in reality pitched surfaces. Most commonly used types of stone in roading are shown in figure 2.1 below.

Setts are often idiomatically referred to as "cobbles", although a sett is distinct from a cobblestone by being quarried or shaped to a regular form, whereas cobblestone is generally of a naturally occurring form. Note that *cobble* is a generic geological term for any stone having dimensions between 2.5 and 10 inches (6.4 and 25.4 cm).

Figure 2.1 Types of stone use in roading

Cobblestones are typically either set in sand or similar material, or are bound together with mortar. Paving with cobblestones allows a road to be heavily used all year long. It prevents the build-up of ruts often found in dirt roads. It has the additional advantage of not getting muddy in wet weather or dusty in dry weather. Shod horses are also able to get better traction on stone cobbles, pitches or sets than tarmac/asphalt. The fact that carriage wheels, horse hooves and even modern automobiles make a lot of noise when rolling over cobblestone paving might be thought a disadvantage, but it has the advantage of warning pedestrians of their approach. In England, the custom was to strew the cobbles outside the house of a sick or dying person with straw to dampen the sound.

Cobblestones set in sand have the environmental advantage of being permeable paving, and of moving rather than cracking with movements in the ground. [3]

Use today

Cobblestones were largely replaced by quarried granite setts (also known as Belgian block) in the nineteenth century. The word cobblestone is often wrongly used to describe such treatment. Setts were relatively even and roughly rectangular stones that were laid in regular patterns. They gave a smoother ride for carts than cobbles, although in heavily used sections, such as in yards and the like, the usual practice was to replace the setts by parallel granite slabs set apart by the standard axle length of the time.

Cobblestoned and setted streets gradually gave way to macadam roads, and later to tarmac, and finally to asphalt concrete at the beginning of the 20th century. However, cobblestones are often retained in historic areas, even for streets with modern vehicular traffic. Many older villages and cities in Europe are still paved with cobblestones or pitched. In recent decades, cobblestones have become a popular material for paving newly pedestrian zed streets in Europe. In this case, the noisy nature of the surface is an advantage as pedestrians can hear approaching vehicles. The visual cues of the cobblestones also clarify that the area is more than just a normal street. The use of cobblestones/setts is also considered to be a more "up market" roadway solution, having been described as "unique and artistic" compared to the normal asphalt road environment.

In older U.S. cities such as Philadelphia, Boston, Pittsburgh,[4]New York City, Chicago, San Francisco, Portland, (Maine), Baltimore, Charleston, and New Orleans, many of the older streets are paved in cobblestones and setts (mostly setts); however, many such streets have been paved over with asphalt, which can crack and erode away due to heavy traffic, thus revealing the original stone pavement.

In some places such as Saskatoon, Saskatchewan, Canada, as late as the 1990s some busy intersections still showed cobblestones through worn down sections of pavement. In Toronto streets using setts were used by streetcar routes and disappeared by the 1980s, but still found in the distillery district.

Many cities in Latin America, such as Buenos Aires, Argentina; Zacatecas and Guanajuato, in Mexico; Old San Juan, Puerto Rico and Montevideo, Uruguay, richly influenced by many European architectural features, are well known for their many cobblestone streets, which are still operational and in good condition. They are still maintained and repaired the old fashion way, by placing and arranging granite stones by hand.

Cobblestone roads are a decisive element in some of the biggest professional cycling races. The Tour of Flanders and Paris–Roubaix are especially well known for their many long cobblestone sections.

In the Czech Republic, there are old cobblestone paths with colored marbles and limestone's. The design with three colors (red/limestone, black/limestone, and white/marble) has a long tradition in Bohemia. The cubes of the old ways are handmade. [4]

Measurement of Physical Properties

The various physical properties of dimension stones are tested by means of the procedures documented by ASTM. ASTM also publishes standards for the major stone types, listing the minimum/maximum values to be expected from a particular stone type in a particular test. The standard specifications are listed on table (2.1). It should be noted that there are many stones that do not meet these values, yet have demonstrated satisfactory performance in a variety of applications. This table should then be considered to be more of a general guide than an absolute pass/fail gauge (2.1). [5]

		Absorption (max) per ASTM C 97	Density (min) per ASTM C 97		Modulus of Rupture (min) ASTM C 99[9][10]		Compressive Strength (min) ASTM C 170		Abrasion Resistance (min) ASTM C 241	Flexural Strength (min) ASTM C 880	
Stone Type	ASTM Standard	%	lbs/ft^3	kg/m^3	lbs/in^2	Mpa	lbs/in^2	Mpa	H_a	lbs/in^2	Mpa
Granite	ASTM C 615	0.40%	160	2,560	1,500	10.34	19,000	131	25	1,200	8.27
Marble	ASTM C 503	0.20%	162	2,590	1,000	6.89	7,500	52	10	1,000	6.89
Limestone[1]	ASTM C 568	12.00%	110	1,760	400	2.76	1,800	12	10	n/a	n/a
Limestone[2]	ASTM C 568	7.50%	135	2,160	500	3.45	4,000	28	10	n/a	n/a
Limestone[3]	ASTM C 568	3.00%	160	2,560	1,000	6.89	8,000	55	10	n/a	n/a
Quartz-Based[4]	ASTM C 616	8.00%	125	2,000	350	2.41	4,000	28	2	n/a	n/a
Quartz-Based[5]	ASTM C 616	3.00%	150	2,400	1,000	6.89	10,000	69	8	n/a	n/a
Quartz-Based[6]	ASTM C 616	1.00%	160	2,560	2,000	13.79	20,000	138	8	n/a	n/a
Slate[7]	ASTM C 629	0.25%	n/a	n/a	9,000	62.05	n/a	n/a	8	n/a	n/a
Slate[8]	ASTM C 629	0.45%	n/a	n/a	7,200	49.64	n/a	n/a	8	n/a	n/a

Table 2.1 dimension stone testing value per ASTM/American Society of Testing Method and Material/ standard specification

Cobble is a geological term used to describe a stone of a particular size, and shape which is approximately two and a half to ten inches (.64 to 256 millimeters) rectangular and square shaped (figure2.2).

Figure 2.2 Shape of cobblestone

Slab/strip production from blocks in natural stone processing plants is mostly carried out by using circular saw blade cutting machines. An efficient sawing operation can only be maintained by selecting proper cutting parameters. Experimental studies and numerical modeling methods are significant in terms of identifying the effective forces occurring during natural stone cutting with circular saw blades. In this study, experimental investigation was performed on real marble, known as Afyon White Marble, using a fully automatic circular saw blade stone cutting machine. Then, numerical modeling of circular sawing was performed with commercially available software called PFC3D. A discrete-element model of the sawing process was developed, and various numerical models were performed for different peripheral speeds and advance rates in compliance with the actual cutting operation being carried out in the laboratory. Finally, data obtained from the experimental studies were compared with the modeling data. A comparison indicates that the reaction cutting forces obtained by means of the numerical modeling are in good agreement with the results of the laboratory measurements. Consequently, the cutting operation can be determined quickly and economically. A literature review showed that, through this study, numerical modeling of the circular saw blade stone cutting process was successfully performed for the first time. It was envisaged that this would dynamically help in the examination of distinct factors in the area of natural stone processing by numerical modeling and in the illustration of the sawing mechanism. [6]

An armed-chained cutting machine is used to obtain blocks with a smooth geometrical structure in marble and travertine quarries. The machine is composed of three main parts: arm group, car group, and rail group. The part which wears most and encounters most problems during operation is the arm group. Therefore, important engineering calculations are made to extend the operational life of arm parts. After arm group parts are assembled, the car group is assembled. All parts are assembled in the appropriate sequence and in suits checks are made. In the last phase of production, the rail group is assembled. Armed-chain cutting machine are manufactured to varying specifications, and are individually designed to meet the operational requirements of specific rock types or quarry locations. Once assembled, they are subjected to post- production efficiency tests. After establishing that all parts meet the required efficiency criteria, the machine is permitted to be used in the natural stone quarries. [6]

Precision cutting with dual function laser technology

The Cobble stone cutting machine is ideally suited for both stationary and mobile work. It offers a wide range of possibilities and is therefore a highly versatile tool for professional applications. The cobble stone cutting machine can be used for the precise cutting of all kinds of concrete slabs, cobblestones, marble and granite slabs, and bricks and tiles, in a diversity of shapes and sizes. Only a few movements are required to perform both miter and double miter cuts and jolly cuts. An integrated coolant pump ensures that the diamond cutting wheel is perfectly cooled at all times while enabling you to work without interference from dust.

The swiveling cutting head enables work pieces of up to 570 mm in length to be cut with ease. The tile cutting machine is equipped with a laser which shows the exact cutting line on the material to be cut. In addition, the laser unit, which is fastened to the machine by a magnetic adapter, can also be removed from the machine and used as a laser leveler when laying flooring materials or similar. The laser unit is therefore equipped with two spirit levels for the purpose.[7]

2.2 Technical Field

The utility model relates to construction machinery and equipment, particularly to a clamped work piece can be fastened, and by adjusting the lateral adjustment means to protect accurately machined pebbles sliced.

Currently, used in cutting stone cutting machine, such as pebbles used to slice various shapes processing, it is difficult to achieve the desired effect, the existing stone cutting machine, due to its feed only with the mobile platform blade for balanced line movement is difficult to control the thickness of the slice, and no clamping device, in practical applications, the use of manpower leaning stones be cut, so that the operation unsafe, a little careless, it will make a security incidents.

For small stones, it makes harder to cut, so the existence of such a cutting machine poor adaptability, low efficiency and poor precision shortcomings.

In order to overcome the above drawbacks of the prior art, the present utility model provides a clamp fixed by pebbles, pebbles and precise slicing machine slices through the horizontal movement of the work platform to control the thickness of the slice(figure2.3)and(figure2.4).

The technical solution for solving the technical problem of the utility model is used: one cobblestone slicing machine comprising a base, the base is mounted on a lateral movement of the platform, provided with a threaded hole in the slide hole of the lateral movement of the platform, the slide hole and screw through the slider and adjust screw sets arranged in longitudinal movement of the platform surface is provided on both sides of the shaft with the screw holes in the seat; the lateral surface of the side of a mobile platform equipped with fixed clip holder, clip holder corresponding to the fixed side is equipped with support Block, located tightening the screw on the holder, at the lower end of the fastening screw with movable clamp block.

The active clamp block contact surface, the retaining clip seat contact surfaces and horizontal mobile platform consisting of a right triangle triangular face contact surface. The active clamp block contact surface, the retaining clip has a non-slip seat contact surface layer. The utility model has the advantages that: for precise slicing through the horizontal movement of the work platform to control the thickness of the slice, effectively improve the accuracy of the slices on a mobile platform equipped with lateral clamping device can be securely fixed in different shapes pebbles at work slicing processing platform. Has a simple and reasonable structure, high precision cutting, manipulating security simple, low power consumption and high efficiency advantages, pebbles or other applicable sections of stone processing. [8]

Figure 2.3 locally manufactured available cobble stone cutting machine

Figure 2.4 Imported cobble stone cutting machine

2.3 Technology transfer

International Technology Transfer (ITT) has been a common practice and played a great role in the creation of worldwide manufacturing. ITT includes the transfer of systematic knowledge for the manufacture of a product, for the application of a process or for the rendering of a service.

