ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

SCHOOL OF MECHANICAL, CHEMICAL AND MATERIALS ENGINEERING

DESIGN AND MANUFACTURING OF BIOMASS THRESHER, MIXER AND SCREW PRESS EXTRUDER MACHINE

A Thesis /Project Submitted In Partial Fulfillment Of The Requirements For The Award Of Degree Of Master Science In Manufacturing Technology Teacher's Education

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MAY 29, 2015 G.C

ADAMA, ETHIOPIA

DECLARATION

We declare that this project entitled, "**DESIGN AND MANUFACTURING OF A LOW COST BIOMASS THRESHER,MIXER,AND SCREW PRESS EXTRUDER BRIQUETTE MACHINE FOR RURAL COMMUNITIES IN ETHIOPIA** "is a record of our own project work. The information derived from the literature has been duly acknowledged in the text and a list of references provided. No part of this project was previously presented for another degree or diploma at any university.

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APPROVAL SHEET

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ABSTRACT

Briquettes are biomass fuels made by compacting agricultural wastes (coffee husk, sugarcane trash, dry leaves, grass etc). They are used as fuel instead of firewood. However in Ethiopia people have been unable to take advantage of the socioeconomic and environmental benefits briquettes offer. The existing lever arm and hydraulic press briquetting machines used for briquette making have low production capacity and product quality in densification due to human force is used for compression mechanism, Because biomass materials used for briquetting are crushed into small pieces so as to enhance their workability and compactness, but crushing process using mortar and pestle consumes time and energy, therefore to solve these problems an improved briquetting machine is required. This project work is aimed at re-designing and manufacturing of the existing lever arm and hydraulic briquetting presses to replace by improved screw press briquetting machine which combines three functions including crushing, mixing and briquetting in a single unit. By eliminating individual machines, the great savings in space, material handling, time, energy and worker, and the improved efficiency can be realized. The improved machine has production capacity 180kg/hr continuous briquettes with a dimension depending on the diameter of the die and with a better compression capacity .Methodology used in the study is observation, discussion and design the machine components, developing machine are the major one. Power driven crushing system, mixing system and extrusion screw press for compression replace the manual process in briquette production. It is hoped that the machine will be very useful for small scale enterprises. This technology also helps to reduce cost and production time, and improve productivity, and eventually lead to be able to survive in competitive environments .Finally, a cost analysis for the compact briquetting machine is presented.

Keywords**: **Briquetting machine, Briquettes, Biomass fuel and extrusion screw press.

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CHAPTER ONE
INTRODUCTION

1. 1 Background

Consumption of traditional fuels has negative environmental, economic and health impacts. That is, increased use of firewood and charcoal leads to deforestation, leading to ecological imbalance, and increased use of agricultural residues and animal dung deprives the land of essential nutrients that are necessary for soil fertility. Furthermore, smoke from the use of fuel wood and dung for cooking contributes to acute respiratory infections. This latter problem, that is, indoor air pollution is worse in poor countries where households' houses are not equipped with separate living and cooking places.

Nonetheless, almost 2 billion people are dependent on wood fuels as their main or source of energy for cook their food and all of these are in low-income countries (Anderson, 1996). Meanwhile, many African countries adopted structural adjustment programs on "Renewable Energy Technologies" then biomass briquetting is one of the renewable energy technologies selected for promotion.

Table 2.1 Ethiopia's renewable energy resources

Resource	Unit	Exploitable Reserve	Exploited	
			Amount	Percent
Hydropower	MW	45,000	~2100	<5%
Solar/day	kWh/m2	4 – 6		<1%
Wind: Power Speed	GWm/s	1350 > 7	171MWUnder construction	<1%
Geothermal	MW	7000	7.3 MW	<1%
Wood	Million tons	1120	560	50%
Agricultural Waste	Million tons	15-20	~6	30%
Natural gas	Billion m3	113	-	0%
Coal	Million tons	>300	-	0%
Oil Shale	Million tons	253	-	0%

Source: Africa CEC session 3_Ministry of Water and Energy Ethiopia.

Wood charcoal has been the primary fuel for cooking in Ethiopia. In 1995/6 the contribution of wood fuel alone was about 77% of the final consumption, agricultural residue and dung accounted for about 16% which means that the share of traditional fuels in the national energy

consumption was above 90% (Samuel Faye Gamtessa, 2002). Therefore with deforestation becoming increasingly prevalent in many regions of the nation, there is an urgent need to find alternative fuels. Large quantities of agricultural and wood residues are generated yearly in developing countries but they are neither managed nor utilized efficiently. Agricultural residues which are freely available are often discarded or burned as wastes. According to (Kebede, 2001) and (Hiwot, 2007) the annual potential of biomass residue in Ethiopia is about 4milion tones. This data accounts only for agricultural wastes such as coffee residues, cotton, and bamboo wastes and saw dust residues but there are other residues occur in large amounts and have the potential to be an important input for fuel production in briquette forms.

Agricultural residues in their natural forms will not bring a desired result because, they are mostly loose, low density materials in addition to the fact that their combustion cannot be effectively controlled (Enweremadu, et al., 2004; Wilaipon, 2009). Although, there are many conversion routes through which these residues can be converted into biomass energy, one of such promising technologies is that of the briquetting process.(Wilaipon, 2008) described briquetting as a process of compaction of residues into a product of higher density than the original material, while (Kaliyan and Morey, 2009) defined briquetting as a densification process.

Generally, techniques of briquetting are grouped into two major classes: namely high-pressure technique and low-pressure technique (Bhattacharya et al., 2002). There are also two ways in which briquettes can be formed and these are briquettes with binders and briquettes without binders. Both techniques mentioned above can produce any shape, be it rectangular, spherical, and pellet form and so on . In Ethiopia, there are plans to build briquetting plants based up on wheat, maize and cotton and other residues (WorldBank1986). But those plants demand expensive industrial machinery. Thus, there is a need for an intermediate technology to produce briquettes with small capital investment. Currently in Ethiopia a lever arm briquetting press is at work which has been introduced by some non governmental agencies for making briquettes from biomass residues to use as a fuel instead of wood burning.

1.2 The existing briquetting machine in Ethiopia.

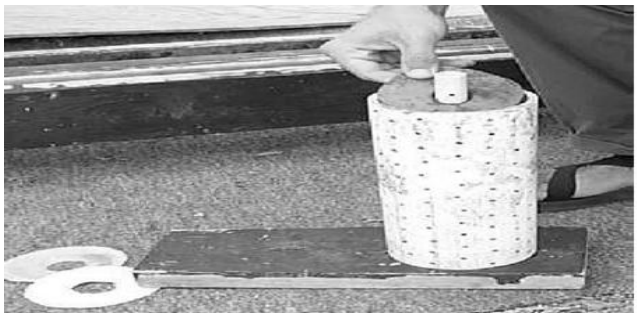


Figure 1.1 Briquetting dies site visit

Figure 1. 2 Lever arm briquetting press site visit

The Lever Arm Briquette Press: is built almost entirely out of lumber. The pressing is achieved through a simple lever mechanism. The molding die for the briquettes is made from a piece of PVC pipe 15cm long with a 10cm diameter (figure 1.1). The compression mechanism is done by lifting the handle of the press and place feed stock is poured into the molds under the compaction arm of the press then Place a ramming block on top of the mold (figure 1.2). Lower the handle and press the ramming block down into the briquette mold. Water will flow out the hole as you press the slurry. Now the briquettes are partially pressed. Slide the briquette mold down to the far end of the press which is lower than the end with the lever. Repress the mold with the ram block in order to fully compact the slurry. The briquettes are now pressed. To remove the briquettes from the mold a small wooden frame is used then the molding die rest on its edges then by pressing it one more time to force the briquettes from the bottom of the mold. Finished briquettes are set in the sun to dry. The process requires at least two workers and produced a single unit of the briquette at a time. Thus, the machine is a manual type, which has less product density after compression and low production capacity that does not satisfy the demands supplies of the product. The machine also utilizes large space and difficulty to handle and since it is separated machine that is crushing machine, mixing machine and briquetting machine is not synchronized the sum of the costs of this individual machine is relatively high when compared to the synchronized machine.

Hydraulic press: These machines operate by hydraulic pressure acting upon a piston that compresses the material through a longitudinal die to form briquettes. To obtain high quality briquettes, high human force is required during pressing. Crushing system, mixing system

briquetting system of the machine also not synchronized and mixing system is a manual type. This machine produces multiple briquettes in one operation, entirely 36 briquettes at a time.

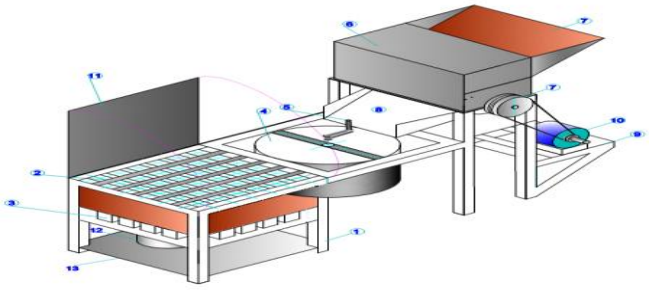


Figure1.3 Hydraulic press briquetting machine

Thus, the present study is aimed at re-designing and manufacturing of the existing lever arm and hydraulic briquetting presses to replace by improved screw press extruder machine which synchronized three functions including crushing, mixing and briquetting in a single unit with low cost. Also the process are required one operator per machine which not mandatory high skills to operate. The production capacity of the new machine is high.

1.3 Idea Generation

The national governmental economic policy of Ethiopia taking as a bench mark we decide to brain storm on making a machine which has an important contribution to the goal of national policy. Through our observation on governmental strategic policy document, The Federal Democratic Republic of Ethiopia, Ministry of Mines and Energy has clearly put in its Energy policy document in (1994) that emphasizes the use of local resource and renewable energy. This document has attracted the attention to indigenous energy resource, and work a briquetting machine which support the policy. Generally this intends to provide an alternative source of energy by using briquettes instead of burning wood in domestic and some commercial sectors such as cooking and heating activities and also in brick kilns.

1.4 Justification of Research

The abundantly available agricultural and wood residues can efficiently be used for resolving energy problems to a significant extent by adopting proper measures. Several kinds of agricultural residues can be utilized properly by densifying loose residues to produce a compact product of different sizes. Briquetting is essentially a mechanical process requiring investment in equipment and training to ensure a product of reasonable quality that will perform the task for

which it is intended. (Russell, 1997) considered that briquetting is often seen as a relatively high-cost high-pressure technology, and that it is possible to use a low-cost low-pressure (up to 2Mpa) technique to produce acceptable briquettes. For low income communities the most suitable briquetting methods are those which are based on available waste and building materials. The manufacturing should be done in locally made hand operated presses and the briquettes held together mainly by a binder.

- ✓ Briquette making saves trees and prevents problems like soil erosion and desertification by providing an alternative to burning wood for heating and cooking.
- ✓ Briquetting substitutes agricultural waste like hulls, husk, corn stocks, grass, leaves and other garbage for a valuable resource.
- ✓ Briquetting encourages many micro enterprise opportunities making the presses from locally available materials, supplying materials, and making the briquettes, selling and delivering the briquettes.
- ✓ The availability of briquette as an alternative fuel to replace firewood can also improve the living conditions of women and children, who spend most of their time collecting firewood instead of engaging in other income generating activities or attending school.

1.5 Statement of the Problem

In Ethiopia a lever arm briquetting press has been introduced by some non governmental agencies for making briquettes from biomass residues to use as a fuel instead of wood burning. But as we observe from site visit there is a need for improvement.

According to our observation and discussion with producers, the critical problems encountered when Producing briquettes using the existing machines include

- ✓ It is hard to densify the biomass as required with human force as a result, the quality of the briquette is low and it consumes energy and time.
- ✓ Low production capacity
- ✓ The briquetting die is not durable since it is made from plastic material (PVC)
- ✓ No crushing system (for dry materials with low density (<100kg/mm^3) grass, leaves and others)
- ✓ It requires high human force during pressing

- ✓ Crushing mixing and briquetting are not synchronized.
- ✓ Mixing system is not power driven.
- ✓ The cost of producing separated machine is comparatively high.

Thus, the present, synchronized screw press extruder machine designed is thought to resolve the troubles mentioned above.

1.6 General Objective of the Project

The general objective of the study is to design and manufacture the synchronized screw press extruder machine, which combines three functions including crushing, mixing and briquetting in a single unit.

1.6.1 Specific Objective of the project

- ✓ To replace the human force used for compression by screw press extruder.
- ✓ Survey existing briquette production areas.
- ✓ Identify problems related to briquetting product operations.
- ✓ Design biomass thresher, mixer and extruder which is more efficient and effective manner.
- ✓ Manufacture different parts and components of the machine.
- ✓ Assembly and testing for functionality.

1.7 Significance of the Project

Some of the benefits of improvement the machine and produce briquettes using agricultural wastes, such as sugarcane trash, grass, and saw dust and so on, as an alternative renewable energy are described as follows:

- ✓ It is good to find better alternative to firewood. But as manufacturing students could you try to improve manufacturing processes so that the overall production cost reduces and efficiency of the product improve.
- ✓ To avoid import and make easy to offer the machine with a reasonable price.
- ✓ It can be used in every rural and urban area of the country.
- ✓ It minimizes the numbers of labors and space requirements.
- ✓ Improvement of the machine helps to maximize production capacity and product quality
- ✓ Micro-enterprise can be formed around the production of briquettes derived from

agricultural waste.

- ✓ Creating job by reducing un employment
- ✓ Generate income for us
- ✓ Contribute for the development of the country by paying tax.
- ✓ Satisfying the need of the customer by providing quality service with reasonable price.
- ✓ Reduction of deforestation and soil erosion by eliminating the need to cut down trees for fuel wood, and developing a practice of using wastes as a fuel source instead.

1.8 Scope of the project.

The project's intent is to design and manufacture biomass thresher, mixer with screw press briquette extruder that performs three operations together. This machine can be operated electrically and it is capable of producing 180kg per hour briquette. Development of hydropower is very expensive and will take considerable amount of time to develop it before the country can totally rely on it. Till then biomass briquetting could serve as an alternative source of energy for domestic and industrial use. The scope of this project is to reach or address the facilities using briquetting fuels and provide biomass thresher, mixer and screw press machines with optimize price for community who are using the fire wood for cooking, heating, and uses for other purposes.