Most ITT has been carried out by multinational companies for various reasons like:

- securing the supply of imported raw materials or components for its home market production (vertical integration),
- serving the host market with products, especially if import of these products would be expensive (horizontal integration),
- Serving the world market by developing manufacturing capabilities in a foreign country that has the most profitable conditions in regard to costs of labor, capital, raw materials and transport (globalization)

In making the decision to transfer a technology, the first and main step is

- The Needs Assessment –indicating the needs to be satisfied by the technology and its strategic importance.
- The technology needs specification-specifying the detailed requirements and constraints
- The specification and assessment of direct and indirect effects of the transfer of a technology
- The technology selection- considering the available technologies. [9]

2.4 History and development of coble stone cutting technology

There is only one historic context identified for inclusion in the Multiple Property Submission, i.e., the history of cobblestone masonry in New York State. Information included in the following Historic Overview is based on four main sources: Cobblestone Architecture (1944) and Cobblestone Masonry (1966) by Carl F. Schmidt, Cobblestone Landmarks of New York State (1978) by Olaf William Shelgren, Jr., et alia, and an unpublished inventory/ survey of approximately 660 cobblestone buildings/structures in New York State conducted by Robert Roudabush during the late 1970s (copies of which are on file at the Landmark Society of

Western New York in Rochester) . Excerpts from the Robert Roudabush Inventory are found at the end of this section in Appendix I. The cobblestone structures of New York State resulted from the adaptation of prevailing masonry construction technology to a special building material commonly found in Central and Western New York at the time of its settlement and early development. Cobblestones - rounded building stones of roughly 2 1/2" to 10" in length - were shaped and deposited in this part of the state by glaciers at the time of the Last Ice Age, and were readily collected as a building material by settlers who were clearing land and preparing fields for planting. The construction of the Erie Canal of 1817-1825 brought many skilled masons to the area, and the completion of that project left masonry workers available for work in building construction. Cobblestone architecture developed in the late 1820s, reached its peak of popularity in the 1830s and 1840s, and continued at a lesser pace through the 1860s, after which time it became an outdated technique, used only sporadically for repairs or additions to earlier cobblestone structures.

Geological Background; The size range for cobblestones has been established by geologists, who consider a stone of less than 2 1/2" to be a "pebble" and a stone larger than 10" to be a "boulder". The cobblestones of Central and Western New York are largely sedimentary stones of the Paleozoic Era, when the entire area was covered by a shallow sea. The limestone deposits and sediments of this period formed bedrock layers of limestone, dolomite, sandstone and shale over time. After the uplifting of these layers formed the current land mass, the exposed surfaces of these rock layers weathered, cracked and crumbled to form loose stones on the surface. The repeated periods of glaciation over the past million years ground away at the upper surfaces of these bedrock layers, and carried massive loads of stones southward before and in the glaciers, depositing them as rocky debris at the southern limit of the glaciers. Some Canadian metamorphic stones, such as gneiss and quartzite, were deposited in New York State through this process and mixed in with the sedimentary stones. Cobblestone Technology; The practice of constructing masonry walls with small stones laid in horizontal rows has precedents in England, France and Italy going back at least as far as the Romanesque Period (Schmidt, Cobblestone Masonry, p. 1, Shelgren et alia, pp.7-13).While there is no direct historical thread to trace New York State's cobblestone architecture back to a specific European precedent, there are several groups of buildings in southeastern England built in the last decade of the eighteenth century and the early part of the nineteenth century which very closely resemble their American counterparts. This type of building is known as "flint" construction in England, with the term "flints" referring to water rounded stones. Cobblestone Landmarks of Western New York by Shelgrenet alia documents a number of British examples of this building technique, some employing horizontal mortar joints tooled in a way that is similar to the New York State structures. As a general rule, the European precedents feature very simply struck horizontal and vertical mortar joints; the marked attention to careful tooling and the great variation of joint treatments appears to be unique to New York State cobblestone architecture.[10]

2.5 Types of cobblestones

Two types of cobblestones are commonly found in building construction: ice-laid or field cobbles, and water-laid cobbles. Ice-laid cobblestones are most often found in areas of drumlins - the north-south hills that characterize areas where glaciers receded, dumping their cargo. Cobblestones can be found on or just below the ground surface, or can be quarried out of a drumlin, mixed with many other sizes of rock. Water-laid cobbles are found in areas where the cobblestones were deposited in what became and may still be a lake or stream. Water-laid cobbles are significantly more smooth and rounded than field cobbles, due to the polishing action of the waves. [10]

2.6 Working principles and feasibility of the project

Technical feasibility

Hence the materials that will be used to make the machine are always available in the local market, parts can be replaced and the machine can be maintained easily In case of failure. Therefore, by taking these points in to consideration developers can say that the machine is technically feasible

Operational feasibility

The machine has no complex parts, and any person with small skills can operate the machine by taking a one or two days training. Hence the machine is operationally feasible

Economic feasibility

The materials and parts used for the machine are available in local market with a reasonable cost. In general the cost for manufacturing the machine is reasonable. Therefore team study can say that the machine is economically feasible

Efficiency

It is much more efficient in increase the production rate as compared to traditional method replacing the labor force by means of motor power driven machine

Affordability

Developers target groups are micro and small enterprise/MSE/ who are engaged in cobble stone production/manufacturing/,government road construction authority, TVET institutions and individual contractors, and they can buy with reasonable cost and operate it easily.

2.7 Maintenance of the machine

Even though maintenance engineering and maintenance have the same end objective or goal (i.e., mission-ready equipment/item at minimum cost), the environments under which they operate differ significantly. More specifically, maintenance engineering is an analytic al function as well as it is deliberate and methodical. In contrast, maintenance is a function that must be performed under normally adverse circumstances and stress, and its main objective is to rapidly restore the equipment to its operational readiness state using available resources. Nonetheless, the contributing objectives of maintenance engineering include: improve maintenance operations, reduce the amount and frequency of maintenance, reduce the effect of complexity, reduce the maintenance skills required, reduce the amount of supply support, establish optimum frequency and extent of preventive maintenance to be carried out, improve and ensure maximum utilization of maintenance facilities, and improve the maintenance organization.

To apply maintenance program, the following points should be taken in to account:-

- Why maintenance is performed?
- What type of maintenance needed?
- What time interval should be to maintain the machine?

- ❖ Which parts of the machine will be damaged frequently? So what type of maintenance will be applied?
- ❖ Knowing common tasks of preventive maintenance.

Maintenance Terms and Definitions

- ❖ Maintenance: All actions appropriate for retaining an item/part/equipment in, or restoring it to, a given condition.
- ❖ Maintenance engineering: The activity of equipment/item maintenance that develops concepts, criteria, and technical requirements in conception and acquisition phases to be used and maintained in a current status during the operating phase to assure effective maintenance support of equipment.
- ❖ Preventive maintenance: All actions carried out on a planned, periodic, and specific schedule to keep an item/equipment in stated working condition through the process of checking and reconditioning. These actions are precautionary steps undertaken to forestall or lower the probability of failures or an unacceptable level of degradation in later service, rather than correcting them after they occur.
- ❖ Corrective maintenance: The unscheduled maintenance or repair to return items/equipment to a defined state and carried out because maintenance persons or users perceived deficiencies or failures.
- ❖ Predictive maintenance: The use of modern measurement and signal processing methods to accurately diagnose item/equipment condition during operation.
- ❖ Maintenance concept: A statement of the overall concept of the item/product specification or policy that controls the type of maintenance action to be employed for the item under consideration.
- ❖ Maintenance plan: A document that outlines the management and technical procedure to be employed to maintain an item; usually describes facilities, tools, schedules, and resources.

- ❖ Reliability: The probability that an item will perform its stated function satisfactorily for the desired period when used per the specified conditions.
- ❖ Maintainability: The probability that a failed item will be restored to adequately working condition.
- ❖ Active repair time: The component of downtime when repair persons are active to affect a repair.
- ❖ Mean time to repair (MTTR): A figure of merit depending on item maintainability equal to the mean item repair time. In the case of exponentially distributed times to repair, MTTR is the reciprocal of the repair rate.
- ❖ Overhaul: A comprehensive inspection and restoration of an item or a piece of equipment to an acceptable level at a durability time or usage limit.
- ❖ Quality: The degree to which an item, function, or process satisfies requirements of customer and user.
- ❖ Maintenance person: An individual who conducts preventive maintenance and responds to a user's service call to a repair facility, and performs corrective maintenance on an item. Also called custom engineer, service person, technician, field engineer, mechanic, repair person, etc.
- ❖ Inspection: The qualitative observation of an item's performance or condition.

2.7.1. The need for maintenance

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

2.7.2. Maintenance and their functions

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

1. Inspection or checkups
2. Lubrication

3. Planning and Scheduling
4. Records and analysis

1. Inspection or Check-ups

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

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

2. Lubrication

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

3. Planning and Scheduling

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

4. Records and Analysis

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

2.7.3. The expecting problems in our machine

The main expected problems in the operations and the elements that will require maintenance activities are:-

- ❖ Bolt and nuts are loosen or easily damaged or broken;

- ❖ Bearing parts can be easily worn-out;
- ❖ During the operation, vibration might be observed;
- ❖ The belt parts might be tensioned or it will produce slippage;
- ❖ Most parts of the machine might be corroded easily;
- ❖ Improper alignment of pulley;

Due to the above problems operator must not work without taking training and without being informed of the risks, the precautions required and operating instructions for the guards and compulsory safety devices. The maintenance system should be applied regularly.

CHAPTER THREE

MATERIALS AND METHODS

3.1 Instrumental development

In-order to make successful project, exploratory research method is used to identify main issues and key variables. Exploratory research might involve a literature search or conducting focus group interviews. The exploration of new phenomena can help our need for better understanding and test the feasibility of a more extensive study, or determine the best methods to be used in a subsequent study. For these reasons, exploratory research is broad in focus and provides definite answers to specific research issues.

3.2 Sample selection

Sampling involves selecting relatively small number of elements from the large defined group of elements and expecting that the information gathered from small group allow generalization to be made about the larger group of population. (Research method for construction 3rdedition) The sampling units are the defined target population elements available for selection during the sampling process. In this research, Adama Town cobble stone producers are selected purposely as the total population since the result can be considered for the whole cobble stone producers are in the country. A total of 10numbers of cobble stone producers are randomly selected from the population working in the field. The reason why Adama Town is selected for this study is because the town is near to the university and due to limited budget and time. The sampling is selected by using systematic random sampling method.

3.3 Data Collection

Three data gathering techniques have been used to identify the problems and the need for cobble stone cutting machine; Data are collected by questionnaires (closed and open questionnaires), interviewing and direct observation. The documents which are analyzed for the project are internet, and types of reports and researches about stone cutting and cobble stone cutting machine. After gathering the quantitative and qualitative data from those sources, our project

/cobble stone cutting machine /is designed and manufactured as a solution for the shortage and expensiveness's of the machine on the market by providing portable and less costs for users.

3.3.1 Survey questionnaire

The Survey questionnaire is designed for assessing problems in production of cobble stone and to assess attitude and tendency to use the machine. The questionnaire contained objective and subjective questions. The questionnaire was distributed to different persons around us for their comment and suggestions. And then finalized according to the given comment and suggestions. Ten questionnaires were distributed randomly to persons who are involved in the cobble stone work area.

3.3.2 Interview

The aim of conducting the interview is to assess existing cobble stone production system, to investigate filling of workers and to observe overall activities on the working area. The interview is conducted or held with coordinators of the cobble stone work in Adama town and cobble stone workers who does not get questionnaire in order to cross-check with the response given on the questionnaire . Most of the questions are similar with the questions in the questionnaire.

3.3.3 Direct observation

Developers used direct observation method for gathering the required data and information from different documents. Also we have observed the traditional method of cobble stone cutting method.

3.4 Data Analysis and Interpretation

This analysis is important to get clear information from the respondents. The data collected through questionnaires, interview and direct observation are analyzed and interpreted. The finding indicates that there is no available simple and less cost cobble stone cutting machine in the market. But there is a need of this machine in the cobble stone cutting area.

Table 3.1 Data Analysis and Interpretation

No.	Questions	No. of sample size	Yes	No
1	Which type of production method /operation/ do you used to cut cobble stone?			
1.1	Manual/using hand tools/	10		100%
1.2	Using machine	--		--
2	Are the hand tools that you are using Comfortable?	10		100%
3	Are the machines that you are using Comfortable?	10		100%
4	Is there cobble stone cutting machine on the market?	10		100%
5	Have you ever used cobble stone cutting machine?	10		100%
6	Are you interested to buy cobble stone cutting machine with reasonable cost?	10		100%
7	Can you buy cobble stone cutting machine privately /individually/?	10	50%	50%
8	Can you buy cobble stone cutting machine in group /with shear/?	10%	50%	50%

According to the responds (table3.1), there is no cobble stone cutting machine rather they used traditional instruments such as chisel, hammer hack saw and so on. This traditional tool is less productive and causes tiredness. The reasons why they are using these tools are due to unavailability of the machines on the market. To improve their products for their safety, they understand that cobble stone cutting machines is very important. After studying the above need assessment we arrived on conclusion to design and manufacture portable cobble stone cutting machine with reasonable cost.

CHAPTER -FOUR

DESIGN AND MATERIAL SELECTION

4.1 Introduction to Design

Design is the activity in which engineers accomplish the preceding task, usually by responding to a design imperative for the required task. It is an activity which uses wide range of experiences knowledge and skills to find the best solution to a problem with in certain constraints.

General Considerations in Design:-

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

The improper material selection results in-Failure of the component, unnecessary cost and poor services performance. The proper material to be selected is one that meets the engineering requirements of the designers, the production and the cost requirements.

Steps in the material selection process are:-

- Analyzing of functional requirements
- Identification and screening of alternative materials
- Evaluation of the remaining candidate material.
- Development of design data for critical application.
- Material selection requires familiarity with available materials, their properties and their fabrication [11].

4.2 Material Selection

After the general lay out of the machine has been made and the mechanism to be used has been decided upon, it is necessary to select the proper material for each critical component.

This involves the consideration of many factors such as the engineering properties of materials, weight, size, shape of member, material cost, fabricating cost, overhead charges and any properties peculiar to the use of which the member is to be put. A few examples of the engineering properties to be considered are strength, stiffness, toughness, ductility, fatigue resistance, shock resistance, and weld ability.

4.1.1 Materials selection of the critical components of the machine

The criteria for material selection of the various components of the machine is based on the type of force that will be acting on them, the work they are expected to perform, the environmental condition in which they will function, their useful physical and mechanical properties, the cost and their availability in the local market or the environment.

Materials for each component are selected by using experiences, familiarities and knowledge's with the available materials of their properties, fabrication methods, functional requirements, cost and so on.

After studying and knowing the nature and functional requirement of indigenous engineering materials, the following materials are selected for the basic components of our project/ machine/.

The most critical machine elements that need design analysis in our project include motor/ Power/, Pulley, shaft, belt, and bearings.[11]

Design of Power (motor)

This project is designed to cut cobble stones size (10cmx10cm, 7cmx7cm, and 6cmx6cm) based on the need of the Customer (user individuals). Since cobble stones is a family of natural stone/ granite or marble/ with a tensile strength of 104-140n/mm^2, we recommend the consumption of power to be single phase AC motor having 600-1000 RPM and 0.7 – 3.5 Kw by considering functional requirements and the availability of Ethiopian electrical power so as to the required energy and to work for 8 hours continuously. But based on most available electric motor we preferred AC motor n = 1000 RPM and P = 2 Kw. [11]

Design of pulley

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

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

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

Candidate materials to manufacture the pulleys are Aluminum, wood, Cast iron and steel. Aluminum is light in weight, can be easily machined non-corrosive, available on market and possesses moderated strength but comparatively it is expensive than wood and steel. However, since the torque on the pulley can easily break the wood and the steel may add extra load on the Shaft and it corrodes, therefore our selected material for the pulley is Aluminum. Two different diameters of pulleys with smaller diameter on the motor shaft and larger diameter

On the cutter shaft is designed to reduce the RPM of cutter shafts to have gradual feed of the Stone piece. For the case of this design, it is decided to have a velocity ratio of 1:3. According to Indian Standards, the V-belts are made in five types i.e. A, B, C, D and E. The dimensions for standard V-belts are shown in Appendix L. So the small diameter pulley is selected from the standard table which is 75 mm. [11]

The V-belts are also manufactured in non-standard pitch lengths (i.e.in oversize and undersize). The standard pitch length belt is designated by grade number 50. The oversize belts are designated by a grade number more than 50, while the undersize belts are designated by a grade number less than 50. It may be noted that one unit of a grade number represents 2.5 mm in length from nominal pitch length.

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

VR = d/D……………………………………………………4.1

Where:

d = diameter of small pulley on the motor shaft

D = diameter of larger pulley on the drive shaft

D = 3x75 mm =225 mm

Now by taking 750 rpm for the speed of motor shaft, the rpm of the larger pulley (on the Driven shaft) is given by:-

$$\frac{N1}{N2} = \frac{d2}{d1}$$

Where

N1 –is rpm of smaller pulley (motor shaft)

N2- is rpm of larger pulley (on the Driven shaft).

$$\frac{N1}{N2} = \frac{d2}{d1}$$

$$N2 = \frac{d1xN1}{d2} = \frac{1000rpm\ x\ 75mm}{225mm} = 333.3rpm$$

Determining Length of the Belt

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

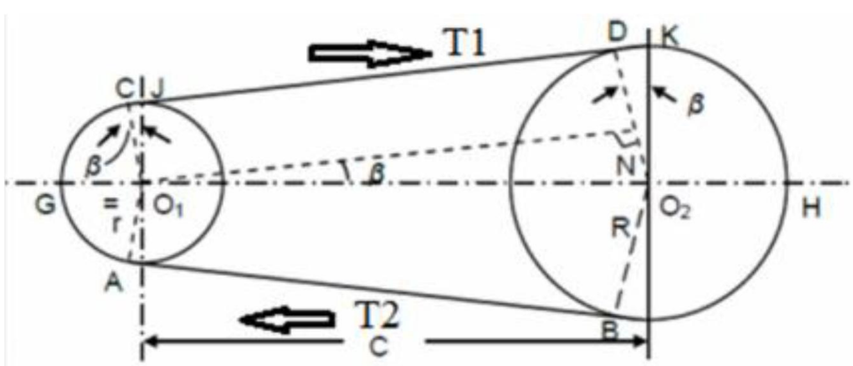

Figure 4.1 Belt drives [11]

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

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

L = AB +Arc BH + DC+ Arc CGA, equals to the formula; $L = 2C + 1.57(D+ d) + ((D - d)^2) / 4C$

Where:

C= center distance,
D = driven pulley (larger pulley),
d = driver pulley (smaller pulley)

Let r be the radius of the smaller pulley, R = the radius of the larger pulley,

C is the center distances between the pulleys which 250 mm for our design and the groove angles of 32° to 38° are used And β be the angle subtended by the tangents AB and CD with $O_1 O_2$.Type equation here.

By geometry, $< O_2 O_1N = < C O_1 J = < DO_2K = \beta$

Arc BHD = (π + 2 β) R, and Arc CGA = (π + 2 β) r

$AB = CD = O1N = O_1 O_2 \cos\beta = C \cos\beta$

$\sin\beta = \frac{D-d}{c} = \frac{225-75}{25} = 0.6$

$\beta = \sin^{-1}(0.6) = 36.87$

$\sin\alpha = \frac{d2-d1}{2c} = \frac{225-75}{2\,x\,250} = \frac{150}{500}$

$\sin\alpha = o.333$

$\alpha = \sin^{-1} 0.333 = 19.45$

$L = 2C + 1.57(D+ d) + \frac{(D-d)^2}{4c}$

$L = 2(250) + 1.57(225 + 75) + \frac{(225-75)^2}{4x250}$

= 500 +1. 57(300) + 22500/1000

=500+471+22.5 = **993.5** mm

From standard table, S it is close to the datum length = 1001mm and inside diameter, Li=965 mm.

where

B=L p-1.57(D1 + d2)

=1001-1.57(225+75) =1001-471=530mm

The actual center distance is

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

$$=530+\sqrt{\frac{530^2-2(225-75)}{4}}$$

$$=530+\sqrt{\frac{280600}{4}}$$

$$=530+\frac{529.7}{4}=\frac{1059}{4}=264.9mm$$

Angle contact of the belt on each pulley

These angles are important because commercially available belts rated with on assumed contact angle of 1800. This will occur only if the drive ratio is 1:1(no speed change). The angle of contact on the smaller of the two pulley will always less than 1800, requiring a lower power rating.

On the tight side of the belt tensile force is maximum. The bending of the belt around the pulley, maximum at the tight side of the belt bends around the smaller pulley.

$$\angle AGC = \Theta_1 = 180^0 - 2\sin^{-1}\left[\frac{D-d}{2c}\right] \quad \text{……………………………… 4.2}$$

$$\angle BHD = \Theta_2 = 180^0 + 2\sin^{-1}\left[\frac{D-d}{2c}\right] \quad \text{……………………………... 4.3}$$

Where:

Θ_1 = Contact angle of belt on small pulley.

Θ_2 = Contact angle of belt on large pulley.

L = Belt length.

C = Center distance between pulleys

d = Small pulley diameter.

D = Large pulley diameter

Contact angle of small pulley (Ɵ 1)

$\Theta 1 = 180^0 - 2\sin\text{-}1 \left[\frac{D-d}{2c}\right]$

$= 180^0 - 2\text{Sin}^{-1} \left[\frac{225-75}{2x250}\right]$

$= 180^0 - 2\text{Sin}^{-1} \left[\frac{150}{500}\right]$

$\Theta 1 = \mathbf{145.10^0}$

Contact angle of large pulley (Ɵ 2)

$\Theta 2 = 180^0 + 2\text{Sin-}1\left[\frac{D-d}{2c}\right]$

$= 180^0 + 2\text{Sin}^{-1}\left[\frac{225-75}{2x250}\right]$

$= 180^0 + 2\text{Sin}^{-1}\left[\frac{150}{500}\right]$

$\Theta 2 = \mathbf{214.91^0}$

Tensions in the belt

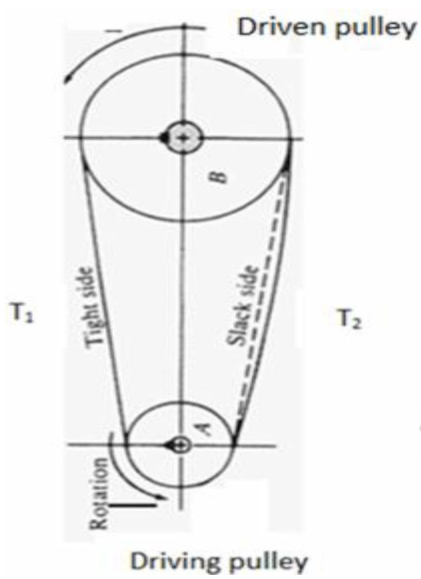

Figure 4.2 Belt tension

Determination of the tension of belt on the slack side (T2) tight side of the belt (T1)

$T= (T1-T2)\ r$……………………………………..…….4.3

Where:

T1= tension on the tight side of belt,

T2 = is tension on the slack side of belt

r = is the radius of the shaft

$T1-T2=T/r = T1-T2 = 57x10^3/112.5=507N$

$2.3 \log (T1/T2) = \mu \Theta \operatorname{cosec} \beta$……………………………..……………4.4

Where:

μ- is coefficient of friction between the smaller pulley and v-belt by taking μ= 0.45 from table

ϴ - is contact angle on small pulley in radian that is 145.10^0 = 2.53 rad and contact angle on large pulley in radian that is 214.91^0=3.74 rad and Groove angle = 36^0

$2.3 \log (T1/T2) = 0.45x2.53 \operatorname{cosec} 36^0$

$=\text{Log}\ (T1/T2) =0.45x2.53/2.3 =\text{Log}\ (T1/T2) = 0.495=T1/T2=10^{0.495}=T1/T2=3.12$

(T1/T2)= 3.12 by taking anti log of 0.495

T1=3.12T2………………………………………………4.5

Substituting T1 in equation (4.3)

T1-T2 = 507 N=3.12 T2-T2 =507 =2.12 T2=507=T2=507/2.12 =239N

So, T1=3.12T =3.12x239 =745N

The total tension of belt is (T_{otal})

T_{otal}=T1+ T2 =745+239 =984N

Design of Driver Shaft

This shaft is a rotating solid part which is used to transmit power from the electric motor through belt and pulleys to the cutter by means of key. 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 transmitted to the cutter. The required torque to transmit power to the cutter is obtained by using the following relation. We know that power transmitted (in watts) by the shaft, the members like pulleys, bearings, on the shaft are exerted forces which cause the shaft to bending and twisting.