1.9 Methodology

- ✓ Primary and secondary data collection on the availability raw materials and the demand of the machine.
- ✓ Design and material selection for machine components
- ✓ Developing the machine.
- ✓ Testing the machine and redesigning
- ✓ Cost analysis

1.10 Limitation of the project

- ✓ Lack of preheating die.
- ✓ Maximum size reduction is 2mm grain size
- ✓ Lack of briquette cutter at appropriate length.

- ✓ Lack of multiple number die exit.

1.11 Feasibility Study

Feasibility study is to check the viability of the project under consideration. For the project it was being conducted three types of feasibilities explained as below.

1.11.1 Technical Feasibility.

The biomass thresher, mixer and screw press briquette extruder will be manufactured using simple mechanisms, and the materials that will be used to make the machine and its spare parts are easily available in the market. Therefore, by taking these points in to consideration we can say that the biomass thresher, mixer and screw press extruder machine is technically feasible.

1.11.2 Operational Feasibility

We have already mentioned that the biomass thresher, mixer and screw press briquette extruder will have simple mechanisms. This makes it simple to operate. Even a person with low skills can operate the machine by taking a one or two days training. It is gender friendly and needs less physical effort. Hence the machine is operationally feasible.

1.11.3 Economic Feasibility

The cost of manufacturing process, the materials to produce the machine, and the price of the product is reasonable and easily affordable. Besides, the price of the briquette is cheaper than fire wood. Its economic feasibility is so great when it is viewed from its contribution on poverty reduction policy of our country through micro enterprises, and prevention of deforestation and soil erosion.

1.12The Machine Description

The briquette machine is synchronized screw press extruder machine which combines three functions including crushing, mixing and briquetting in a single unit. It consists mainly of driving motor, screw, die, belts, and the housing with a hopper, drum, blade, hub, shaft, impeller. The belt transmits power from the motor to the screw and shaft through the pulley. When the motor is started, raw materials are fed into the machine through the hopper then it enters to the crushing chamber to be crushed and mixed and finally it will go to the barrel to be compressed, and extruded through the die. The machine has a production capacity of about 180kg/hr and it is driven by a 3 kW, 1440 rpm electric motor driving the crushing shaft, mixer shaft and screw shaft at 1440, 800 and 360 revolutions per minute (rpm) respectively. During operation, the

rotating screw takes the material from the hopper through the barrel and compresses it against the die which forms a buildup of pressure gradient along the screw. The screw continuously forces the materials into the die. Pressure is built up along the screw rather than in a single zone as in the piston type machines.

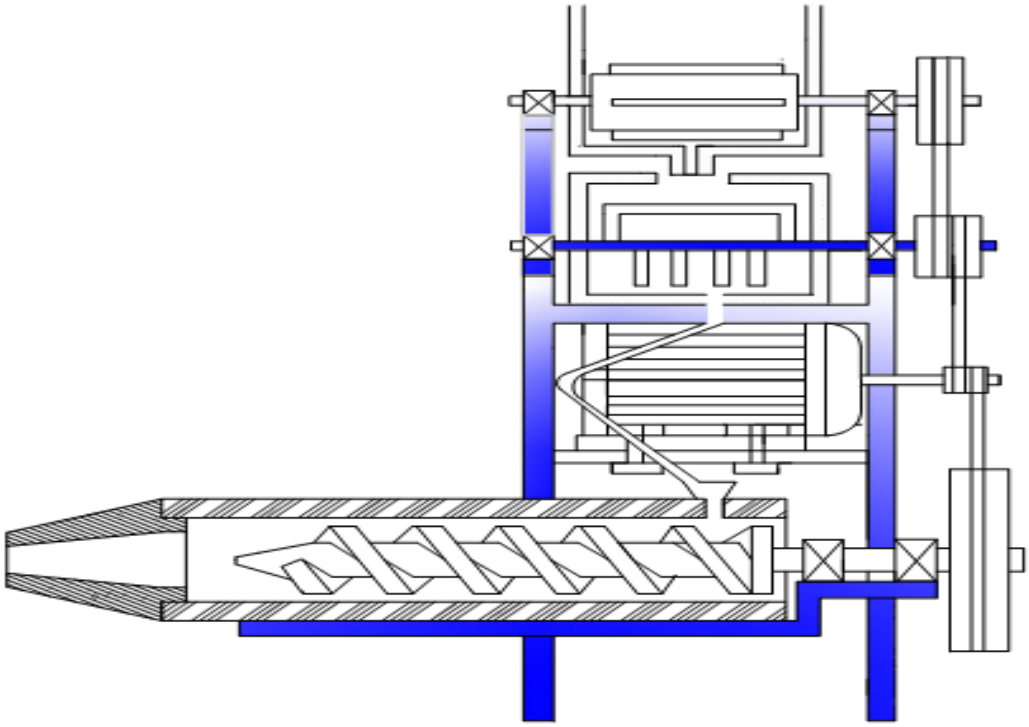


Figure1.4 Section A-A Biomass Thresher, Mixer and Screw press extruder machines (the improved machines)

1.13 Organization of the Study

Chapter one presents background of the study, the problems and the main objectives of the study. next reviewing the literatures of the previous studies concerning briquetting machines, The detailed explanations on the procedures to be used in carrying out the project to achieve the specified objectives are presented in the methodology.

The methodology to be used consists of: identifying the problem on the existing briquetting systems, redesigning of critical components, material selection, manufacturing process and cost analysis, conclusion and recommendation

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

According to Grover and Mishra (1996), briquetting is one of the several agglomeration techniques which are broadly characterized as densification technologies. Agglomeration of residues is done with the purpose of making them denser for their use in energy production. Raw materials for briquetting includes waste from wood industries, loose biomass and other combustible waste products. On the basis of compaction, the briquetting technologies can be divided into:

1. High pressure compaction,
2. Medium pressure compaction with heating device,
3. Low pressure

Eriksson and Prior (1990), stated that if the material is compacted with low to moderate pressure (0.2-5MPa), then the space between particles is reduced. Increasing the pressure will at certain state particular to each material, collapse the walls of the cellulose constituent (primary structural component of plant cell walls), thus approaching the physical, or dry mass, density of the material. The pressures required to achieve such high densities are typically in excess of 100MPa.

2.2 Research and Development Efforts in the Use of Agricultural Residues as Energy Source for Cooking Purpose Using Low Cost Technique

Russell (1977) carried out a study of a simple briquette making technique which was developed in Sri Lanka to produce corrugated briquette sheets made from coir. A small amount of binder, lime, is mixed with the wet coir which is then placed into a tobacco bailing box in alternate layers between sheets of corrugated metal until the box is full. Pressure is exerted on the layers, pressing water out of the material and also helping a chemical reaction to occur between the coir and the binder. After the briquettes have been formed it requires drying for a number of days before being used. The resulting briquettes can be cut easily or broken along the corrugation to produce small logs.

Vogler (1986) technically assesses some simple sawdust briquetting techniques in which various attempts have been made to devise methods by which people in rural areas can use sawdust to

make briquettes. The simplest idea, for areas where dung is shaped by hand and sun dried for use as fuel, is that the dung cake will burn longer if wood ash is added. He found that most efforts have been devoted to making simple briquetting machines.

Lardinois and Klundert (1993) stated that the use of organic waste as cooking fuel in both rural and urban areas is not new. In seventeenth century England, the rural poor often burned dried cow dung because of acute shortage of wood fuel due to widespread deforestation. And they went further saying that during the two world wars, households in many European countries made their own briquettes from socked newspaper and other combustible domestic waste using simple lever operated press.

Kartha and Leach (2001) carried out a study using modern bio energy to reduce rural poverty. Good results were obtained by adapting presses for bricks or earth blocks in briquetting wood and agricultural wastes.

Adegoke(2001) pointed out, that results of a recent study in the Mechanical Engineering Department of the Federal University of Technology, Akure, have shown that sawdust mixed with certain biomass materials of appropriate grain sizes and in certain proportions have improved calorific values. This mixture of the sawdust and the biomass materials are compressed using a specially developed briquetting machine and the briquettes dried either directly in the sun or in an oven. When burned in internally lined stoves, heat a loss to the environment is much reduced, a lot of cooking energy is obtained from a relatively small amount of the sawdust briquettes.

The Forest Products Research and Development Institute (2002) second prize winner in the mechanical inventions category in 1984 developed a carbonizes, simple, lowcost machine. It has a rectangular channel, hopper, charcoal receiver, swing-type metal plate cover and fire box. The briquetting machine is a simple energy- and money-saving device used in converting charcoal fines from sawdust, rice hull, coconut coir dust and other carbonaceous fine materials into charcoal briquettes for industrial uses. It consists of molds, plungers, top sliding platen, common lever, fulcrum, steel plates where the molds are welded, with a casing assembly.

Fernando, (2002), developed a technology for small scale briquetting, oriented to briquetting agricultural waste and basically all kinds of burnable wastes. He achieved very interesting and exciting results in his aim to find an alternative to the costly extruder machine. He designed and operated his own machine based on the very principle of the world wide known

CINVA RAM machine, for producing compressed earth blocks. With a pressure of around 3 – 7MPa using a lever to apply a compressive force through a piston he pressed the biomass into a briquette, shaped like an ordinary 6cm x 13cm x 24cm brick.

Inegbenebor (2002) compressed fibrous agricultural and wood waste materials with suitable adhesive into briquettes in a compressing machine, which was designed and constructed for this purpose. Nine samples of fibrous waste materials were prepared into different categories: - (100% saw-dust, 100% rice-husk, and 50-50% rice-husk/sawdust), using starch as adhesive for category A, while category B employs gum Arabic as adhesive and category C used bentonite as adhesive. The results from a water boiling test (WBT), involving comparison of the burning abilities of the solid fuel briquettes and fire wood of the same quantity (200 grams) in boiling 1.5liters of water. Results showed that the solid fuel briquettes bound with each of the three adhesives; boiled water within a period of 14 to 22 minutes. While, firewood boiled the same quantity of water within a period of 22 to 27 minutes.

Olorunnisola (2004) carried out, a study involving experimental production of briquettes from chopped rattan strands mixed with cassava starch paste. Samples of rattan strands of mixed species (Laccospermasecundiforum and Eresmopathamacrocarpa) were collected from a furniture workshop in Ibadan, Oyo State, Nigeria. The strands, having an average moisture content of 12% and an average dimension of 630 mm (length) by 4.0 mm (width) and 1.8 mm (thickness), were reduced to 25 mm (length) by 4.0 mm (width) and 1.8 mm (thickness) particles by manual shearing. They were subsequently mixed with cassava starch at six proportions by weight, i.e.50%, 100%, 150%, 200%, 250%, and 300%. It was observed that the minimum proportion by weight of cassava starch required for briquette formation was 200%. Compression experiments were performed using a simple tabletop closed - end die piston press fitted with both a pressure and a dial gauge. It was concluded that stable briquettes could be formed from rattan strands mixed with cassava starch paste.

Bello (2005) carried out a research project in processing of agricultural residues into briquettes as fuels for cooking purposes in the department of agricultural engineering, Ahmadu Bello University, Zaria in which she produced briquettes from agricultural residues using gum Arabic as her binder and evaluated their performance characteristics based on fuel efficiency, cooking efficiency, boiling time and fuel consumption rate respectively. Her

briquettes were produced using a manual hand press used in making coal briquettes in Amil Nigeria Limited in Kaduna State.

Muru gappaChettiar Research Centre (2005) is carrying out a research project based on income generation through biomass charcoal briquetting work being implemented at Kanathur and Thiruvidanthai villages in India where casuarinas leaf litter is available abundantly as waste biomass. The moisture, ash, volatile matter and fixed carbon content and biochemical properties of the biomass viz; cellulose, hemi cellulose, lignin, crude fiber, content have been estimated. The selected biomass has been carbonized at different temperatures ranging from 200^{o}C to 400^{o}C and the charcoal yield determined.

Also, a hand operated biomass briquetting mould, have been fabricated with locally available materials to prepare the charcoal briquettes for its ultimate analysis.

Olorunnisola (2007) undertook a study to investigate the properties of fuel briquettes produced from a mixture of a municipal solid waste and an agricultural residue, i.e., shredded waste paper and hammer milled coconut husk particles. Briquettes were manufactured using a manually-operated closed – end die piston press (see plate I) at an average pressure of 1.2 x 10^3 N/m^2using four coconut husk: waste paper mixing ratios (by weight), i.e., 0:100; 5: 95; 15: 85; and 25:75. Results obtained showed that briquettes produced using 100% waste paper and 5:95 waste paper-coconut husk ratios respectively exhibited the largest (though minimal) linear expansion on drying. While the equilibrium moisture content of the briquettes ranged between 5.4 % and 13.3%, there was no clearly pattern in equilibrium moisture content variation with increase in coconut husk content. A reciprocal relationship was observed between compressed/relaxed density and relaxation ratio of the briquettes. The mean durability rating of all the briquettes exceeded 95%. It was concluded that stable briquettes could be formed from waste paper mixed with coconut husk particles.

Figure 2.1 Manually operated briquetting machine source: Olorunnisola (2007)

Grover and Mishra (1996, p.5, 10, 41) made a comparison study between piston press and screw press briquette. They reported that the screw press briquette fuel has advantage over piston press like very good in combustion performance, uniform quality and suitable for gasifiers etc. The energy consumption for screw press briquette was only60 kWh/ton. They reported that "Screw press briquette (SPB) are easy to burn and give better combustion than wood. Since the density of these briquettes is higher than wood, the amount of air required is correspondingly greater for the same volume of briquettes. Moreover, SPB should be places in a vertical position as far as possible so that the air can easily pass through the central holes. The specific air requirement for these briquettes is about 1.6 Nm^3/hour per kWh of heat output."

2.3 Existing Briquetting Technology

2.3.1 Wu-Presser

The Wu-presser was developed by the Washington University. It is constructed from either metal or wooden parts as shown in figure 2.2 below.