The shaft material/ desirable properties/ for our project/machine/ should meet the following criteria's:-

- Sufficient in strength
- Machine able
- Impact resistance
- Tough and resist fatigue
- Heat resistance
- Good heat treatment
- Wear resistance

Considerations in designing shafts on the bases of strength cases

I. Shafts subjected to twisting moment or torque only

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

$$\frac{T}{J} = \frac{\tau}{r} \quad \text{...4.6}$$

Where:

T= twisting moment acting up on the shaft

J= polar moment of inertia of the shaft about the axis of rotation

τ = torsional shear stress and

r = radius of the shaft = d/2

For round solid shafts polar moment of inertia,

$$J = \frac{\pi}{32} d^4 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4.7$$

The torsion equation may now be written as

$$\frac{T}{\frac{\pi}{32} \times d^4} = \frac{\tau}{\frac{d}{2}} \quad \text{or} \quad T = \frac{\pi}{16} \times \tau \times d^3$$

$$\rightarrow d = \sqrt[3]{\frac{16T}{\pi\tau}} \ldots\ldots\ldots\ldots\ldots\ldots 4.8$$

II. Shafts subjected to bending moment only

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

We know that

$\frac{M}{I} = \sigma_{b/r}$ Where; M = bending moment acting up on the shaft I = moment of inertia of cross sectional area of the shaft about the axis of rotation σb = is bending stress and r = radius of the shaft = d/2

For round solid shafts moment of inertia,

$$I = \frac{\pi}{64} d^4 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4.9$$

Substituting these values in bending equation we have

$$\frac{M}{\frac{\pi d^4}{64}} = \frac{\sigma b}{\frac{d}{2}} \text{ or } M = \frac{\pi}{32} \sigma b d^3 \rightarrow d = \sqrt[3]{\frac{32M}{\pi \sigma_b}} \ldots\ldots\ldots\ldots\ldots\ldots 4.10$$

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

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

Stresses on the shafts

- The stresses induced in the shaft are:-
- Shear stress due to transmission of torque (i.e. due to torsion load)
- Bending stress (compression) due to forces acting up on the shaft
- Stress due to combined torsion and bending loads

The two types of theories are:

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

b. Maximum normal stress theory: - used for brittle material such as Cast iron

According Maximum shear stress theory, the maximum shear stress in the shaft is given by

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

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

$$\tau_{max} = \frac{1}{2}\sqrt{\left(\frac{32M}{\pi d^3}\right)^2 + 4\left(\frac{16T}{\pi d^3}\right)^2} = \frac{16}{\pi d^3}\left[\sqrt{M^2 + T^2}\right]$$

or $$\frac{\pi}{16} \times \tau_{max} \times d^3 = \sqrt{M^2 + T^2} \quad \text{..4.11}$$

The expression $\sqrt{M2 + T^2}$ is known as equivalent twisting moment and is denoted by Te.

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

$$Te = \frac{\pi}{16}\tau d^3 \quad \text{... 4.12}$$

Determination of shaft

The shaft is subjected to combined twisting and bending moment's .so that the diameter of the shaft can be computed using maximum shear stress and maximum normal stress theory

Determining the torque (T) transmitted by the shaft. The material selected to manufacture the shaft is a mild steel having ultimate bending strength (σ_u) and ultimate shear strength (τ_u), 448 Mpa and 224 Mpa respectively with safety factor (s.f) = 10

Predetermine parameters

Power motor (p) =$2x10^3$watt

Rotational speed of shaft (N) =333.3 rpm

Coefficient of friction between pulley and belt (μ) =0.45

Overlap angle (θ) =2.53 rad

$$T=\frac{Px60}{2\pi N}\text{..4.13}$$

$=\frac{2x10^3x60}{2x3.14x333}$ $=\frac{120000}{2093}$ = 57 N.M = $57x10^3$ mm

From the derivation of maximum shear stress theory,

$T_e= \sqrt{T^2 \ + M^2} = \frac{\pi}{16}\tau d^3$

Where:

- Te= Equivalent twisting moment
- T=Torque transmitted by the shaft
- M =Bending moment

So to find $T_{e,}$Bending moment (M) must be competed

$\sum M$ =0 Where:

M =Bending moment

MR2 =5x250+974x80-R1 (80) = 0 R1 = 440N

$\sum F$ = 0 Where: F =shear force

5N+R2 =R1+974+R2=440+974R2= (440+974)-5N=1409N

Bending moment

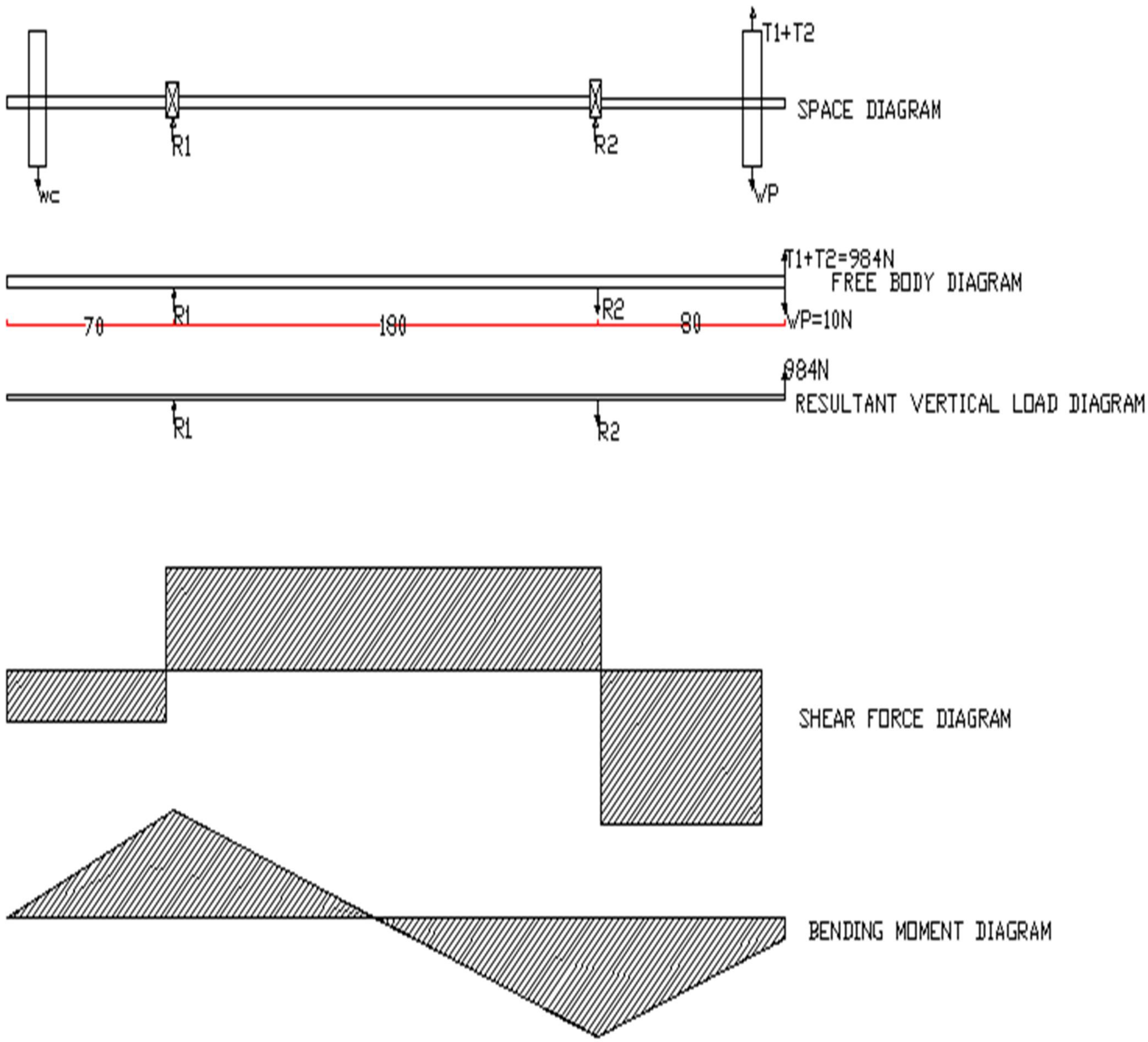

Figure 4.3 Bending moment of driver shaft

Maximum bending moment

M_B(Bending moment at point B) = 5x70 =350N

Mc (Bending moment at point C) =5N

Mc =5Nx250-440x180 = -77950N

M_D (Bending moment at point

D) = 5(300)-440(260)+1409(80) =1650-114400+112720 =-30

M_A(Bending moment at point A) =440(70) +974(330)-1409(250) =0

Therefore, the maximum bending moment 77950N is located at point C.

Then $T_e = \sqrt{T^2 \ + M^2}$ Te $=\sqrt{(57x10^3)^2 + (77950)N}$ =96567N

Te= $\frac{\pi}{16}\tau d^3$ =96567N = $\frac{\pi}{16}\tau d^3$ = $d^3 = \frac{16x96567}{3.14x2.24}$ $= \frac{1545072}{70.336}$ = 22072d= $\sqrt[3]{22072}$= 28.05mm

M0=M+$\sqrt{M^{2+T^2}}$ Where, Mo is equivalent bending moment

=77950+$\sqrt{M^{2+T^2}}$ =77950+To =77950+96567 =174517Nmm

Mo=174517=$\frac{\pi}{32}\sigma d^3$=174517 =$\frac{3.14}{32}$x44.8xd^3=d^3=$\frac{32x174517}{3.14x44.8}$=$\frac{5584544}{140.6}$=39890 d= $\sqrt[3]{39890}$ = 34.15

Therefore, 34.15mm is the largest value. We have taken 35mm for the diameter of the shaft.

Design of key

A key is a piece of mild steel inserted between shaft and hub or boss of the pulleys to connect these parts in order to prevent relative motion between them. It is always inserted parallel to the axis of the shaft. Keys are used as temporary fasteners and are subjected to considerable crushing and shear stresses. The most widely used method of torque transfer is by the use of keys. Keys transmit torque by the mechanism shown in Figure 4.4 below. A longitudinal groove called a keyway is machined into the shaft and a corresponding groove into the bore of the hub. The key fits simultaneously into both grooves, locking them together.

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

a. Design of Square Key

Diameter of the shaft = 34.15 mm, Width of the key, W = $\frac{D}{4}$= $\frac{35}{4}$=8.75mm =9mmThickness of key, t = $\frac{W}{3}$=$\frac{dD}{2}$=35/6= 5.83 = 6 mm

The material selected to manufacture the shaft is a mild steel having ultimate bending strength (σ_u) and ultimate shear strength (τ_u), 448 Mpa and 224 Mpa respectively with safety factor (s.f) = 10 .

b. Design Analysis

A key has two failure mechanisms: 1) it can be sheared off, and 2) it can be crushed due to the compressive bearing forces.

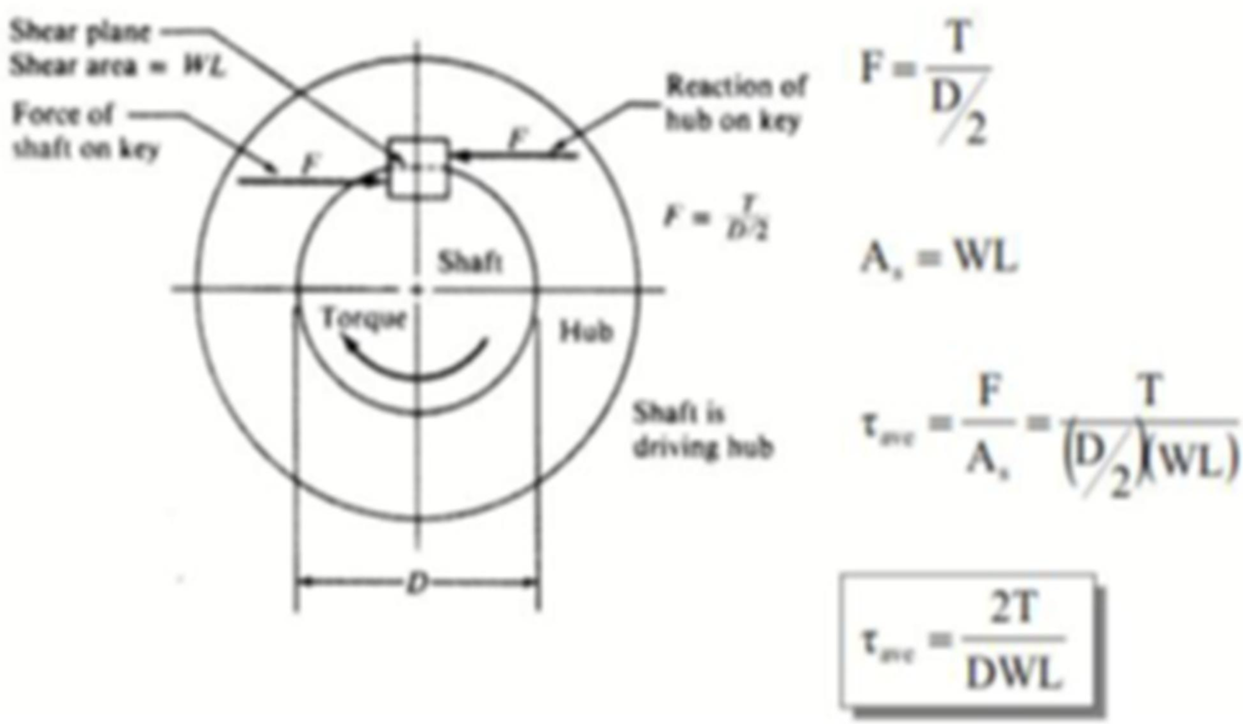

Figure 4.4 Forces exerted on the key

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

Shearing of key

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

Shear force (F) = Area of resisting shear x shear stress

$F = L \times w \times \tau$ ……………………………………………4.14

$T = F \times \frac{d}{2}$, $T = L \times w \times \tau \times \frac{d}{2}$……………………………………4.15

Torsional strength of shaft of the key (T) = Te= $\frac{\pi}{16}\tau d^3$……..4.16

Substitute the above formula

$\frac{\pi}{16}\tau d^3 = L \times w \times \tau \times \frac{d}{2} = \frac{\pi}{16} \times 224 \times (35)^3 = L \times 8 \times 6 \times \frac{35}{2} \times 224 = 0.19625 \times 224 \times 42875 = L \times 24 \times 17.5 \times 224$

$L = \frac{1884785}{68600} = 27.4$ mm

Crushing of key

In order to find the length of the key to transmit full power of the shaft, the shearing strength of the key is equal to the torsional shear strength of the shaft. We know that the shearing strength of key,

$T = L \times W \times \tau x \frac{d}{2}$ ……………………......4.17

And torsional shear strength of the shaft,

$T = \frac{\pi}{16} \times \tau_1 \times d^3$ … … ..……………………....4.18

(Taking τ_1 = Shear stress for the shaft material)

From equations **4.17**and **4.18,**we have

L x w x $\tau x \frac{d}{2} = \frac{\pi}{16}$ x τ_1 xd^3

$\therefore$ L = $\frac{\pi}{8}$ x $\frac{\tau_{1d^2}}{wx\tau}$ = $\frac{\pi d}{2}$ x $\frac{\tau_1}{\tau}$ = 1.571 d xs$\frac{\tau_1}{\tau}$ (Taking *w* = *d*/4)........ 4.19

When the key material is same as that of the shaft, then $\tau = \tau_1$

L = 1.571 ……………….... [From equation (4.19)]

L= 1.571x35 = *54.95mm*

The permissible crushing stress for the usual key material is at least twice the permissible shearing stress. Therefore, we have *w* = *t*. In other words, a square key is equally strong in shearing and crushing.

4.3 Material selection processes and its factors

Material selection is a step in the process of designing any physical object. In the context of product design, the main goal of material selection is to minimize cost while meeting product performance goals. Systematic selection of the best material for a given application begins with properties and costs of candidate materials. The selection of materials and the processes used in fabrication are integral parts of the design of a machine component.

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

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

4. Process ability which includes cast ability, workability, weld ability and machinability.

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

The selection of proper materials for engineering purpose is one of the most difficult problems for the designer. The best material is one which services the desired objectives at the minimum cost and the following factors should be consider while selecting material

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

Generally material selection factors are service performance (specifications), availability, economics (total cost), material properties, manufacturing processes, formability and joinability and so on.

4.4 Material selection for critical parts/components

Selecting the right material for the machine can fulfill the functional requirement for the specific part is very important. We use to select the suitable material we follow the digital logic methods.

The steps for digital logic methods are: - Set the functional requirements for the part under consideration. This are used to set rating factor; Rank the rating factors (properties) then determine the weight factors; Total number of decision/N/= $\frac{n(n-1)}{2}$ Where = n number of rating factors/properties/; Write the most suitable candidate materials and enlist properties from standard data table /the data quantitative or qualitative/; Normalize the outcomes of the parts value outcomes and overall satisfaction of parts. The overall satisfaction shall at last ranked, and the ranked shows the result on the basis of the allocated weight factors which gives the best overall satisfaction for the functional requirements of the part.

4.4.1Material selection for Shafts

In order to minimize deflections, steel is the logical choice for a shaft material because of its high modulus of elasticity, though cast or nodular iron is sometimes also used, especially if gear or other attachments are integrally cast with the shaft. Most machine shafts are made from low-to-medium carbon steel, either cold rolled or hot rolled, though alloy steels are also used where their higher strength are needed. Cold-rolled steel is more often used for small-diameter shaft(less than about 3- inch in diameter) and hot-rolled used for large size.

Functional requirement for Shaft

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

Material requirement for shaft

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

- No. of properties to be evaluated
- Yield strength and tensile strength
- Wear resistance
- Corrosion resistance
- Modulus of elasticity

Therefore No. of decisions (N) $=\frac{n(n-1)}{2}=\frac{5(5-1)}{2}$ =10 (Material selection in mechanical design)
Where, n=no. of properties to be evaluated so digital logic with different decision, material requirement with its weight factor and normalized value, performance index, figure of merit etc of shaft is shown below.

Weight factor (Wf) $=\frac{\textbf{Positive desision}}{\textbf{Total no.of desision}}$

Table 4.1 Application of digital logic with different decision number

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

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

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

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

4.4.2 Material selection for Pulley

Functional requirement for pulley

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

Material requirement for pulley

- The material should possess optimal tensile strength;
- The material should have adequate value of yield strength;
- Density of the material should meet value of safe operation;

- ❖ It possesses moderate specific heat capacity;
- ❖ Coefficient of linear expansion of the material should lie at range of minimal value
- ❖ Wear resistance.

Total number of decision/N/ $=\frac{n(n-1)}{2}$Where n=5N=$\frac{5(5-1)}{2}$ =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			**2/10 = 0.2**
Yield strength		0				0			0	1	**1/10 = 0.1**
Density	1	1	1				0				**3/10 = 0.3**
Specific heat capacity			0		1	0		0			**1/10 = 0.1**
Coefficient of linear expansion				1			1		1	0	**3/10 = 0.3**

Therefore, from the above candidate materials **AISI1035** is a best suitable for the pulley material which is relatively less weight.

4.4.3 Material selection for bearing house

Function requirement

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

Material Requirement of bearing house

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

- Have better yield strength - better tensile strength
- Have higher young's modulus of elasticity
- Have high corrosion resistance
- Be tough enough - it should be machine able
- Be light in weight

Aluminum alloy is selected for bearing house because it satisfies the above requirements.

Material Requirement of bearings

The following are the widely used bearing metals:-

1 Copper-base alloys
2 Lead-base alloys
3 Tin-base alloys and
4 Cadmium-base alloys

The selection of a particular type of bearing metal depends upon the conditions under which it is to be used. It involves factors relating to bearing pressures, rubbing speeds, temperatures, lubrication, etc.

- A bearing material should have the following properties:
- It should have low coefficient of friction.
- It should have good wearing qualities.
- It should have ability to withstand bearing pressures.
- It should have ability to operate satisfactorily with suitable lubrication means at the maximum rubbing speeds.
- It should have a sufficient melting point.
- It should have high thermal conductivity.
- It should have good casting qualities.
- It should have minimum shrinkage after casting.
- It should have non-corrosive properties.

- ❖ It should be economical in cost.
- ❖ To satisfy the functional requirement of the bearings should have:-
- ❖ Direction of load relative to bearing axis
- ❖ Intensity of loads. Ball bearings can sustain considerable loads
    - ❖ Speed of rotation
    - ❖ Thermal stability
    - ❖ Shaft stiffness. Rigid bearings are used for stiff well designed shafts
    - ❖ Class of accuracy of the machine.

Already, we have designed shaft diameter to be **31mm**. therefore based on the diameter of shaft and the properties of bearing mentioned above, ball bearing with Bearing Basic Number **306**, from the above table is selected for this project.

4.4.4 Material selection for keys

Functional requirement

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

Material requirement

- ❖ The material for the key should be selected based on the following criteria:-
- ❖ The key should be tough enough.
- ❖ It should be resistance to wear.
- ❖ Having sufficient high strength.
- ❖ Has high fatigue strength

4.5 Ergonomics considerations

Human aspects play an important role in the ergonomic considerations. An effort has been made to understand the muscular problems faced by the workers.

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

The machine is aimed to solve the problems such as musculoskeletal injuries that come due to the awkward postures of the traditional cutting method of by using hand tools.