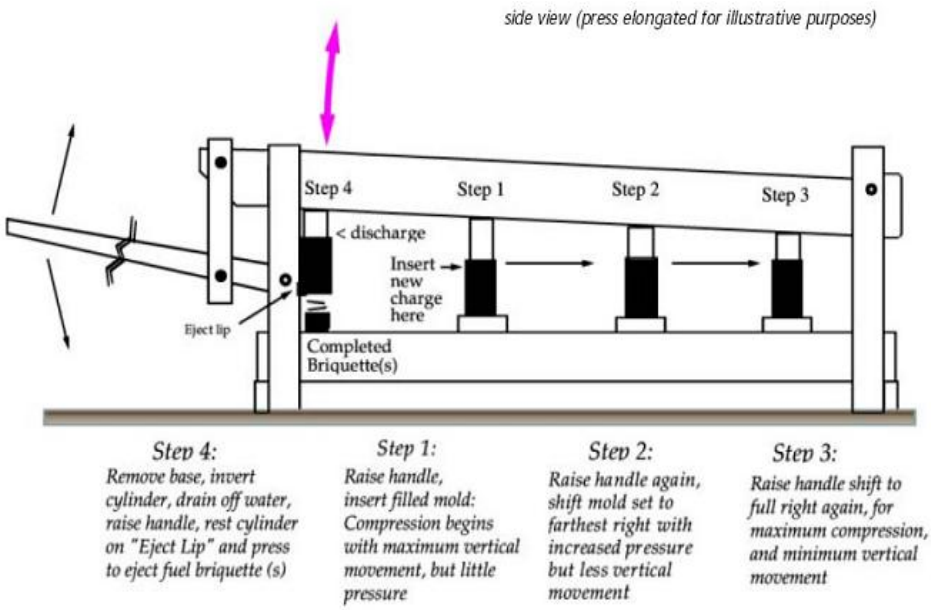


Figure 2.2 The Wu-presser Source: Legacy Foundation (2003)

The Wu-presser presses briquettes in three steps shown in the illustration above. Each step will press with increasing pressure. This takes advantage of the non-linear force to distance property of briquetting pressing.

2.3.2 Earth Rams

Presses currently in use for making stabilized earth blocks might be modified to make briquettes. The Combust ram, similar to the CINVA-Ram and Tersa ram, is commercially available or can be manufactured locally, see figure 2.3 below. The lever arm is put in the open position, feed stock is poured into the molds and the lever is then quickly pushed up, over the top of the press, and down. This movement positions the lever over the top of the press and compresses the briquettes on the downward stroke.

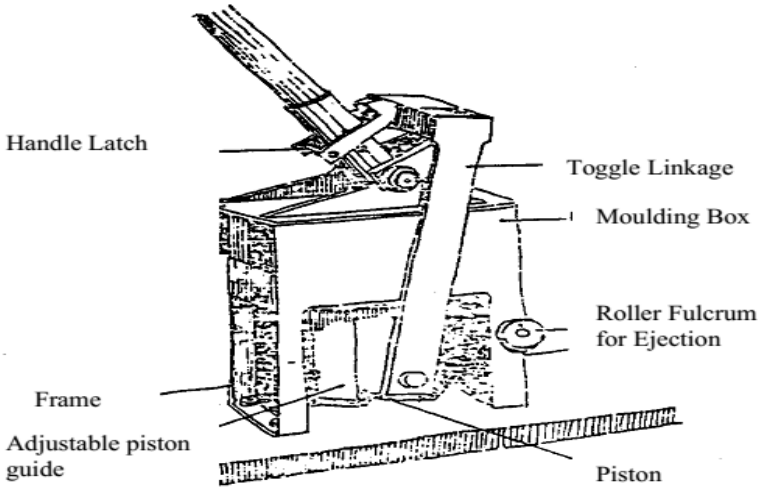


Figure 2.3 Combust ram Source: Davies (1985)

The lever is then moved back to the original position and again pushed down, thus forcing the briquettes out of the molds. Finished briquettes are set in the sun to dry. The process requires at least two workers.

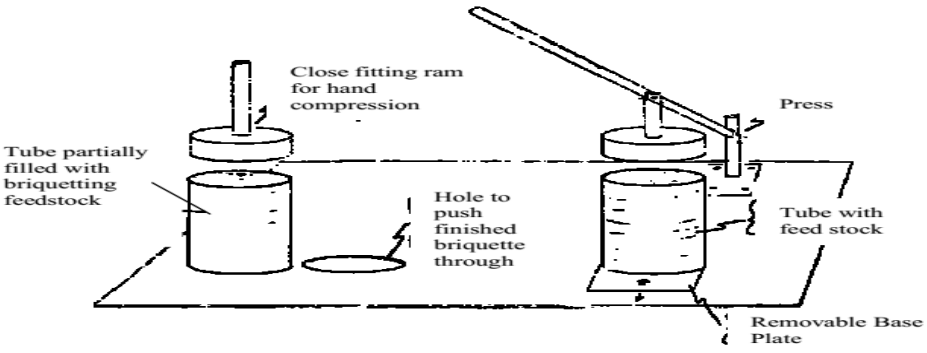


Figure 2.4 Tube Press Source: Davies (1985)

2.3.3 Tube-Presses

Metal or plastic pipe provides a good briquetting mould since it produces cylindrical briquettes. The tube press, illustration shown in figure 2.4 below, consist of a tube mounted vertically on a platform and a close fitting ram used for compaction. The basic design can be varied considerably, as the figure indicates. Feed stock is poured into the tube and compressed with the ram. The tube is then positioned over a hole (or a slide is removed) below the tube exposing a hole and the briquette is pushed through. Briquettes are then dried in the sun before storage and use.

2.3.4 Screw Presser

The screw presser makes briquettes in upright cylinders. The raw material is compressed by lowering a metal disc which is moved vertically by a screw that is turned by hand. The screw press is most commonly made of metal as shown in figure 2.5 below.

Figure 2.5 Screw presser in use. Source: Olle and Olof (2006)

2.3.5 Hydraulic Press

These machines operate by hydraulic pressure acting upon a piston that extrudes the material through a longitudinal die. The machine operates rather slowly which minimizes the wave rates. However, they operate at much lower pressures and the briquette quality is of lower density. They are typically used for low outputs of 40kg/hr but can be made to achieve up to 80kg/hr.

Figure 2.6 Hydraulic jack briquetting (www.BeavertonRotary.org)

2.3.6 Piston Press

These machine works best with dry (15% moisture content maximum) cellulose material, which is fed into a compression chamber. A reciprocating piston then forces the material through a tapered die to form a long briquette as shown in figure 2.7 below. Typically flywheel drive machines produce between 300kg and 500kg of briquettes per hour.

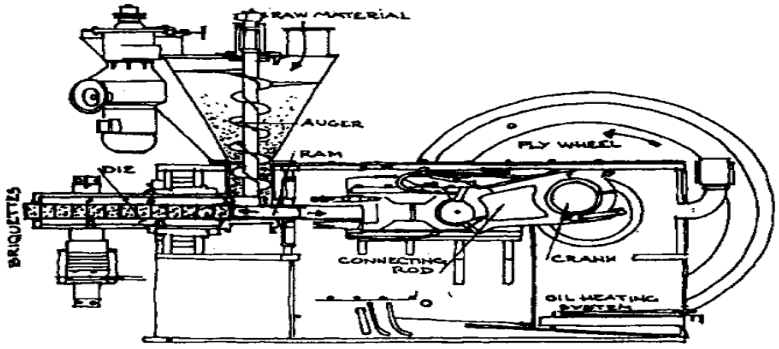


Figure 2.7 Piston Press Source: Bhattacharya et al, (1984)

The machine can achieve a service life of between 500 hours and 1000 hours using relatively clean material such as sawdust. Use of agricultural wastes containing high levels of silica (sand) will reduce the operating hours considerably. The initial cost of this type of machine is high and the briquettes are prone to breaking.

2.3.7 Pelletizer

Pellet presses have dies with small diameter (usually about 30mm). The machine has a number of dies arranged as holes bored in a thick steel disk or ring. The material is forced into the dies by means of a ram, perpendicular to the centerline of the dies. The main force applied

results in shear stresses in the material which often is favorable to the final quality of the material. The pellets are cut to lengths normally about one or two times the diameter (Eriksson and Prior, 1990). Pelletizers can produce up to 1000kg of pellets per hour but require high initial capital investment and high energy input.

2.3.8 Heat Die Extrusion Screw Press

The heat die extrusion screw press is an industrial machine for producing briquettes (see figure 2.8 below). It consists basically of an electric motor, a hopper, a die heater and muff, and the screw which densifies the raw material.

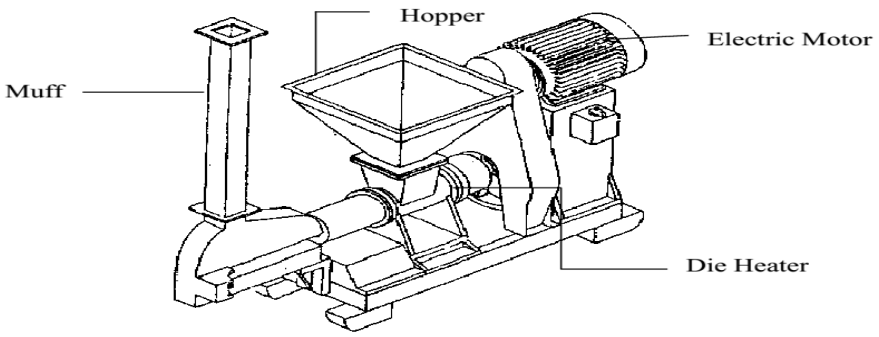


Figure 2.8 Heated die extrusion screw press Source: Bhattacharya et al, 1984

The electric motor drives the briquetting screw, which is housed inside the die, through a V-belt and pulley arrangement. Biomass raw material is fed to the screw through the hopper. The electric die-heater softens the lignin in the raw material as it passes through the die which acts as a binding material. A smoke trapping system traps and removes the smoke from the vicinity during the briquetting process. Besides the cost of the investment, the machine has a cost for the electricity consumed. Another cost is the screw that gets worn and has to be replaced frequently.

Review of previous research works carried out to provide the rural communities with a briquetting machine revealed that most of the low cost low pressure briquette machines focused on producing a single briquette in one operation. None of these machines have been successful in the market because of their low output with time spent in producing briquettes which cannot compensate for the demand for energy (firewood) in the rural homes. Use of briquettes in Ethiopia is nil because of the cost of imported briquetting machines and adequate research work not conducted in the country to find alternative machines.

Above all, the need to identify a technology which can be successful in the Third world

marginalized communities; like Ethiopia, where the high pressure mechanized process have not been successful, infrastructure is weak, supply of raw material is inconsistent in quantity and the market populations are widely dispersed over areas which are difficult to access brought about this project.

This project is aimed at re-designing the most popular existing low cost low pressure technology to produce continuous briquettes operation, in order to meet the demand for fuel in the rural community, to save trees and prevent soil erosion. Having in mind that the machine can be produced in the areas of local need by local citizen, with no technical skills and the community would have little cash flow and the local market would be price driven in their fuel price decision.

Table 3.1 Summery of literature review

Existing machines	Drawbacks of existing machine	This new thresher, mixer, and screw press briquette extruder
1. Manually operated closed-end die piston press	It is hard to deliver the pressure required with human power, i,e 1.2 x $10^3 \frac{N}{m^2}$	It delivers a pressure of 6505303 $\frac{N}{m^2}$
2. Earth rams	The process may need two or more workers	The production process can be carried out with one person
3. Tube press	It consumes more time and power of human	As this machine is automated, it has a power of 2999.3 Watt and produces with high rate,150 $\frac{kg}{hr}$
4. Manually operated screw press	The screw is turned by hand so, it can't deliver the required pressure	Screw is turned with electric motor and has a pressure of 6505303 $\frac{N}{m^2}$
5. Hydraulic press	It has low output of 40 $\frac{kg}{hr}$ and the briquette is with low density	This machine produces 150 $\frac{kg}{hr}$ and produces a briquette with density of 1200 $\frac{kg}{m^3}$
6. Piston press	It has more number of critical parts and complex construction	It has a few number of critical parts and is simple in construction
7. Pelletizer	It requires high initial capital investment and high energy output	This machine has reasonable cost of capital investment
8. heat die extrusion screw press	It requires high cost of capital investment and high cost for electricity as it has a heater	This new machine doesn't consume electricity except for the electric motor

CHAPTER THREE
METHODOLOGY

3.1 Introduction

This chapter is discussed the research methodology that were used to gather the data required to support the development and analysis of the study. This portion includes planning, data collection on the availability of raw material and demands of the machine, design of a compact briquetting machine, developing machine and test functionality, cost analysis and the ergonomic aspects of the new system from the materials collected also will be discussed.

3.2 planning

Planning is a first stage in any area of study. To identify all the information and requirement planning must be done in the proper manner. At this stage; project resources and requirements, prepare literature review, the summit of the paper and project are careful scheduled on Gantt chart.

3.3 Data collection

Data collection is one of the essential works of the methodology. At this phase all the necessary data for completion of the project are gathered.

3.3.1 Primary data collection

The following Primary data were collected during the study:

At production level, the questions were asked to know the production capacity, technological aspects, income generation activities, employment, problems facing with the technology, cost of raw material, wage, energy cost and other relevant cost etc. The type of raw material used was identified as well as from where they collect the raw material and where to sell the product. This data was needed to identify the flow channel of the densified biofuel.

3.3.2 Secondary data collection

The following secondary data were collected during the study:

- ✓ Background information on potential of loose biomass material used for densification
- ✓ Available previous information on biomass densification technology in country context
- ✓ Information on present energy status of the country as well as of the study area

- ✓ Key information of the study area
- ✓ Information on densified biofuel in the context of use, socio-economical aspects, research and development achievement from other countries.

The secondary data were collected by reviewing the literature, publications, internet searching and discussion with the focal persons.

3.3.3 Consultations and informal discussions

Consultations were held with our advisor, and informal discussions were conducted with other individuals who have the engineering knowledge about briquetting machine.

3.4 Design of compact briquette machine

The compact briquetting machine has been designed with the aim of eliminating individual machines, reducing material handling, manpower and space, and improving productivity. The important matter is that the obtained briquette quality with in an acceptable range.

The new compact screw-press biomass briquetting system which synchronizes crushing, mixing and briquetting in a single unit as shown in figure 3.1 The briquetting machine designed has a capacity of about 180kg/hr and is driven by a 3 HP electrical motor.