CHAPTER-FIVE

MANUFACTURING PROCESS AND ASSEMBLY

5.1. Manufacturing process

Each part or component of a product must be designed so that it is not only meets design requirements and specifications, but also can be manufactured economically and with relative cost. Manufacturing process is the part of the production process which is directly concerned with the change of form or dimensions of the part being produced. It is usually carried out as a unit operation, which means that it is a single step in the sequence of steps required to transform the starting material into a final product.

The broad categories of processing methods for materials are:

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

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

General steps to manufacture components of the machine:-

- ❖ Take the material for the component according to the design parameters.
- ❖ check the selected diameter (dimension) to assure by proper measuring tool
- ❖ Mark the selected material to the recommended dimensions. (Layout)
- ❖ Select the appropriate machine or tool for cutting the material to prepare the rough dimension.

- Hold the selected material in the selected machine or tool to make the rough dimensions.
- Perform the operation within the recommended and measured dimension on the marked line with allowance.
- Perform the joining operation (welding, bolt & nut)
- Finishing operation to the recommended exact dimension.

5.1.1Manufacturing operation

It is series of operation in which components are manufactured in their sequential order.

Manufacturing operations can be divided into two basic types:-

1) Processing operations and
2) Assembly operations

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

Processing operation is done by using operation sheet which is the best & simplest way of showing how the part is manufacture through different steps to complete the work. Therefore process operation of our project is explained by using operation sheet.

An assembly operation joins two or more components to create a new entity, called an assembly, subassembly, or some other term that refers to the joining process (e.g., a welded assembly is called a weldment).

Note: The reader should refer to the detailed drawings in Appendix for every information regarding shapes and sizes in the operations sheets.

5.1.2 Operation sheet for critical parts

Operation sheet for driven shaft

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

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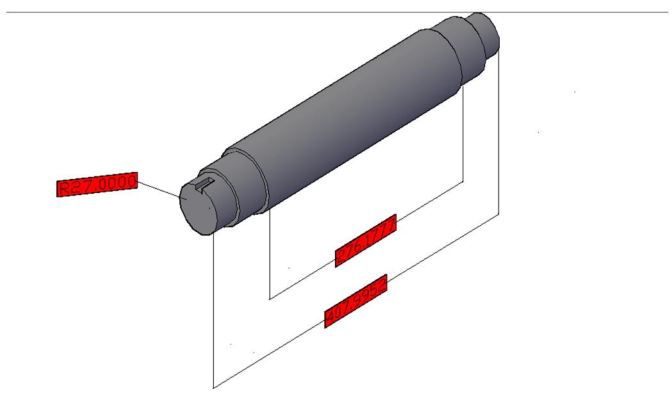

Figure 5.1 Shaft

Table 5.1 Operation sheet for driven shaft

No	**Operation**	**Machine used**	**Tools & Equipment's used**	**Dimension**
1	Measuring and cutting to size	Power hacksaw	verniercaliper, steel rule	Ø = 40 mm L= 340 mm
2	Facing on one side	Lathe machine	Carbide cutter &v.caliper	Ø = 40 mm L =339 mm
3	Turning both side	Lathe machine	Vernier caliper , carbide cutter	Ø =31 mm L = 38 mm
4	Facing on the other side	Lathe machine	Vernier caliper , carbide cutter	Ø = 40 mm L = 338 mm
5	Turning one side	Lathe machine	Vernier caliper , carbide cutter	Ø = 22mm L = 24 mm
6	Chamfering	Lathe machine	Vernier caliper , carbide cutter	Ø = 21mm L = 24 mm
7	Turning one side	Lathe machine	Vernier caliper , carbide cutter	Ø =27 mm L = 28 mm
8	Milling a key way at one end	Milling machine	End mill	L = 9 x6 x27 mm

Operation sheet for connecting plate and movable jaw

This movable jaw is one part of the vice of the machine used to tighten and lose the cobblestone while the cutting operation. The connecting plat is used to hold and guide the tightening screw.

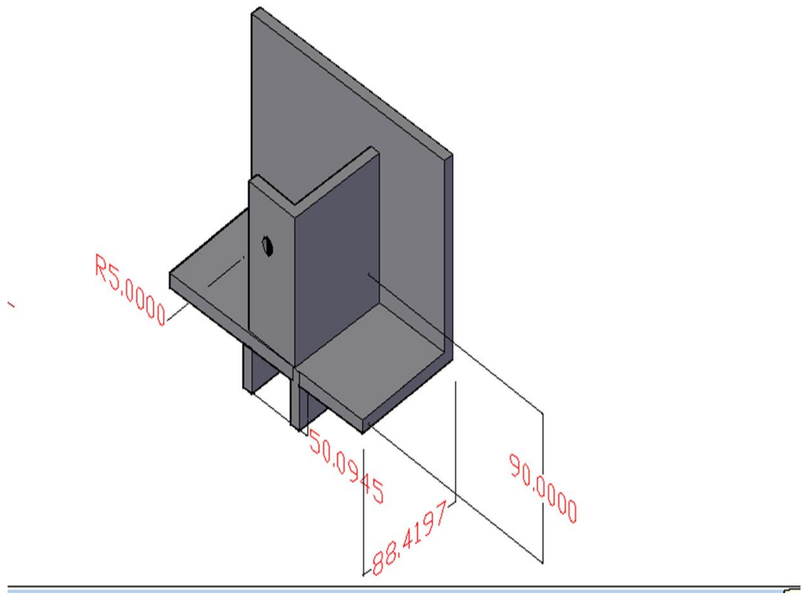

Figure 5.2 Connecting plate and movable jaw

Table 5.2 Operation sheet for connecting plate and movable jaw

No	**Operation**	**Machine used**	**Tools & Equipment used**	**Dimension**
1	Measuring and cutting to size for connecting plate	Power shear	Steel rule	90 x 50 x 5
2	Drilling	Drilling machine	Drill bit	11mm diameter
3	welding	Arc welding		
4	Measuring and cutting to size for movable jaw	Power shear		123 x88 x180
5	Measuring and cutting to size for moveable jaw	Power shear	Steel	
6	Make smoothing		Files	
7	Drilling	Drilling machine	Drill bit	11mm diameter
8	Welding	Arc welding		

Operation sheet for fixed jaw

This jaw is one part of the vice of the machine used to support the movable jaw while tightening the cobblestone to be cut.

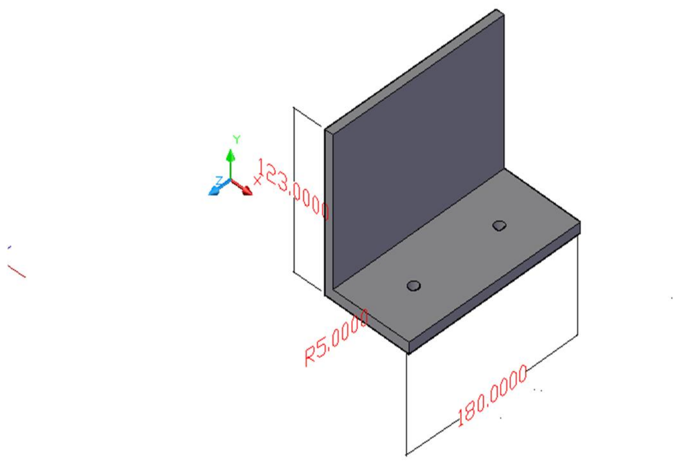

Figure 5.3 Fixed jaw

Table 5.3 Operation sheet for fixed jaw

No.	**Operation**	**Machine used**	**Tools & Equipment's used**	**Dimension**
1	Measuring & cutting to size	Power shear	Scriber,Steel rule	124 X 181 X 8
	Measuring & cutting to size	Power shear	Scriber,Steel rule	81 X 181 X 8
2	Make the edge smooth the one plate		file	123 X180 X 8
	Make the edge smooth other plate		file	80 X 180 X 8
3	Make two hole drilling	Drilling machine	Drill bit	Ø =11 mm
4	welding	Arc welding machine		

Operation sheet for large pulley

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

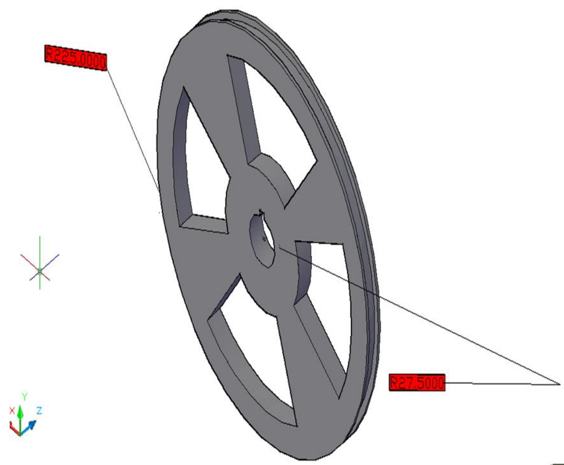

Figure 5.4 large pulley

Table 5.4 operation sheet for large pulley

No.	Operation	Machine used	Tools & Equipment's used	Dimension
1	Preparing pattern from wood to the required size	Wood lathe and jig saw	Venire caliper, steel rule	Ø = 300 mm W= 30 mm
2	Preparing Aluminum scrap			
3	Preparing sand for molding	Sand conditioner	Cop and drag, Sprue, riser. rammer, etc	
4	Melting the scraps	Fuel Furnace		
5	Pouring the molten metal to the prepared cavity		Crucible	
6	Facing oneside	Lathe Machine	Carbide cutter and V. Caliper	Ø = 300 mm W = 29 mm

7	Facing the other side	Lathe Machine	Carbide cutter and V. Caliper	Ø = 300 mm W = 28 mm
8	Drilling	Lathe Machine	Center drill, Drill bit and V. Caliper	Ø = 27mm
9	Turning	Lathe Machine	Carbide cutter, V. Caliper and mandrel	Ø = 28mm
10	V-groove turning	Lathe Machine	HSS Parting tool V. Caliper	
11	Milling a key way	Milling machine	Slotting attachment with HSS cutter	

Operation sheet of small pulley

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

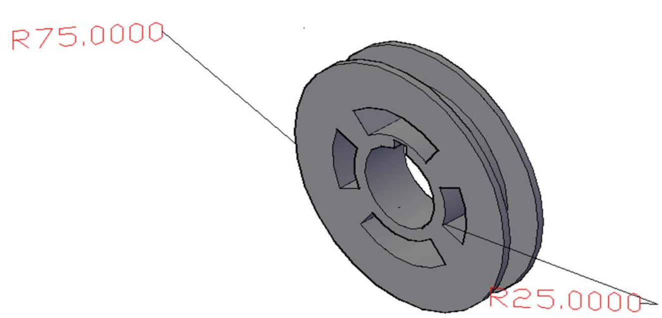

Figure 5.5 small pulley

Table 5.5 Operation sheet of small pulley

No.	Operation	Machine used	Tools & Equipment's used	Dimension
1	Preparing pattern from wood to the required size	Wood lathe and jig saw	Venire caliper, steel rule	Ø = 300 mm W= 30 mm
2	Preparing Aluminum scrap	-	-	-
3	Preparing sand for molding	Sand conditioner	Cop and drag, Sprue, riser. rammer, etc	
4	Melting the scraps	Fuel Furnace		
5	Pouring the molten metal to the prepared cavity		Crucible	
6	Facing one side	Lathe Machine	Carbide cutter and V. Caliper	Ø = 300 mm W = 29 mm
7	Facing the other side	Lathe Machine	Carbide cutter and V. Caliper	Ø = 300 mm W = 28 mm
8	Drilling	Lathe Machine	Center drill, Drill bit and V. Caliper	Ø = 27mm
9	Turning	Lathe Machine	Carbide cutter, V. Caliper and mandrel	Ø = 28mm
10	V-groove turning	Lathe Machine	HSS Parting tool V. Caliper	
11	Milling a key way	Milling machine	Slotting attachment with HSS cutter	

Operation sheet for push pull adjuster

The push pull adjuster is used to adjust the position of the motor and to alien or keep the distance of the pulleys.