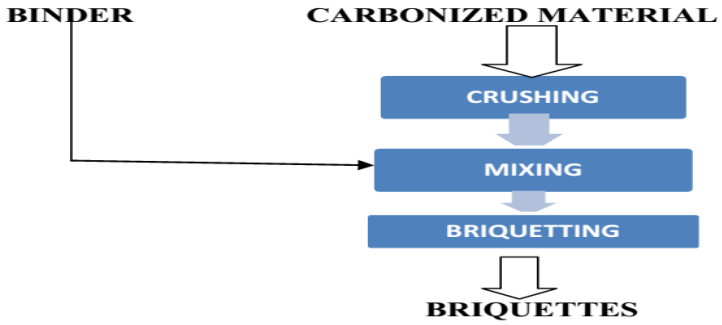


Figure 3.1 the new compact briquetting machine as a single unit

The existing briquetting system (three individual machines working together, including crushing, mixing and briquetting machine and three workers): carbonized material is transferred to a crushing machine which has a hammer mill for grinding and crushing the carbonized, the fined charcoal and binder are completely mixed at a predetermined mixing ratio and then transferred to a briquetting machine to be extruded into briquettes. After that the briquettes are cut and dried before sending to its store. The new briquetting system as the proposed design (a compact machine and one worker): carbonized material is transferred to a compact machine and then the binder is added into the mixing container. Briquettes are extruded out at the die exit. Finally, the briquettes are then cut and dried before sending to its store. In doing so, it helps to reduce

worker, material handling, transfer time, space and production time. That leads to improve its productivity.

3.5 Material selection: The proper materials have been selected for the components of the machine according to the required properties.

3.6 Description of the new compact briquetting machine.

The briquetting process is achieved by pre-treatment and densification processes. Biomass thrashing and mixing are systems for pre-treatment and screw press extruder is a system for densification process. From this point of view the description will be focus on the three systems namely biomass thrasher, mixer and screw press briquetting machine.

3.6.1 Biomass crusher

Operational description: Biomass residues are feed uniformly through feeder to the concave crushing channel then the rotor cut the materials by the effect of pressure shear and impact effect of the crushing blades then the cut pieces pass through the concave holes. To ensure this need we design a community base crushing machine in order to be suitable for crushing biomass residues in to the required grain size(<2mm).

Table 3.1Technical specifications of biomass crusher machine

Item	Specifications
Hopper (feeder) Rectangular drum top WxHxL	(380x400x445)mm
Rotor drum; • Hub - Number - Mass - Diameter - Length • Blade - Number - Mass - Width x Length x Thickness Spacing b/n blades	 Two hubs 2.5kg each Total=5kg diameter 100mm,Length 10mm Four blades 0.5kg each Total=4 x05=2kg 40 x300 x5 (mm) 78.55mm
Grinding screen - W x L x T - Diameter of concave screens hole	 380x445x3(mm) 2mm
Total height of the machine	1500mm
Clearance b/n blade and grinding screen	10mm
Electric motor	3hp
Production capacity	64kg/h

3.6.2 Mixing machine

The machine that used to completely mix powder and some binder at a predetermined mixing ratio. Thus, appropriate proportions of raw materials and binder are mixed thoroughly into the mixing container. In some operations it may take up to 15 to 30 minutes to obtain an adequate blend for the materials in the mixing chamber. When this condition of uniformity of mixture of the material constituents, the mixture is discharged through the exit hopper and conveyed to where it is required to be utilized for briquette processing or utilization.

Table 4.2 Technical specifications of biomass Mixing machine

Part No	Part Name	Specification
1	Shaft diameter	30mm
2	Shaft length	400mm
3	Pulley and belt	Diameter of driven pulley = 75mm Diameter of driving pulley = 140mm Belt type V-belt
4	Motor	Three phase motor Power = 3Hp Speed = 1440rpm
5	Impeller (stirrer)	Taper plate (90mm to 50)x75x4mm

3.6.3 Screw press extruder type briquetting machine

The screw press extruder type briquetting machine was used in the present study. It consists of driving motor, screw, die, and hopper and power transmission system. Pulley and belt were used to transmit power from motor to the screw. The raw material was fed to the hoppers, which convey it to screw by gravity. The material was pushed forward due to geometry of screw. As the material was pushed, it got compressed and binded material comes out of die in the form of briquettes. The detail technical specification of screw extruder type briquetting machine is shown in Table 3.3.

Table 3.3Technical specifications of the Screw press extruder machine

Part No	Part Name	Specification
1	Screw Dimensions	No of turns = 6 Screw pitch = 30mm Maximum diameter of screw = 75mm Min diameter of screw =52.5mm2, total length of unthread and thread screw= 550mm
2	Die dimensions	No of exit tubes=1 Diameter of exit taper tube=30mm,25mm Length of exit tube = 60mm
3	Pulley and belt	Diameter of driven pulley = 75mm Diameter of driving pulley = 300mm Belt type V-belt
4	Motor	Three phase motor Power = 3Hp Speed = 1440 rpm
5	Overall dimensions	Overall length of machine = 310mm Overall width of machine = 310mm Overall height of machine = 620mm

3.7 Assembly of the components: All components of the machine are assembled step by step according to the assembling procedure.

3.8 Appearance (aesthetic) of the machine

It is good in appearance. Most of the parts are made to appear good for the operator and visitors, the briquetting die, the frame, the biomass thrasher and the compression system are designed by taking the appearance of the machine in to consideration. Generally the machine is ergonomically good.

CHAPTER FOUR

DESIGN AND MATERIAL SELECTION

4.1 Introduction

This chapter presents the design analysis and material selection of the improved machine. Design can be defined as a decision making process where plans are formulated for the physical development of a machine or equipment for proper functions, whereby all the user's requirements are satisfied. Design is the ultimate function of engineering in the development of products and processes, and an integral aspect of design is the use of mechanical properties derived from mechanical testing. The basic objective of product design is to specify the materials and geometric details of a part, component, and assembly so that a system meets its performance requirements. Modification is to modify the size of the member to agree with the past experience and judgment to facilitate manufacture. The modification may also be necessary by consideration of manufacturing to reduce overall cost and weight.

4.2 General consideration of design

The following are the general consideration in design:

1) **Type of load and stress caused by the load**

   The load, on a machine component, may act in several ways due to which the internal stresses are set up.

2) **Motion of the parts or kinematics of the machine**

   The successful operation of any machine depends on largely upon the simplest arrangement of the parts which will give motion required.

   The motion of the part may be:

   a) Rectilinear motion which includes unidirectional and reciprocating motions.
   b) Curvilinear motion which includes rotary oscillation and simple harmonic
   c) Constant velocity
   d) Constant of a variable acceleration

3) Selection of a material: it is essential that a designer should have a thorough knowledge of the properties of the material and their behavior under working conditions. Some of the important characteristics of the materials are:

- ✓ Strength
- ✓ Durability
- ✓ Flexibility
- ✓ Weight
- ✓ Resistance to heat and corrosion
- ✓ Weld or hardened
- ✓ Machinability etc

4) **Form and size of the part:** The form and size are based on judgment. The smaller practicable cross sectional may be used, but it may be checked that the stresses induced in the designed cross-section may be used are reasonably safe. In order to design any machine part for form and size, it is necessary to know the forces which the part must sustain. It is also important to anticipate any suddenly applied or impact load which may cause failure.

5) **Frictional resistance and lubrication.**

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

6) **Convenient and economical features.**

In designing, the operating features of the machine should be careful studied. The starting controlling and stopping levers should be located on the basis of convention handling. The adjustment for wear must be provided employing the various take up devices and arranging them so that the alignment of the parts is preserved. If the parts are to be changed for different products or replaced on account of wear or breakage, easy access should be provided and the necessity of removing other parts to accomplish this should be avoided if possible.

7) **Use of the standard parts**: The use of standard parts is closely related to the cost, because the cost of standard or stock parts is only a fraction of the cost of similar parts made to order.

The standard stock or parts should be used whenever possible; parts for which patterns are already in existence such as gear, bearing and parts which may be selected from regular shop stock such as power screw, nut and pins.

8) **Safety operation:** some machines are dangerous to operate, especially those which are speed up to insure production at a maximum rate. Therefore, any moving part of a machine which is within the zone of a worker is considering.
9) **Workshop facility:** a design engineer should be familiar with the limitations of his employer's workshop, in order to avoid the necessity of having work done in some other workshop.
10) **Modification:** modify the size of the member to agree with the past experience judgments to facilitate manufacture. The modification may also be necessary by consideration of manufacturing to reduce overall cost
11) **Detailed drawing:** draw the detail drawing of each component and the assembly of the machine with complete specification for the manufacturing process suggested. A designer engineer is faced with two important responsibilities in the evaluation of a product from concept to completion. Those are material selection and understanding fabrication process associated with design.

4.3. Material selection

The selection of a proper material, for engineering purposes, is one of the most difficult problems for the designer. The aim of material selection in manufacturing is to create products and components that perform properly under operating conditions. When selecting materials for a machine, first consideration is what materials are suitable for the product, the way the product will be made, method of construction and cost are all vital elements. The following factors should be considered while selecting the material:

1. Availability of the materials,
2. Suitability of the materials for the working conditions in service, and
3. The cost of materials

The important properties, which determine the utility of the material are physical (include luster, color, size and shape, density, electric and thermal conductivity, and melting point.), chemical (oxidation, corrosion, and diffusion) and mechanical properties (include strength, stiffness,

elasticity, plasticity, ductility, brittleness, malleability, toughness, resilience, creep and hardness.) Thus most important goals of the material selection are to:

- ✓ Minimize the cost of manufacturing, by reducing the time spent in the design stage.
- ✓ Minimize the cost of the material.
- ✓ Maximize the performance of the product

4.4 Design Considerations for biomass crusher

Biomass residues are chopped into small pieces so as to enhance their workability and compactness. The process is dependent on the type of biomass feedstock. For example, coffee husks and saw dust would not require shredding but materials such as ground nut waste, bagasse, wheat straws, barley and maize straws and cobs would need to be chopped into small sizes. Before briquetting, biomass material often needs to be broken down in size by processing. To ensure this need we redesign a community base threshing machine in order to be suitable for crushing biomass residues in to the required grain size(<2mm). This machine is consisting of the following major parts; feeding system, rotor drum (two hubs and four blades), concave screen, frame, Electric Motor, Shaft Pulley, Motor Pulley, Bearings, Shaft, V-Belt etc. The desired target can be achieved based on the following design specifications;

- ✓ The shaft is designed to rotate at a relative speed of 1440rpm as electric motor speed and achieved by proper pulley selection to reduce the speed of the electric motor that has a speed of 1440rpm.
- ✓ Production capacity of the machine is 64kg/h
- ✓ Grinding screen (concave) with 2mm diameter hole

The design will provide for ease of operation and maintenance as well as the safety of the operator.

4.4.1 Description of Parts and Functions

The biomass crushing machine consists of four main parts:

1) Feeder(hopper)
2) rotor drum
3) External drum
4) Main frame

- ✓ **Feeder;** It is made from 3mm thick mild steel sheet metal and used as sliding mechanism for materials to be crushed.
- ✓ **Rotor drum;** This part consists of two cylindrical hubs made from 10mm thick mild steel plate and four threshing blades made from 5mm thick mild steel plate then crushing mechanism is done through the rotation of rotor drum.
- ✓ **External crushing drum;** this crushing component is a combination of rectangular top with concave screen bottom. The trough is made from 3mm thick mild steel sheet and its function is used for holding and outlet chamber for materials to be crushed. At the bottom section of the crushing trough output component is positioned for collecting crushed materials.
- ✓ **The main frame:** The main frame is made from 50mm x 50mm x 4mm x1200mm angle iron welded to produce a rectangular shape structure which is capable for supporting all the machine components.

4.4.2 Design Analysis of critical parts of Crushing machine.

The biomass crushing machine has a number of components but this topic focuses on the design of some of the components which are critical for proper functioning of the machine. The other components of the machine like frame etc are produced through experience.

Hopper design.

The hopper is designed as a frustum of a square pyramid. Using similar triangles, figure 4.1 below

$$\frac{220+x}{160} = \frac{x}{60} \quad \ldots\ldots (1)$$

$$x = 132mm$$

Volume of hopper = volume of the big cone – volume of the small cone.

$$= \frac{1}{3}\pi(R^2H - r^2h) \quad \ldots\ldots (2)$$

$= 2.235 \times 10^{-3} m^3$

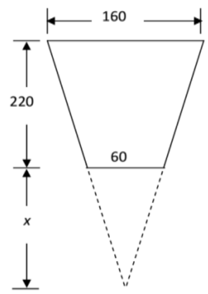


Figure 4.1 hopper

Determination of outer and inner crushing drums volume.

Outer crushing drum:

The crushing drum is combination of rectangular top with concave screen bottom. The trough is made from mild steel with density of 7850kg/m3 at room temperature with thickness of 3mm.The average production capacity of the briquetting machine is 180Kg/hr; therefore the volume of the crushing trough is designed by considering the required volume of the material to be crushed at a time.

- ✓ Volume of the rectangular box

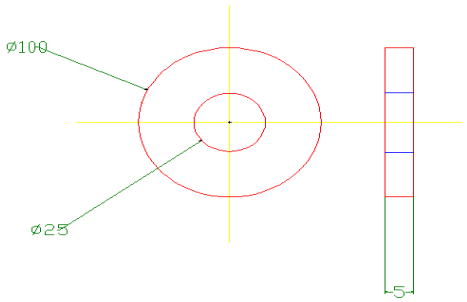
$$\boldsymbol{Vr = WLH} \quad \text{......} (\mathbf{3})$$

Where Vr (mm^3), W = Width (400mm), L = length (500mm), H = Height (400mm)

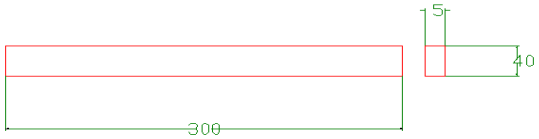
$$Vr = 400x500x400 = 80x10^6 mm^3 = 8x10^{-2} \text{m}^3$$

- ✓ Mass of rotor drum;

It consists of two hubs, four blades made from mild steel with density of 7850kg/m^3 and mounted on a solid shaft made from mild steel with dimension of 25 mm diameter and 400 mm long.



Hub of the crusher



blade of the crusher

$$M_{rd} = M_h + M_b \quad (4)$$

Where, M_{rd} is mass of rotor drum, M_h is mass of the Hub and M_b is mass of the blades.