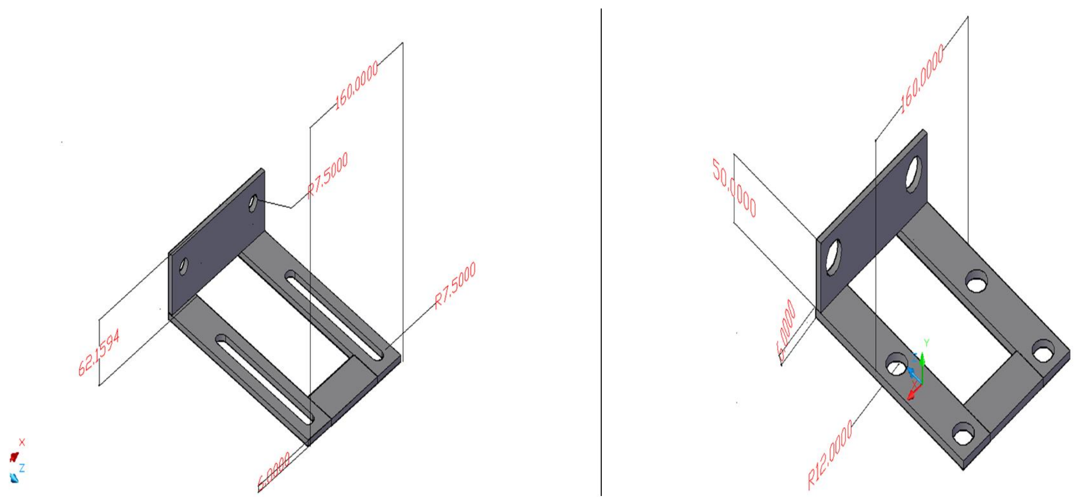

Figure 5.6 Push pull adjuster

Table 5.6 Operation sheet for push pull adjuster

No.	Operation	Machine used	Tools & Equipment's used	Dimension
1	Measuring & cutting to size	Power shear	Steelrule ,meter scrber	L=241 x 62 mm L=62 X62 mm L=221 X 56 mm
2	Making a hole	Drilling machine	Drill bit	Ø =12mm
3	Making a hole	milling machine	End milling	L = 150 mm Ø =15 mm or 7.5 mm

Note: The operation sheet for other parts like bearing house , stud bolt, frame, belt cover ,handle, feeding and supporting plate is similar to the operation sheet of parts mentioned above based on size, operation, tools and machines required and their operation sequences are explained in Labor cost for manufacturing components.

4.1. Assembling procedure

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.

Assembling of components with their step is as follows.

1-asembling of frame and arm of the machine

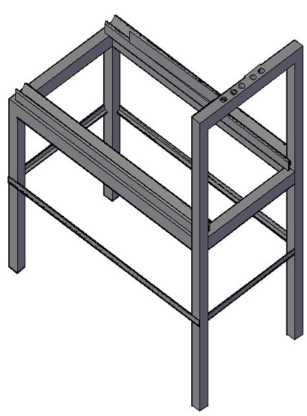

Figure5.7 **Assembling** of Frame

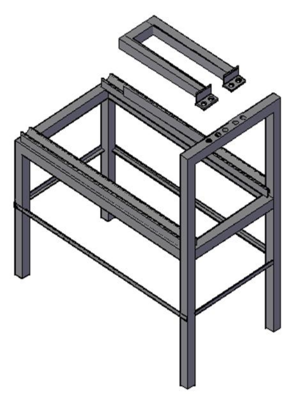

Figure5.8 **assembling** of frame and arm

NB. The arm is used to carry or hold bearing house, shaft, pull push adjuster (belt tensioner) and motor.

2-assembling the push pull adjuster with motor on arm

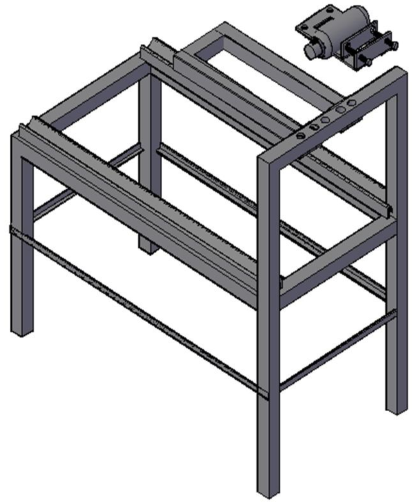

Figure 5.9 **Assembling of** Frame and push pull adjuster with motor on arm

3-assembling of pulleys, motor and shaft

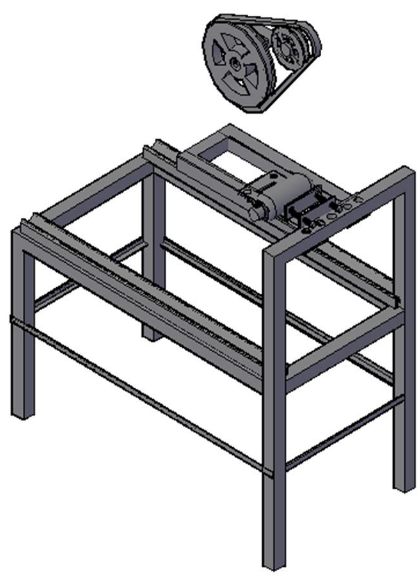

Figure 5.10 assembling of pulleys, motor and shaft

4-assembling of trolley and vice

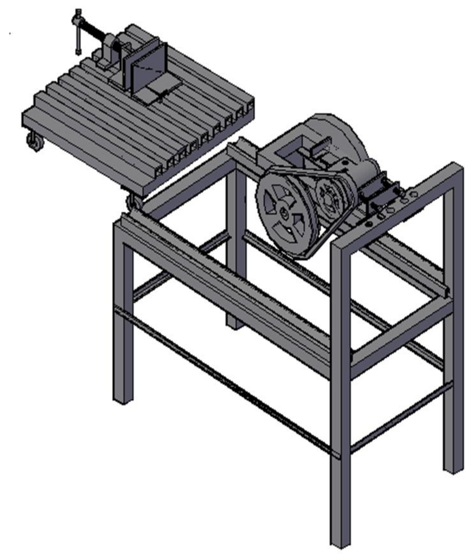

Figure 5.11 assembling of trolley and vice

5-final assembly

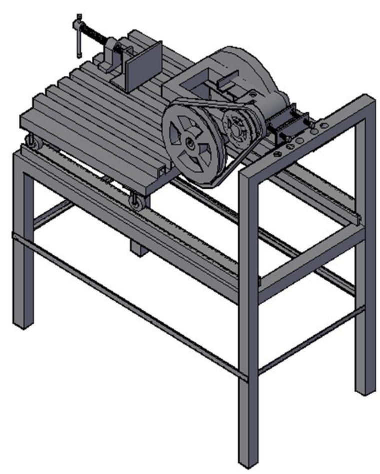

Figure 5.12 final assembly

CHAPTER- SIX

COST ANALYSIS AND MAINTENANCE OF THE MACHINE

The chief cost elements of direct material cost and direct labor cost determines prime cost. The factory expense such as light, power, maintenance, supply plus prime cost gives factory cost. The general expense such as marketing and sales cost, legal expense, and security cost, financial, and administrative plus factory cost gives manufacturing cost. The sales expense such as taxes, office stuff, and purchasing plus manufacturing cost gives total cost. (Total cost=manufacturing cost + sales expense). Finally the selling price established by adding a profit to the total cost for a business.

6.1 Cost Analysis

6.1.1 Elements of cost established selling price

Design and manufacture a product according to a certain specification by minimizing total cost and maximizing efficiency of the product or machine to meet service requirements is only one aspect of production. Based on these the design and manufacture of certain cobble cutting machine analysis should be done in order to be competitive. The way element of cost builds upto establish a selling price is shown on figure below (6.1)

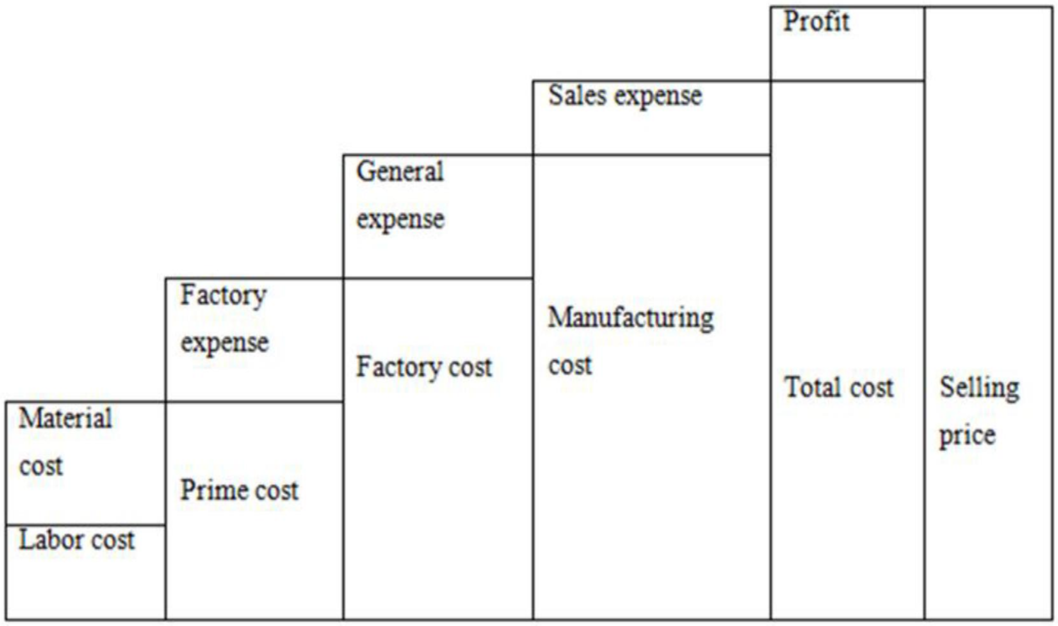

Figure 6.1 Establishing of selling price

6.1.2 The costs of raw materials and standard items

The material costs are refer to those materials which are consumed to produce a real components of our machine and the standard item costs are those costs which is purchased.