- ✓ Mass of Hub;

There are two Hubs positioned on the shaft with dimension of 200mm diameter and 10mm long and the material is made from mild steel with density of 7850kg/m^3.

$$M_h = \rho_h v_h \quad (5)$$

Where ρ_h is density of the hub and v_h is volume of the hub

$$v_h = \pi r^2 l_h \quad (6)$$

Where, r is the diameter of the hub, and l_h is the length of the hub.

$$\pi(100mm)^2(10mm) = 314{,}159mm3 = 314.159x10^{-6}m^3$$

For two Hubs

$$v_h = 2(314.159x10^{-6}\text{m3}) = 0.628x10^{-3}m^3$$

Therefore $M_h = \rho_h v_h$

$$= 7850kg/m^3 x 0.3142x10^{-3}m^3 = 2.5kg$$

For two Hubs;

$$2xM_h = 2x2.5kg = 5kg$$

- ✓ Mass of the blades;

There are four blades welded on the hubs and made from mild steel with a dimension of 40mm width, 300mm length and 5mm thickness.

$$\boldsymbol{V_b = WxLxT} \quad \ldots\ldots(7)$$

Where W is width, L is length and T is thickness of the blade.

$$V_b = \ 40mmx300mmx5mm = \ 60{,}000mm^3 = 6x10^{-5}m^3$$

$$M_b = \rho_b v_b = 7850kg/m3x6x10^{-5}m^3 = 0.5kg$$

For four blades;

$$M_b = 4(0.5kg) \ = 2kg$$

There for Total mass of the rotor drum will be;

$$M_{rd} \ = \ M_h \ + M_b = \ 5kg \ + 2kg = 7kg$$

Determination of biomass quantity to be threshed at a time.

The biomass residues used for briquetting are materials with relatively low bulk density there for the average bulk density of materials for this study is estimated to 100kg/m^3

$$\boldsymbol{M_{bm} = \rho v_{bm}} \quad \ldots\ldots(8)$$

Where M_{bm} mass of biomass in kg, ρ density of biomass (kg/m^3), v_{bm} volume of biomass (mm^3)Volume of the biomass to be threshed is determined by the feeding volume and which is equal to the volume of the outer drum plus volume of hopper minus the volume of hub and blades given by;

$$\boldsymbol{v_{bm} = \left(Vr \ + v_{hop}\right) - \left(V_h \ + v_b\right)} \quad \ldots\ldots(9)$$

$$(8x10^{-2}\text{m}^3 \ + 2.235x10^{-3}\text{m}^3) - \ (0.628x10^{-3}m^3 \ + 4x(6x10^{-5})m^3) = 0.08m^3$$

$$M_{bm} \ = \ \rho v_{bm} = 100\text{kg/m}^3\text{x}0.08\text{m}^3 = 8\text{kg}$$

Determination of pulley diameter and Design of the recommended V- belt

Among flexible machine elements, perhaps V-belt drives have widest industrial application. These belts have trapezoidal cross section and do not have any joints. Therefore, these belts are manufactured only for certain standard lengths. To accommodate these belts the pulleys have V shaped grooves which makes them relatively costlier. Multiple groove pulleys are available to accommodate number of belts, when large power transmission is required. V-belt drives are most recommended for shorter center distances. In comparison to flat belt drives, these drives are slightly less efficient. V-belt can have transmission ratio up to1:15 and belt slip is very small. As

the belts are endless type, V-belt drives do not suffer from any joint failure and are quiet in operation. V-belts constitute fabric and cords of cotton, nylon etc and impregnated with rubber.

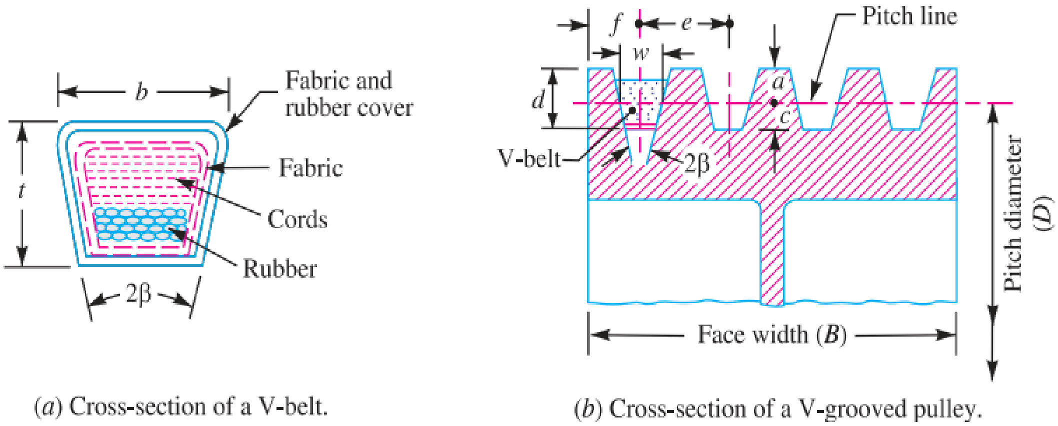


Figure 4.2 V-Belt and V-grooved pulley (Gupta, 2004)

The included angle for the V-belt is usually from 30° to 40°. The power is transmitted by the wedging action between the belt and the V-groove in the pulley or sheave. A clearance must be provided at the bottom of the groove in order to prevent touching of the bottom as it becomes narrower from wear. The V-belt drive may be inclined at any angle with tight side either at top or bottom. In order to increase the power output, several V-belts may be operated side by side. It may be noted that in multiple V-belt drive, all the belts should stretch at the same rate so that the load is equally divided between them. When one of the set of belts breaks, the entire set should be replaced at the same time. If only one belt is replaced, the new unworn belt will be more tightly stretched and will move with different velocity.

According to Indian Standards, the V-belts are made in five types (A, B, C, D and E) the dimensions for standard V-belts are shown in Appendix A. The dimensions for the standard V-grooved pulley according to IS: 2494 – 1974, are shown in Appendix B

The given parameters for recommended V-belt are Drive: 3hp three phase motor, operating speed is 1440 rpm and operates for over 8 hours. The equipment driven is a biomass thrasher, which runs at 800 rpm and the required power transmission is 3hp.

The expression for diameters of driver pulley (motor pulley) and driven pulley (shaft pulley) is given by Khurmi and Gupta (2006) as;

$$Rs = \frac{D1}{D2} = \frac{n1}{n2} \qquad (10)$$

Where, D1 driver pulley diameter (mm), D2 driven pulley diameter (mm),n1 speed of electric motor (rpm),n2 speed of driven.

Hence, obvious choice for belt selection is: A (Appendix. A)

Now, calculate the pulleys diameter (D1, small pulley pitch diameter) and (D2, Large pulley pitch diameter). Choose the minimum pulley diameter (motor pulley) from data book

$D1 = 75mm$

Speed ratio (Rs) is given by;

$$Rs = \frac{n1}{n2} = \frac{D1}{D2}$$

$Wheren1 = 1440rpm, n2 = 1440rpm$

Rs = 1440/1440 = 1

The pitch diameter of large pulley (Dp) is given,

$$D2 = RsxD1 = 1\,x\,75 = 75mm$$

The center distance, C[mm], between two adjacent pulleys is determined using the relation

$$\boldsymbol{C = \frac{D1}{2} + \frac{D2}{2} + D1} \quad \ldots\ldots(\mathbf{11})$$

$$C = 75/2 + 75/2 + 75 = 150mm$$

The length of the V- belt, L (mm) is given as ;(temporary)

$$\boldsymbol{L = \frac{\pi}{2}(D1 + D2) + 2C + \frac{(D2-D1)^2}{4C}} \quad \ldots\ldots(\mathbf{12})$$

$$L = \frac{\pi}{2(75+75)} + 2x150 + \frac{(75-75)2}{4x150} = 300mm$$

According to IS: 2494 – 1974, 36mm is subtracted to get the inside length of the belt thus it is 673.

The standard inside length is 696mm.

The exact center distance of the pulleys after the belt length has been determined.

$$\boldsymbol{C = \frac{b + \sqrt{b^2 - 2(D_1 - D2)^2}}{4}} \quad \ldots\ldots (13)$$

Where b = Lp – 1.57(D1 + D2)

$$b = 696 - 1.57(75 + 75) = 460.5mm$$

$$C = \frac{460.5 + \sqrt{460.5^2 - 2(75 - 75)^2}}{4} = 230mm$$

The length of the span S (mm) between two sheaves over which the belt is unsupported is

$$\boldsymbol{S = \sqrt{C2} - \left[\frac{D2 - D1}{2}\right]^2} \quad \ldots\ldots (\mathbf{14})$$

$$\sqrt{230^2} - [(75 - 75)/2]^2 = 230\text{mm}$$

- ✓ Lap angles determination

The angle of lap $\theta 1$ for driver pulley (motor) is given as;

$$\boldsymbol{\theta 1 = 180^O - 2sin^{-1}\left[\frac{D2-D1}{2C}\right]} \quad \ldots\ldots (\mathbf{15})$$

$$= 180^O - 2sin^{-1}\ \overline{\ } [(75 - 75)/2\ x15$$

$$= 180^0 - 2(11.5) = 157^0 = 3.09rad$$

The angle of lap $\theta 2$for driven pulley (motor) is given as;

$$\boldsymbol{\theta 2 = 180^O + 2sin^{-1}} \quad \ldots\ldots (\mathbf{16})$$

$$= 180^O + 2sin^{-1}\left[\frac{75 - 75}{2} x\ 230\right]$$

$$= 180^0 + 2\ (11.5) = 203$$

$$= 196.4^0 = 3.09rad$$

- ✓ Determination of belt tension

$P = (T1 - T2)\ V$ (Akintude et al, 1983):

Where p is design power (KW) =2.24kw, T1is tension on the tight side of the belt, $T_2$is tension on the slack side of the belt, V speed =11m/s. Using belt ratio;

$$\boldsymbol{2.3log\left(\frac{T1}{T2}\right) = \mu\theta cosec\beta} \quad \ldots\ldots (\mathbf{17})$$

Where, $\mu$is coefficient of friction $= 0.2$, θ is angle of contact in $\frac{\text{rad}}{\text{sec}} = 2.74\text{rad}$,

is β groove angle $= 180^0$

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

$$2.3log\left(\frac{T1}{T2}\right) = 0.28x2.7xcosec180 = 2.7$$

$$log(T1/T2) = 2.7/2.3 \ = \ 1.1$$

$$(T1/T2) \ = \ 12.5 \quad (Taking\ antilog\ of\ 1.1)$$

$$T1 = \ 12.5T2$$

$$T1/12.5 = \ T2$$

$$P = (T1 \ - \ T1/12.5)V \ = 2.24KW = (0.92T1)11m/s$$

$$2.24kw \ = \ 10.12T1m/s$$

$$T1 = 147N$$

$$T2 \ = \frac{147}{12.5} = 11.8N$$

Determining the diameter of the shaft

The shaft is cylindrical with circular cross sections, pulley and bearing mounted on it. It has two hubs and four chopping blades mounted on it. The shaft will be subjected to combined stress bending and twisting which is equivalent twisting moment.

Maximum twisting moment acting on the shaft:-

- ✓ Maximum bending moment acting on the shaft will be calculated.
- ✓ Find the load acting on the shaft due to the belt tension and the weight of the pulley.

The force of belt tension and weight of the pulleys and drum bend the shaft vertical plan. Effective tension in the belt on the tight and slack sides,T_1=147N, T_2=11.8Nrespectively Weight of the drum W_d = 70N, Pulley weight Pw= 10N, V-belt tension T_b= 158.8N.Mild steel selected for the design of shaft, because the load that applies on the shaft twisting moment and bending moment that requires a material with high yield strength and the pulley is keyed into it.

Table 4.1 Material properties of mild steel

Material	yield strength of the material	ultimate tensile strength(MPa)
mild steel	345 N/mm^2	521 N/mm^2

The standard value of factor of safety based on ultimate tensile strength for steel at dynamic load is 6. From mechanical design data book.

Therefore the allowable stress is,

$$\sigma_{max} = \frac{\sigma_{ut}}{F.S} \ = \ \frac{521}{6} \ = 86.83\ N/mm^2$$

Let d= diameter of shaft,

T = torque transmitted by the shaft,

P= power transmitted by the shaft (W),

N= rpm of the shaft,

τ = permissible shearing stress, and

Mb= bending moment.

- ✓ Forces acted on the shaft by pulley = T_b + Pw = 158.8N+10N = 168.8N
- ✓ Forces acted on the shaft by the drum =70N

The power transmitted by shaft and the torque in the shaft are related according to Machine elements (2013) as

$$\boldsymbol{P = T\omega} \quad (\mathbf{18})$$

$$\boldsymbol{\omega = \frac{2\pi N}{60}} \quad (\mathbf{19})$$

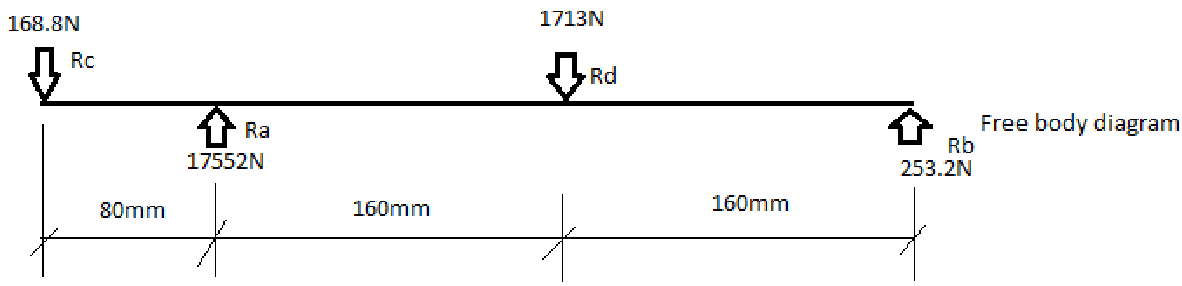
$$\boldsymbol{P = T\frac{2\pi N}{60}} \quad (\mathbf{20})$$

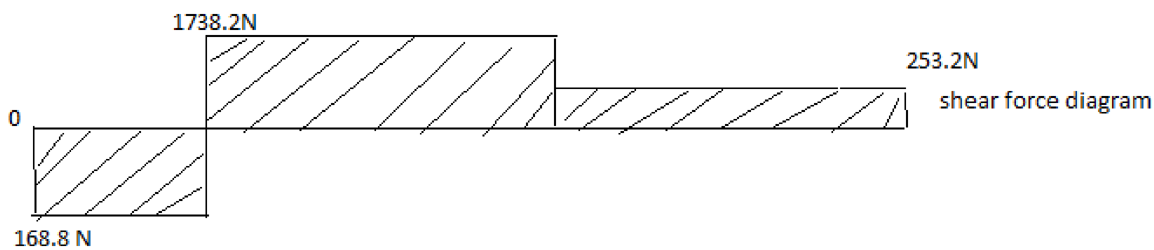
$$\boldsymbol{T = \frac{30P}{\pi N}} \quad (\mathbf{21})$$

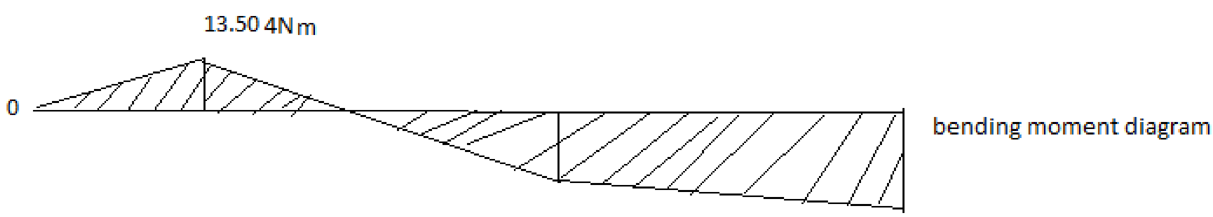
The shear stress and transmitted torque are relate das

$$\boldsymbol{\tau = \frac{16T10^3}{\pi N}} \quad (\mathbf{22})$$

$$\boldsymbol{T = \frac{\pi\tau \times d^3}{\pi N} \times 10^{-3}\frac{N}{mm^2}} \quad (\mathbf{23})$$







There fore the maximum bending moment is:

M_b max. = 13.564Nm

To determine the reaction Force on the Shaft use moment equation;

$$\sum \boldsymbol{MA} = \mathbf{0} \qquad \ldots\ldots (\mathbf{24})$$

$$= 168.8x0.08 + RBx0\ .32 - \ 70x0.16$$

$$RB = 253{,}2N$$

$$RA = 168.8 \ + \ 70 - 2.304 \ = \ 17552N$$

Maximum bending moment (M_{max})

$$\text{Mb at RA} = \ 168.8\text{x}.08 = 13.5\text{Nm}$$

$$\text{Mb at Rd} \ = 168.8\text{x}0.24 - 236.5\text{x}.160 = 2.664\text{Nm}$$

$$\text{Mb at RB} \ = 168.8\text{x}0.4 - 236.5\text{x}0.32 + 70\text{x}0.16 = 3.04\text{Nm}$$

Therefore the maximum bending moment will be at RA=13.5N-m

We know that the allowable tensile stress, $\sigma_b = \frac{s_{ut}}{F.S} = \frac{521}{6} = 86.83N/mm^2$

and allowable shear stress, $\tau = \frac{s_y}{F.S} = \frac{345}{6} = 57.5N/mm^2$.

Now, Determining the twisting moment, in which p=2.24KW, N=1440rpm

$$T = Px60/2\,\pi N$$

$$T = \frac{2.24x1000x60}{2x1440\pi} = 14.8Nm = 14{,}852.5N/mm$$

Equivalent twisting moment T_e.

$$(\boldsymbol{Te}) = \sqrt{(\boldsymbol{Mb})^2 + (\boldsymbol{T})^2} \quad \ldots\ldots(\mathbf{25})$$

where, $Mb = 13.5Nm$ T=14.8Nm

Te = $\sqrt{((13.5)^2 + (14.8Nm))^2}$ = 20Nm

The Equivalent twisting moment, Te =20Nm is greater than the torque in the shaft, T=14.8Nm therefore it is a safe consideration and then find the diameter of the shaft as follows:

According to maximum shear stress theory, the maximum shear stress in the shaft,

$$\boldsymbol{\tau_{max}} = \frac{1}{2}\sqrt{(\boldsymbol{\sigma_b})^2 + 4\boldsymbol{\tau^2}} \quad \ldots\ldots(\mathbf{26})$$

Substituting the values of τ and σ_b

$$\boldsymbol{\tau_{max}} = \frac{1}{2}\sqrt{\left(\frac{32M}{\pi d^3}\right)^2 + 4\left(\frac{16T}{\pi d^3}\right)^2} = \frac{16}{\pi d^3}\left[\sqrt{M^2 + T^2}\right] \quad \ldots\ldots(\mathbf{27})$$

Or

$$\boldsymbol{\tau_{max}} \times \frac{\pi}{16}\boldsymbol{d^3} = \sqrt{M^2 + T^2} \quad \ldots\ldots(\mathbf{28})$$

$$d = 24.27mm$$

Where, $\tau_{max} = 57.5N/mm^2, M = 13.5, T = 26.7Nm, \sigma = 86.83Nm$,

Now according to maximum normal stress theory, the maximum normal stress in the shaft

Maximum Shear Stress (Maximum Shear Stress Theory)

A material will fail when the maximum shear stress at yield point obtained from a uniaxial tensile test (ductile)

$$\tau_{max} < \sigma_{yield}$$

Maximum Normal Stress (Maximum Normal Stress Theory)

A material will fail when the maximum normal stress at a point exceeds the ultimate normal stress obtained from a uniaxial tensile test (brittle)

Maximum ($\sigma_1,\ \sigma_2, \sigma_3\ <\ \sigma_{ult}$

$$\boldsymbol{\sigma\ =\ \frac{16}{d^3\pi}\left[M\ +\ \sqrt{M^2\ +\ T^2}\right]} \quad (\mathbf{29})$$

Or

$$\sigma \times \frac{\pi}{32} \times d^3\ \ = \frac{1}{2}\left[M\ +\ \sqrt{M^2\ +\ T^2}\right] \quad (30)$$

$$d = 23.95$$

From this two expression, diameter of the shaft(d) 24.27mm and 23.95mm.use the larger, 24.27mm. The maximum diameter of the shaft is 24.27mm use 30mm

Determination of power required for threshing

The Total power required is calculated using equations as specified by (Akintundeetal,2005)

$$\boldsymbol{P_{\mathrm{T}} = \ P_{\text{Rotor drum}} + P_{\text{shaft}} + P_{\text{threshing}}} \quad (31)$$

But the shaft and the rotor drum are joined together therefore

$$\boldsymbol{P_{\mathrm{T}} = \ P_{\text{Rotor drum with shaft}} + P_{\text{threshing}}} \quad (32)$$

The force (F) required to chopping out the biomass by the rotor drum with shaft of mass M (8kg) having a tangential acceleration a is given by;

$$\boldsymbol{F = Ma} \quad (33)$$

From the equation motion;

$$Vf\ =\ Vi\ + at \quad (34)$$

From this equation

$$\boldsymbol{a\ =\ (Vf\ +\ Vi)/t} \quad (\mathbf{35})$$

Since the drum is turn in tangential average constant speed by the time the chopping begins ,the initial speed v_i is zero. Hence equation(35)reduces to;

$$\boldsymbol{a\ =\ Vf/\ t} \quad (\mathbf{36})$$

Substituting equation 36 to 33 gives

$$\boldsymbol{F\ =\frac{M_{rs}Vf}{t}} \quad (\mathbf{37})$$

Where M_{rs}Mass of rotor drum with shaft (kg)

We know that speed, Vf in terms of angular speed, when N (rpm) given by,

$$\boldsymbol{Vf} = \frac{\boldsymbol{2\pi rN}}{\boldsymbol{60}} \quad (\mathbf{38})$$

Where r is radius of the chopping drum, N number of revolution per minute of rotor drum therefore equation (37) becomes

$$\boldsymbol{F} = \boldsymbol{M_{rs}} \frac{\boldsymbol{2\pi rN}}{\boldsymbol{60t}} \quad (\mathbf{39})$$

This is the load per second on the chopping drum.

The torque, T due to this load is given by;

$$\boldsymbol{T}_{\text{Rotor drum with shaft}} = \boldsymbol{Fr} \quad (\mathbf{40})$$

Substituting equation 39 to 40 it gives;

$$\boldsymbol{T}_{\text{Rotor drum with shaft}} = \boldsymbol{Mrs(2\pi r2\ N)}/\boldsymbol{60t} \quad (\mathbf{41})$$

The power required to drive this torque is given by:

$$\boldsymbol{P}_{\text{Rotor drum with shaft}} = \boldsymbol{T}_{\text{Rotor drum with shaft}}(\boldsymbol{\omega}) \quad (\mathbf{42})$$

Where, ω is the angular speed, which is given by

$$\boldsymbol{\omega} = \frac{\boldsymbol{2\pi N}}{\boldsymbol{60}} \quad (\mathbf{43})$$

Therefore, equation(42)becomes:

$$\boldsymbol{P}_{\text{Rotor drum with shaft}} = \mathrm{T}_{\text{Rotor drum with shaft}} \frac{\boldsymbol{2\pi N}}{\boldsymbol{60}} \quad (\mathbf{44})$$

Substituting equation(42)into(44), gives

$$\boldsymbol{P}_{\text{Rotor drum with shaft}} = \boldsymbol{M}_{\text{rs}}(\boldsymbol{2\pi rN/60})^2 \quad (\mathbf{45})$$

Therefore P_T is given by

$$P_{\mathrm{T}} = (T_{\text{Rotor drum with shaft}})x\ (\mathrm{V}_{\text{Rotor drum with shaft}}) + P_{\text{threshing}}$$

$$Where\ (\mathrm{T}_{\text{Rotor drum with shaft}}) is\ torque(Nm), (\mathrm{V}_{\text{Rotor drum with shaft}})\ is\ angular\ speed$$

$$V_{\text{Rotor drum with shaft}} = (2\pi N)/60$$

$$P_{\mathrm{T}} = P_{\text{threshing}} + M_{\text{rs}}\ (2\pi rN/60)^2$$

Therefore the distance from the center of the shaft to the tip of the blade(r) is the sum of radius of the hub and width of the blade in which 1/4 of blade width is inserted in to the hubs for fixation purpose thus r = 130mm, Mass of the rotor drum= 7kg, N=1440rpm,

$P_{\text{Rotor drum with shaft}} = M_{rs}(2\pi rN/60)^2$

$$P_{\text{Rotor drum with shaft}} = 7(2x\pi x0.13x1440/60)^2 = 2{,}690.78w = 3hp.$$

Using the factor of safety of 1, power required is 3hp =2.24KW.

Therefore a motor of 3Hp, 2.24KW is chosen to power the rotor drum, shaft and threshing.

Bearings

A bearing is a machine element that supports apart—such as a shaft—that rotates, slides, or oscillates in or on it. There are two broad classifications of bearings, plain and roll in element (also called anti-friction). Plain bearings are based on sliding motion made possible through the use of a lubricant. Anti- friction bearings are based on rolling motion, which is made possible by balls or other types of rollers. In modern rotor systems operating at relatively high speeds and loads, the proper selection and design of the bearings and bearing-support structure are key factors affecting system life.

Types of movement

The type of bearing used in a particular application is determined by the nature of the relative movement and other application constraints. Movement can be grouped in to the following categories: rotation about a point, rotation about a line, translation along a line, rotation in a plane, and translation in a plane. These movements can be either continuous or oscillating. Although many bearings perform more than one function, they can generally be classified based on types of movement, and there are three major classifications of both plain and rolling element bearings: radial, thrust, and guide. Radial bearings support loads that act radically and straight angles to the shaft center line. These loads may be visualized as radiating in to or away from a center point like the spokes on a bicycle wheel. Thrust bearing support or resist loads that act axially. These may be described as end wise loads that act parallel to the centerlinetowardstheendsoftheshaft.Thistypeofbearingpreventslengthwise or axial motion of a rotating shaft.

Design of the Key

A key is a piece of mild steel inserted between the shaft and hub or boss of the pulley to connect these together in order to prevent relative motion between them. It is always inserted parallel to the axis of the shaft. Keys are used as temporary fastenings and are subjected to considerable

crushing and shearing stresses. A keyway is a slot or recess in a shaft and hub of the pulley to accommodate a key.

Generally there are a number of key types but according to the condition of the machine and fit standards between the shaft and pulley the recommended type of key is the rectangular key. These are the standard forms of keys used in practice, and it is rectangular in cross-section. The end may be squared or rounded. Generally, half the thickness of the key fits into the shaft keyway and the remaining half in the hub key way. These keys are used for heavy duty, as the fit between the key and the shaft is positive.

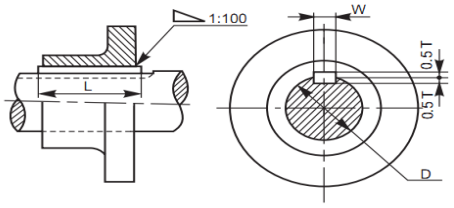


Figure 4.3 keyed joint.

The rectangular key is designed as follows:

From data books we find that:

$$width of the key\ (w)\ =\ d/4\ =\ 25/4\ =\ 7.5mm$$

$$Thickness of the key\ (t)\ =\ 2w/3 =\ d/6\ =\ 25/6\ =\ 4.2mm$$

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 torsion shear strength of the shaft. We know that the shearing strength of key, $T = l$x w x τ x $\frac{d}{2}$ and torsional shear strength of the shaft, $T = \frac{\pi}{16}$ x τ_1 xd^3

From the above equations we have, l x w x τ x $\frac{d}{2} = \frac{\pi}{16}$ x τ_1 xd^3

$$l = \frac{\pi}{8} x \frac{\tau_1 d^2}{w x \tau} = \frac{\pi d}{2} x \frac{\tau_1}{\tau} = 1.571 dx \frac{\tau_1}{\tau}$$ ---------- (Taking w = d/4)

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

Then $l = 1.571d = 1.571x25 = 39.25mm = 39mm$

4.5 Design Considerations for Biomass mixing machine

Biomass mixer design is often thought of as the application of two engineering disciplines in sequence. The first step is process design from a chemical perspective and involves the specification of the impeller configuration, speed, temperature, and pressure, etc. The basic need in this step is to make sure the installed unit operation performs the necessary process tasks. The

second step in the design sequence is the mechanical design of the mixer components. The fundamental approach is straight-forward, design for power (torque and speed), then shaft loads, and finally mixer dynamics. The design of mixers usually consists of a prime mover, gear reduction unit (pulley), a shaft, and impellers. The main forces are torque, bending loads, and thrust. The other major analysis in the design is the vibration characteristic of the mixer, especially the shaft since system harmonics can lead to amplification of any of the major forces. In practical mixer design, the main critical components are usually bending loads on the shaft and blades and the system vibration characteristics. Depending upon the magnitude and dynamics of the resultant bending loads on the mixer system, care is needed in the design of the individual mixer components. In addition to designing for the loads in the shaft, these loads are transmitted through the gearbox (pulley), mounting structure, and finally the tank. The choice of impeller not only influences the average load on the individual blades, but also the dynamic behavior of the system. A complete understanding of all process parameters is necessary to ensure proper mixer design and reliable operation. The desired target can be achieved based on the following design specifications;

- ✓ The shaft is designed to rotate at a relative speed of 800rpm and this is achieved by proper pulley selection to reduce the speed of the electric motor that has a speed of 1440rpm.
- ✓ The variety of substances will easily load and mix well in the drum
- ✓ The biomass mixture can easily transfer out through the pipe under the tank which can prevent any accidents and wastages.
- ✓ Capacity of the machine 70kg/Hr
- ✓ Relative density of biomass173.76kg/m^3.