Cost of raw materials is an expense spent to purchase materials to be manufactured in our work shop (**Table 6.1**)

Table 6.1 cost of raw materials

No.	Material description	Size required	unit	Qty	Unit price		Total price	
					Birr	cent	birr	cent
1	Mild steelSheet metal	2m x 1m x 3mm thick	Pcs	2	1200	00	1200	00
2	SHS	S0 x 50	Pcs	3	1O00	00	1000	00
	SHS	40 X40	Pcs	1	800		800	00
3	Flat iron	50 x4	Pcs	4	300	00	300	00
4	Angle iron	50 x4	Pcs	2	600	00	600	00
	Angle iron	90 x50 x 5	pcs	1	700	00	700	00

5	Flat iron	1160 x50 x 4	Pcs	2	300	00	300	00
6	Flat iron	140 x50 x 4 thick	Pcs	1	300	00	300	00
7	Flat iron	80 x40 x 4	Pcs	1	300	00	300	00
8	Aluminum ingot	Ø300 x 50	kg	1	150	00	150	00
9	Mild steel plate	123 x 180x 8	Pcs	2	250	00	250	00
10	Black iron	88 x180 x 8	Pcs	1	200	00	200	00
11	Round bar	Ø40 x 340 mm	Pcs	1	300	00	300	00
12	Mild steel plate	123 x180 50 x 90	pcs	5 2	500	00	500	00
13	Rod	Ø10 x180	pcs	1	100	00	100	00
14	Rod	Ø20 x 385	pcs	1	150	00	150	00
						Sub –total	7650	00

Cost of standard item is an expense spent to purchase manufactured materials/items available in market (**Table 6.2)**

Table 6.2 Cost of Standard Items

No.	Name of material	Size	Unit	Qty	Unit price		Total price	
					Birr	Cent	Birr	Cent
1	Hexagonal Bolt	M 10 x1.5 x30	pcs	12	6	00	72	00
2	Hexagonal with Nut	M10 x1.5 x30	pcs	12	6	00	72	00
3	Ball Bearing	-	pcs	3	120	00	360	00
4	Bearing house	-	pcs	3		00	25	00
5	V belt	-	pcs	1	90	00	90	00
6	Diamond Cutting disk	Ø400	pcs	1	800	00	800	00
7	Electrode	Ø 2.5	pkt	1	120	00	120	00
8	Drill bit	Ø10	pcs	1	10	00	10	00
9	Drill bit	Ø11	pcs	1	10	00	10	00
10	Brush	2.5’’	pcs	1	15	00	15	00
11	Thinner		liter	1	50	00	50	00
12	Paint blue		liter	1	55	00	55	00
					Sub -total		1734	00

6.1.3 Operation process costs

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

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

Table 6.3 Machine operation time used to produce the components of the project

No.	Types of machines	Total working hr
1.	Power hack saw	3hrs
2.	Lathe machine	4hrs
3.	Milling machine	2hrs
4.	Column drilling machine	3hrs
5.	Arc welding machine	12hrs
6.	Sheet metal shear	3hrs
7.	Portable grinder	7hrs
8.	Cylindrical grinder	2hrs
	Total	36hrs

Table 6.4 Machine cost per hour

No.	Types of machine	Cost of a machine per hour	
		Birr	Cent
1	Power hack saw	30	00
2	Lathe machine	40	00
3	Milling machine	45	00
4	Column drilling machine	20	00
5	Arc welding machine	15	00
6	Sheet metal shear	20	00
7	Portable grinder	10	00
8	Cylindrical grinder	40	00

Table 6.5 Cost of each machine part per working hour

No.	Types of machine	Cost of a machine per hour		working hour	Total cost of machine per working hour	
		birr	Cent		birr	Cent
1	Power hack saw	30	00	3	90	00
2	Lathe machine	45	00	4	180	00
3	Milling machine	50	00	2	100	00
4	Column drilling machine	20	00	3	60	00
5	Arc welding machine	15	00	12	180	00
6	Sheet metal shear	20	00	3	60	00
7	Portable grinder	10	00	7	70	00
8	Cylindrical grinder	50	00	2	100	00
				Sub Total	840	00

Table 6.6 estimating cost for labor (for machinist or fabricator)

No.	Description	Operation cost of a machine in birr	
		Birr	Cents
1.	Labor cost per person/hour	40	00

Table 6.7 The working hours of table/vice holder/

No	Types of operation	Total time
1.	Layout work	16hrs
2.	Machine work	36hrs
3.	Bench work	19hrs
4.	Assemblies	8hrs
5.	Miscellaneous	10hrs
Total labor hours		89hrs

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

C_{Tlc}= 89 X 40birr = 3560birr

6.1.1.Machine depreciation cost

The expected machine depreciation cost in our case is 100Birr

6.1.2.Cost of power consumption

The power consumption cost are accost given to produce an overall parts of our product in unit power, now a days the power consumption for 1kwh is 0.60birr we consume a power of 100kw.

Total power consumption costs are/Tpcc/:-

C_{Tpcc}= 100kw X 0.60birr = 60.00Birr

Sub- Grand Total cost of the machine is:-

= 4734 + 11,226.70 + 1010 +3395 +100 + 60./6650+1734+3560+100+60+840/

= 12944.00 Birr

Contingences =15%x12944.00 =1941.60Birr

Total costs of the machine = 1941.60+ 12944.00 = 14885.60Birr

Cost of the existing machine is 45,000Birr

Comparatively the cost of this project is inexpensive than the exiting machine.

CHAPTER –SEVEN

RESULT AND DISCUSSION

The machine was locally fabricated and assembled. It is designed for both stationary and mobile work. It offers a wide range of possibilities and is therefore a highly versatile tool for professional applications. The cobble stone cutting machine can be used for the precise cutting of all kinds of concrete slabs, cobblestones, marble and granite slabs, and bricks and tiles, in a diversity of shapes and sizes. During testing of the machine, some activities has been made such as free-load testing of the motor, load testing of motor with the help of belt , direction of motor rotation and vibration testing.

Testing for cobble stone cutting machine

In the testing of cutting, 10mm x 10mm, 7mm x 7mm size cobblestone is tried to cut. The 10mm x10mm size cobblestone could not cut throughout the required size due to the small size/diameter/ of cutting blade, where as 7mm x 7mm size cobblestone is cut to the required size. The reason why we used this small size/diameter/ of cutting blade is it's not available in the market.

In addition to this; the cutting process is done by pushing the cobblestone to be cut towards the cutting blade; this way of cutting needs more force than the opposite; the height of the table is short; it should be improved to average height of a person in order to be ergonomically sweated. In this machine the coolant is applied manually; it is better to be automatic; thus, the project is functional as per the design.

Finally we are bounded to improve only some features of machine due to time and financial constraint and by warehouse to provide tools and equipment as per required. Any interested person or body can improve the machine especially; Small and Medium Enterprises can duplicate the machine without the consent of designers.

CHAPTER – EIGHT

CONCLUSION AND RECOMMENDATION

8.1 Conclusion

According to the survey of this thesis project, in Ethiopia, since this machine is manufactured the users face a problem of cost. Most European machines are reliable in performance but their purchasing cost is high. Therefore, 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.

In research design method, research questions and sample designs are prepared carefully to understand pros and cons of the existing machine to boost our research problem and need assessment.

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.

When we compare the cost of our project machine with the existing; our machine is cheaper than the existing machine. As our costs 14885.60Birr and Cost of the existing machine is 45,000Birr

Besides, we expect the cost will minimize even more than that when it is produced.

Finally, cost analysis is made to ensure manufacturing a cost competent machine but with optimum performance.

Precautions

This machine is a machine that is intended to cut cobble stone. This machine is usually powered by electric motor. The operator first receiving sufficient training concerning the work and being informed of the risks, the precautions to observe and operating instructions for the guards and compulsory safety devices. Operators are strongly recommended to wear protective while using this machine.

8.2 Recommendation

Installation

To guarantee corrected alignment of the working surfaces and prepare a stable, level, concrete floor. When handling, take care to avoid shocks or large forces which could cause damage or put the machine out of adjustment.

Reception handling

The machine is delivered fully assembled. When handling with the machine use the certified lifting equipment and safe instruments. Before placing the machine on working place, the operator has to consider how large pieces of material, which can be cut in the given room. During the transport and stocking it is necessary to protect the machine from excessive vibrations and excessive humidity.

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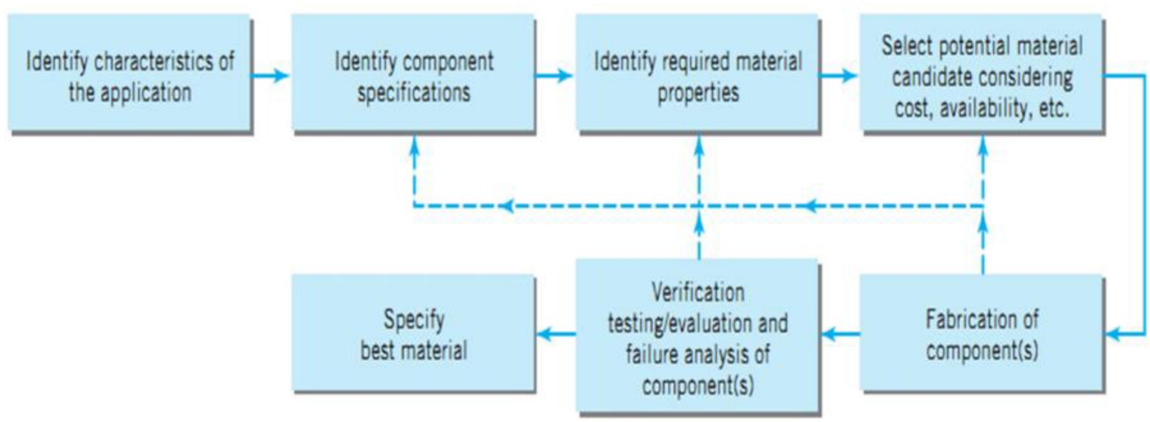
APPENDIX –A Question for data collection

No.	Questions	No. of sample size	Yes	No
1	Which type of production method /operation/ do you used to cut cobble stone?			
1.1	Manual/using hand tools/			
1.2	Using machine			
2	Are the hand tools that you are using confer table?			
1	Are the machine that you are using confer table?			
2	Is there cobble stone cutting machine on the market?			
3	Have you ever used cobble stone cutting machine?			
4	Have you ever seen cobble stone cutting machine?			
5	Are you interested to buy cobble stone cutting machine with reasonable cost?			
6	Can you buy cobble stone cutting machine privately /individually/?			
7	Can you buy cobble stone cutting machine in group /with shear/?			

APPENDIX-B Standard pitch lengths of V-belts according to IS: 2494-1974

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

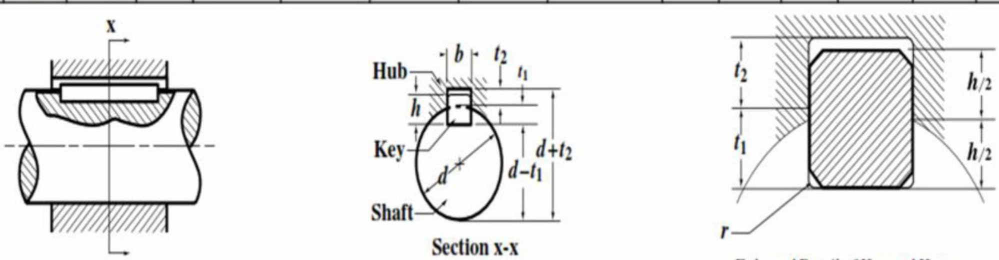
APPENDIX-C Material selections for a machine component



APPENDIX-D British standard metric key way for square and rectangular parallel keys BS4235:part1:1972(1986)

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

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



Section x-x

Enlarged Detail of Key and Keyways

ENDIX–E 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**

APPENDIX –F Candidate material requirements for shaft

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

APPENDIX – G Normalized value of shaft

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

APPENDIX -H Performance index (value out comes)

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

APPENDIX –I Properties of candidate materials for pulley

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

APPENDIX –J Normalized outcomes for pulley

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

APPENDIX -K performance index (value out comes)

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

APPENDIX -L Dimensions of standard V-belts according to IS: 2494 – 1974.

Type of belt	Power range in kw	Minimum pitch diameter of pulley (d)mm	Top width(b) mm	Thickness (t)mm	Weight peer meter length in Newton
A	0.7-3.5	75	13	8	1.06
B	2-15	125	17	11	1.89
C	7.5-75	200	22	14	3.43
D	20-150	355	32	19	5.96
E	30-350	500	38	23	-

APPENDIX -M Properties of v-belt for industrial purpose

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

APPENDIX –N Table 4.4. Coefficient of friction for 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. Canvass stitch	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