The design will provide for ease of operation and maintenance as well as the safety of the operator.

4.5.1 Description of Parts and Functions

The biomass mixer machine consists of three main parts:

1) Mixing Basin
2) Mixer Impeller (Stirrer)
3) Main frame

- ✓ **Mixing Basin:** This part consists of four centrifugal impellers (Stirrer) made from 10mm thick mild steel plate then mixing mechanism is done through the

rotation of shaft that hold the impellers (Stirrer) .

- ✓ **mixer impeller:** is a device used for mixing materials required, such as biomass mixture, food, food ingredients, pap, soap materials etc. They will be of forms as axial or centrifugal impellers.
- ✓ **Main frame**: The main frame is made from 50 mm x 50 mm x 4 mm x 1200 mm angle iron welded to produce a rectangular shape structure which is capable for supporting all the machine components.

4.5.2 Design Analysis of critical parts of Mixing machine.

The biomass mixing machine has a number of components but this topic focuses on the design of some of the components which are critical for proper functioning of the machine. The other components of the machine like frame etc are produced through experience.

Determination of Volume of Mixing Basin

Capacity of the machine 70kg/Hr

Relative density of biomass 173.76kg/m^3(perry, 1998)

Designing for a mixer capable of mixing 10kg of biomass per Batch;

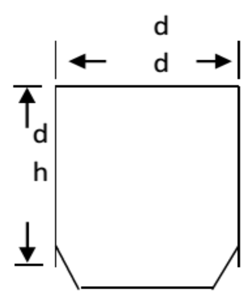


Figure 4.4 mixing basin.

First determine density of the biomass mixture contents that is, density of bulk biomass, cassava starch and density of water.

Bulk biomass density (carbonized powder) = 100 kg/m^3

Cassava starch density =750kg/m^3

Density of water = 1000 kg/m^3

Any individual substance density may be determined by applying the mass of the substance to its Occupied volume, expressed as follows:

$$\rho = \frac{m}{v} \qquad (46)$$

$where\ \rho-\ density, kg \cdot m^{-3};\ m-\ mass, kg;\ V-\ volume, m^3.$

To determine the density of the mixture of biomass as a whole, it is necessary to calculate the coefficient of mass:

$$\boldsymbol{k1 = m1/(m1 + m2)} \quad \textbf{(47)}$$

Where k– coefficient of basic mass;

m1– mass of basic component, kg;

m2– mass of impurity components, kg.

The density, which is produced by the setting up ofa mixture of equal size of the particles, is to be expressed:

$$\boldsymbol{\rho = \frac{(m1+m2)}{\frac{m1}{\rho 1}+\frac{m2}{\rho 2}}} \quad \textbf{(48)}$$

Where ρ_1– density of basic components, kg·mm^{-3}; (bulk biomass).

ρ_2 –density of impurity components, kg/m-3;(cassava starch).

In terms of expression (47) the basic stock mass can be determined experimentally by the formula (49) if the impurity component of weight and impurity factor is known:

$$\boldsymbol{m1 = \frac{k}{1-k} x\ m2} \quad \textbf{(49)}$$

Reunifying equations (48) and (49) it is obtained that:

$$\boldsymbol{\rho = \frac{\frac{k}{1-k} x\ m2+m2}{\frac{k}{1-k} x \frac{m2}{\rho 1}+\frac{m2}{\rho 2}}} \quad \textbf{(50)}$$

Simplifying the expression (50) it is obtained that:

$$\boldsymbol{\rho = \frac{\rho 1\ x\ 2}{k\ x\ \rho 2+(1-k) x\ \rho 1}} \quad \textbf{(51)}$$

To certain components of the mixture of density relations:

$$\boldsymbol{c = \frac{\rho 1}{\rho 2}} \quad \textbf{(52)}$$

where C– mixture components density relation.

The density of the mixture:

$$\boldsymbol{\rho = \frac{c\ x\ \rho_2}{k+(1-k) x\ c}} \quad \textbf{(53)}$$

By substitute the given value, the density of the mixture is equal to $158\,{}^{kg}/_{m3}$

The relationship between the wet (w) and dry (d) bulk density of the samples is represented as a mixture equation in two forms of equation54 (Peleg, 1983) and equation 55 (Hollenbach et al., 1982)

$$\frac{1}{\rho_b} = \frac{1-m_w}{\rho_d} + \frac{m_w}{\rho_w} \quad \ldots\ldots (54)$$

$$\rho_b = \rho_{d(1+m_w)} \quad \ldots\ldots (55)$$

Where ρ_b is the wet bulk density of the samples (kg.m^{-3}) at moisture content of m_w, ρ_d is the bulk density (kg m-3)measured using a bone dried sample. m_w is the moisturecontent of the wet samples (decimal wet basis), ρ_w is the bulk density of water (1000 kg.m^{-3}3).Also by substitute the given value, the wet bulk density of the samples (kg m-3) is equal to $158\,{}^{kg}/_{m^3}$ Then find the volume of the biomass mixture as follows:

$$V = \frac{m}{\rho_b} \quad \ldots\ldots (56)$$

$where, k$ mixer capable, ρRelative density of biomass

$$V = 10/\,173.76 = 0.056m^3$$

But,

$$V_T = \pi r^2 h \quad \ldots\ldots (57)$$

Let $h = 0.3m$; $r = (V/\pi h)^{1/2} = 0.244$; Thus, d = 0.244x2 = 0.487m

Determination of thickness of Mixing Basin, t

Circumferential or hoop stress on mixing basin (Khurmi, 2003);

$$\Delta t = Pix\frac{d}{2t} \quad \ldots\ldots (58)$$

Since the mixing basin is open, longitudinal stress is negligible. Where, Pi is the intensity of internal pressure; d is the internal diameter of mixing basin, and t is wall thickness of the basin, $\Delta t \leq 5$ MPa But Pi = pressure due to (centrifugal force + weight of mixture);

$$\boldsymbol{Pi = Pc + Pw} \quad \ldots\ldots(\mathbf{59})$$

Centrifugal Force on Mixture,

$$\boldsymbol{Fc = mr\omega^2} \quad \ldots\ldots(\mathbf{60})$$

Where, m= mass of mixture, kg

$$\boldsymbol{\omega = \frac{2\pi N}{60}} \quad \ldots\ldots(\mathbf{61})$$

where r is radius of basin, m; ω is the angular velocity, rad/s; and N=800 rev/min

$$\omega = \frac{2\pi \ x \ 800}{60} = 83.79 \frac{rad}{sec}$$

$$Fc = 10 \ x \ 0.244 \ x \ (83.79)^2 = 17{,}130 \ N$$

$$\mathbf{P\omega = \rho g h} \quad \ldots\ldots(\mathbf{62})$$

$where, \rho$is density of mixture, h is height of mixture, and P = pressure

$$P\omega = 173.76x9.818x0.3 = 511.2 \frac{\mathrm{N}}{\mathrm{m}^2}$$

Since Fc is acting on the circumference of the mixing basin; Area on which Fc acts;

$$\boldsymbol{Ac = 2\pi rh} \quad \ldots\ldots(\mathbf{63})$$

$$= 2\pi \ x \ 0.244 \ x \ 0.3 = 0.46m^2$$

$$\boldsymbol{Pc = \frac{Fc}{Ac}} \quad \ldots\ldots(\mathbf{64})$$

$$= \frac{17{,}130 \ N}{0.46m^2} = 37{,}240 N/m^2$$

$$Pi = 37{,}750 + 511.2 \frac{\mathrm{N}}{\mathrm{m}2} = 37{,}750 \ \mathrm{N}/m^2$$

$$t = \frac{Pi \ d}{2\Delta t} = \frac{(37{,}750 \ x \ 0.487)}{2x \ (5 \ x \ 10^6)} = 0.00184m$$ Use 2mm thick plate.

Determination of pulley diameter and Design of the recommended V- belt

The given parameters for recommended V-belt are Drive: 3hp three phase motor, operating speed is 1440 rpm and operates for over 8 hours. The equipment driven is a biomass mixing, which runs at 800 rpm and the required power transmission is 3hp utilized for computation. Using the equations of V-belt drive mechanism as presented by Paul and Adam (1982)

and The expression for diameters of driver pulley (motor pulley) and driven pulley (shaft pulley) is given by Khurmi and Gupta (2006) as; the relevant parameters are determined and presented thus: using the speed ratio 2:1

$$\boldsymbol{Rs} = \frac{\boldsymbol{n1}}{\boldsymbol{n2}} = \frac{\boldsymbol{D2}}{\boldsymbol{D1}} \quad \ldots\ldots(\mathbf{65})$$

$$\mathrm{L} = \sqrt{[\mathbf{4c2} - (\boldsymbol{D} - \boldsymbol{d^2}]} + \tfrac{1}{2}(\boldsymbol{D\theta_1} - \boldsymbol{d\theta_s}) \quad \ldots\ldots(\mathbf{66})$$

Where,$D1$ driver pulley diameter (mm), $D2$ driven pulley diameter (mm),$n1$ speed of electric motor(rpm),$n2$ speed of driven.

Hence, obvious choice for belt selection is: A (Appendix. A)

Now, calculate the pulleys diameter (D1, small pulley pitch diameter) and (D2, Large pulley pitch diameter). Choose the minimum pulley diameter (motor pulley) from data bookD1 = 75mm

Speed ratio (Rs) is given by;

$$Rs = \frac{n1}{n2} = \frac{D2}{D1}$$

$Where, \quad n1 = 1440rpm, n2 = 800rpm$

Rs = 1440/800 = 1.875

The pitch diameter of large pulley (Dp) is given,

$$D2 = RsxD1 = 1.875\,x\,75 = 140mm$$

The center distance, C[mm], between two adjacent pulleys is determined using the relation

$$\boldsymbol{C} = \frac{\boldsymbol{D1}}{\mathbf{2}} + \frac{\boldsymbol{D2}}{\mathbf{2}} + \boldsymbol{D1} \quad \ldots\ldots(\mathbf{67})$$

$$C = 75/2 + 140/2 + 75 = 182.5mm$$

The length of the V- belt, L (mm) is given as ;(temporary)

$$\boldsymbol{L} = \frac{\boldsymbol{\pi}}{\mathbf{2}}(\boldsymbol{D1} + \boldsymbol{D2}) + \mathbf{2}\boldsymbol{C} + \frac{(\boldsymbol{D2} - \boldsymbol{D1})\mathbf{2}}{\mathbf{4}\boldsymbol{C}} \quad \ldots\ldots(\mathbf{68})$$

$$L = \pi/2(75 + 140) + 2x182.5 + \frac{(140 - 75)2}{4x182.5} = 709mm$$

According to IS: 2494 – 1974, 36mm is subtracted to get the inside length of the belt thus it is 673.The standard inside length is 696mm.The exact center distance of the pulleys after the belt length has been determined.

$$\boldsymbol{C} = \frac{\boldsymbol{b} + \sqrt{\boldsymbol{b^2} - \mathbf{2}(\boldsymbol{D_1} - \boldsymbol{D2})^2}}{\mathbf{4}} \quad \ldots\ldots(69)$$

$Where\ b\ =\ Lp\ -\ 1.57(1\ +\ D2)$

$$b\ =\ 696\ -\ 1.57(75+140)\ =\ 358.5mm$$

$$C = \frac{358.5 + \sqrt{358.5^2 - 2(75 - 140)^2}}{4} = 176mm$$

The length of the span S (mm) between two sheaves over which the belt is unsupported is

$$\boldsymbol{S\ =\ \sqrt{C2}\ -\ \left[\frac{D2\ -\ D1}{2}\right]^2} \quad \ldots\ldots(\mathbf{70})$$

$\sqrt{176^2}$ - [(140 – 75)/2]^2= 173mm

- ✓ Lap angles determination

The angle of lap $\theta 1$ for driver pulley (motor) is given as;

$$\boldsymbol{\theta 1 = 180^O - 2sin^{-1}\left[\frac{D2-D1}{2C}\right]} \quad \ldots\ldots(\mathbf{71})$$

$$=\ 180^O - 2sin^{-1}\ \overline{\ }\ [(140-75)/2\ x176]$$

$$=\ 180^0 - 2(11.5)\ =157^0\ =\ 2.74rad$$

The angle of lap $\theta 2$for driven pulley (motor) is given as;

$$\boldsymbol{\theta 2 = 180^O + 2sin^{-1}\left[\frac{D2-D1}{2C}\right]} \quad \ldots\ldots(\mathbf{72})$$

$$=\ 180^O + 2sin^{-1}\left[\frac{140-75}{2}x\ 176\right]$$

$$=\ 180^0\ +\ 2\ (11.5)\ =203$$

$$=\ 196.4^0\ =\ 3.43rad$$

- ✓ Determination of belt tension

$P\ =\ (T1-T2)\ V$ (Akintude et al, 1983):

Where p is design power (kw) =2.24kw, T1is tension on the tight side of the belt, T_2 is tension on the slack side of the belt, V speed =11m/s. Using belt ratio;

$$\boldsymbol{2.3log\left(\frac{T1}{T2}\right) = \theta cosec\beta} \quad \ldots\ldots(\mathbf{73})$$

$Where\ \mu =\ coefficient\ of\ friction\ =\ 0.2, \theta\ =\ angle\ of\ contact\ in\ rad/s$

$$=\ 2.74rad, \beta\ =\ groove\ angle\ =\ 180^0$$

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

$$2.3log\left(\frac{T1}{T2}\right) = 0.28x2.7xcosec180 = 2.7$$

$$log(T1/T2) = 2.7/2.3 = 1.1$$

$$(T1/T2) = 12.5 \quad (Taking\ antilog\ of\ 1.1)$$

$$T1 = 12.5T2$$

$$T1/12.5 = T2$$

$$P = (T1 - T1/12.5)V = 2.24KW = (0.92T1)11m/s$$

$$2.24kw = 10.12T1m/s$$

$$T1 = 147N$$

$$T2 = \frac{147}{12.5} = 11.8N$$

Determining the diameter of the shaft

The shaft is cylindrical with circular cross sections, pulley and bearing mounted on it. It has four bladed impeller mounted on it. The shaft will be subjected to combined stress bending and twisting which is equivalent twisting moment.

Maximum twisting moment acting on the shaft:-

- ✓ Maximum bending moment acting on the shaft will be calculated.
- ✓ Find the load acting on the shaft due to the belt tension and the weight of the pulley.

The force of belt tension and weight of the pulleys and drum bend the shaft vertical plan. Effective tension in the belt on the tight and slack sides,T_1=147N, T_2=11.8Nrespectively Centrifugal Force on Mixture, 17,130N, Pulley weight Pw= 10N, V-belt tension T_b= 158.8N.Mild steel selected for the design of shaft, because the load that applies on the shaft twisting moment and bending moment that requires a material with high yield strength and the pulley is keyed into it.

Table 5.2 Material properties of mild steel

Material	yield strength of the material	ultimate tensile strength(MPa)
mild steel	345 N/mm^2	521 N/mm^2

The standard value of factor of safety based on ultimate tensile strength for steel at dynamic load is 6.

Therefore the allowable stress is,

$$\sigma_{max} = \frac{\sigma_{ut}}{F.S} = \frac{345}{6} = 57.5\, N/mm^2$$

Let d= diameter of shaft,

T = torque transmitted by the shaft,

P= power transmitted by the shaft (W),

N= rpm of the shaft,

τ = permissible shearing stress, and

Mb= bending moment.

- ✓ Forces acted on the shaft by pulley = T_b+Pw = 158.8N+10N = 168.8N
- ✓ Forces acted on the shaft by the Centrifugal Force on Mixture =17,130N

The power transmitted by shaft and the torque in the shaft are related according to Machine elements (2013) as

$$\mathbf{P = T\,\omega} \quad \ldots\ldots(\mathbf{74})$$

$$\boldsymbol{\omega} = \frac{\mathbf{2\pi N}}{\mathbf{60}} \quad \ldots\ldots(\mathbf{75})$$

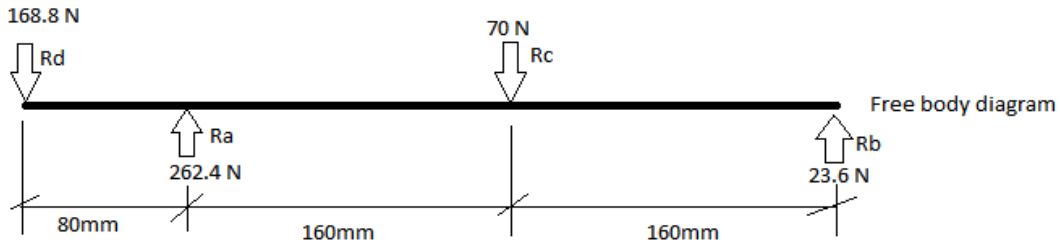
$$\mathbf{P = T}\,\frac{\mathbf{2\pi N}}{\mathbf{60}} \quad \ldots\ldots(\mathbf{76})$$

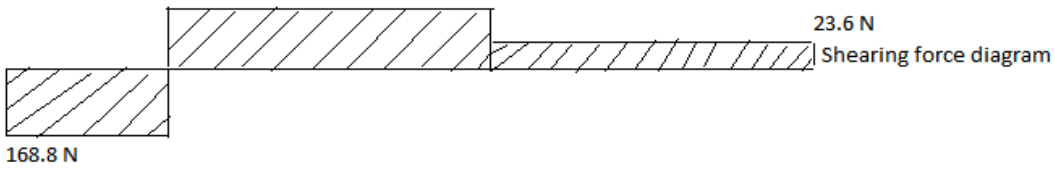
$$\mathbf{T} = \frac{\mathbf{30P}}{\boldsymbol{\pi}\mathbf{N}} \quad \ldots\ldots(\mathbf{77})$$

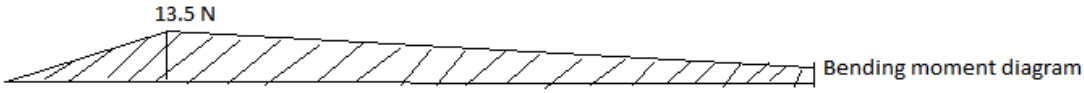
The shear stress and transmitted torque are related as

$$\boldsymbol{\tau} = \frac{\mathbf{16}\boldsymbol{T}\mathbf{10^3}}{\boldsymbol{\pi N}} \quad \ldots\ldots(\mathbf{78})$$

$$\boldsymbol{T} = \frac{\boldsymbol{\pi\tau}\times\boldsymbol{d^3}}{\boldsymbol{\pi N}} \times \mathbf{10^{-3}}\,\frac{\mathbf{N}}{\mathbf{mm^2}} \quad \ldots\ldots(\mathbf{79})$$







To determine the reaction Force on the Shaft use moment equation;

$$\sum \mathbf{MB} = \mathbf{0} \quad \ldots\ldots(\mathbf{80})$$

$$168.8x0.04 - RA\ (0.32 = 70(0.16\ )$$

$$67.72 + 11.2 = \text{RA}\ (0.3)$$

$$RA = 262.4N$$

$$so, 168.8\ +\ 70\ =\ 262.4\ N + \text{RB}$$

$$\text{RB} = 23.6\ \text{N}$$

Maximum bending moment (M_{max})

$$\text{Mb at RA} = \ 168.8\text{x}.\,08 = 13.5\text{Nm}$$

$$\text{Mb at Rd}\ = 168.8\text{x}0.24 - 14{,}571.5\text{x}.\,160 = -2{,}317.9\text{Nm}$$

$$\text{Mb at RB}\ = 168.8\text{x}0.4 - 14{,}571.5\text{x}0.32 + 17130\text{x}0.16 = -1{,}854.56\text{Nm}$$

Therefore the maximum bending moment will be at RA=13.5N-m

We know that the allowable tensile stress, $\sigma_b = \frac{\sigma_{ut}}{F.S} = \frac{700}{6} = 116.6Nmm2$

$and\ allowable\ shear\ stress, \tau = \frac{\tau_{Ut}}{F.S} = \frac{500}{6} = 83.33Nmm2.$

Now, Determining the twisting moment, in which p=2.24kw, N=800rpm

$$T = Px60/2\,\pi N$$

$$T = \frac{2.24x1000x60}{2x800\pi} = 26.7Nm$$

Equivalent twisting moment T_e.

$$(\mathbf{Te}) = \sqrt{(\mathbf{Mb})\mathbf{2} + (\mathbf{T})\mathbf{2}} \quad \ldots\ldots(\mathbf{81})$$

where, Mb = 13.5Nm T=26.7Nm

Te = $\sqrt{((13.5)^2 + (26.7))^2}$ = 29.91Nm

The Equivalent twisting moment, Te =29.91Nm is greater than the torque in the shaft, T=26.7Nm therefore it is a safe consideration and then find the diameter of the shaft as follows:

According to maximum shear stress theory, the maximum shear stress in the shaft,

$$\boldsymbol{\tau_{max}} = \frac{\mathbf{1}}{\mathbf{2}}\sqrt{(\boldsymbol{\sigma_b})^2 + \mathbf{4}\boldsymbol{\tau}^2} \quad \ldots\ldots(\mathbf{82})$$

Substituting the values of τ and σ_b

$$\boldsymbol{\tau_{max}} = \frac{\mathbf{1}}{\mathbf{2}}\sqrt{\left(\frac{\mathbf{32}\boldsymbol{M}}{\boldsymbol{\pi d^3}}\right)^2 + \mathbf{4}\left(\frac{\mathbf{16}\boldsymbol{T}}{\boldsymbol{\pi d^3}}\right)^2} = \frac{\mathbf{16}}{\boldsymbol{\pi d^3}}\left[\sqrt{\boldsymbol{M^2 + T^2}}\right] \quad \ldots\ldots(\mathbf{83})$$

Or

$$\boldsymbol{\tau_{max}} \times \frac{\boldsymbol{\pi}}{\mathbf{16}}\boldsymbol{d^3} = \sqrt{\boldsymbol{M^2 + T^2}} \text{ Equation 1} \quad \ldots\ldots(\mathbf{84})$$

$$d = 24.27mm$$

Where, $\tau_{max} = 57.5Nmm2, M = 13.5, T = 26.7Nm, \sigma = 86.83Nm$,

Now according to maximum normal stress theory, the maximum normal stress in the shaft,

$$\boldsymbol{\sigma} = \frac{\mathbf{16}}{\boldsymbol{d^3\pi}}\left[\boldsymbol{M} + \sqrt{\boldsymbol{M^2 + T^2}}\right] \text{Equation 2} \quad \ldots\ldots(\mathbf{85})$$

Or

$$\boldsymbol{\sigma} \times \frac{\boldsymbol{\pi}}{\mathbf{32}} \times \boldsymbol{d^3} = \frac{\mathbf{1}}{\mathbf{2}}\left[\boldsymbol{M} + \sqrt{\boldsymbol{M^2 + T^2}}\right] \quad \ldots\ldots(\mathbf{86})$$

$$d = 23.95$$

From this two expression, diameter of the shaft(d) 24.27mm and 23.95mm.use the larger, 24.27mm. The maximum diameter of the shaft is 24.27mm use 30mm

Design of mixer impeller.

Since the mixer impeller is variable depending on the mixing materials required, such as different ingredients, biomass materials, they will be of forms as axial or centrifugal

impellers Selected. For simplicity designed impeller here four stirrer types with taper dimension (90x50)x 75mm of 4mm thickness of plate is designed. The flexibly types of the impeller is the upcoming of this study.

4.6 Design Considerations for screw press extruder machine.

The briquetting machine used in the present study was of single extrusion screw press type . The major parts of the machine are a driving motor, screw, die and power transmission system. Pulley and belts were used to transmit power from the motor to the screw. When the motor is started and raw material is fed to the screw, it gets compressed and extruded through the die. The desired target can be achieved based on the following design specifications;

- ✓ The shaft is designed to rotate at relative speed of 360rpmandthisisachievedby properpulleyselectiontoreducethespeedoftheelectricmotorthathasaspeedof 1440rpm.
- ✓ The biomass mixture can easily transfer out through the pipe under the tank which can prevent any accidents and wastages.
- ✓ coefficient of friction b/n pulley &belt, $\mu = 0.3$
- ✓ Capacity of the machine 180kg/Hr
- ✓ Relative density of biomass 173.76kg/m3.

The design will provide for ease of operation and maintenance as well as the safety of the operator.

4.6.1 Description of Parts and Functions

The biomass Screw press extruder machine consists of four main parts:

1) The barrel
2) Screw press extruder(shaft)
3) The cylindrical die
4) Main frame

- ✓ **The barrel** is a cylindrical steel tube in which the densification of biomass takes place by axial force of the screw rotating inside it .One end of the barrel is closed with a die through which a densified briquette is released. In the assembly of screw and barrel, there are two sections: the feeding section and the metering section. Feeding section **(V_f)** is the volume starting from the beginning of tooth up

to the end of tooth of the screw in which the screw moves the biomass to the metering section**.** Metering (compacting) section (V_m**)** is the place where biomass is concentrated and highly densified with high pressure. This section is the free volume around a die.

- ✓ **The screw shaft** rotaring in side the barrel is the main component which plays a great role in moving , compacting (densifying)the biomas , and finally taking out the final briquette product through the die.The complete screw is fabricated by machining a single mild steel circular rod. The first and the second flights of the screw are hard-faced by welding after machining.
- ✓ **The cylindrical die**, on the inner surface, which serve to prevent the densified material from rotating with the screw. the die is made of mild steel and machined on thelathe machine to the required dimensions.
- ✓ **Main frame**: The main frame is made from 40mmx40mmx2mm angle bar welded to produce a rectangular shape structure which is capable for supporting all the machine components.

4.6.2 Design Analysis of critical parts of Screw press extruder machine.

The biomass Screw press extruder machine has a number of components but this topic focuses on the design of some of the components which are critical for proper functioning of the machine. The other components of the machine like frame etc are produced through experience.

Determination of pulley diameter and Design of the recommended V- belt

The given parameters for recommended V-belt are Drive: 3hp three phase motor, operating speed is 1440 rpm and operates for over 8 hours. The equipment driven is a biomass screw, which runs at 360 rpm and the required power transmission is 3hp utilized for computation. Using the equations of V-belt drive mechanism as presented by Paul and Adam (1982) and The expression for diameters of driver pulley (motor pulley) and driven pulley (shaft pulley) is given by Khurmi and Gupta (2006) as; the relevant parameters are determined and presented thus: using the speed ratio 2:1

$$Rs = \frac{n1}{n2} = \frac{D2}{D1}$$

$Where, \quad n1 = 1440rpm, n2 = 800rpm$

Rs = 1440/360 = 4

The pitch diameter of large pulley (Dp) is given,

$$D2 = RsxD1 = 4\,x\,75 = 300mm$$

The center distance, C[mm], between two adjacent pulleys is determined using the relation

$$\boldsymbol{C = \frac{D1}{2} + \frac{D2}{2} + D1} \quad \ldots\ldots(\mathbf{87})$$

$$C = 75/2 + 140/2 + 75 = 262.5mm$$

The length of the V- belt, L (mm) is given as ;(temporary)

$$\boldsymbol{L = \frac{\pi}{2}(D1 + D2) + 2C + \frac{(D2-D1)2}{4C}} \quad \ldots\ldots(\mathbf{88})$$

$$L = \pi/2(75 + 300) + 2x262.5 + \frac{(300-75)2}{4x262.5} = 1{,}162.34mm$$

According to IS: 2494 – 1974, 36mm is subtracted to get the inside length of the belt thus it is 673.

The standard inside length is 696mm.The exact center distance of the pulleys after the belt length has been determined.

$$\boldsymbol{C = \frac{b + \sqrt{b^2 - 2(D_1 - D2)^2}}{4}} \quad \ldots\ldots(89)$$

$Where\ b = Lp - 1.57(D1 + D2)$

$$b = 696 - 1.57(75 + 300) = 537.6mm$$

$$C = \frac{537.6 + \sqrt{537.6^2 - 2(75 - 300)^2}}{4} = 242.7m$$

The length of the span S (mm) between two sheave sover which the belt is unsupported is

$$\boldsymbol{S = \sqrt{C^2 - \left[\frac{D2 - D1}{2}\right]^2}} \quad \ldots\ldots(\mathbf{90})$$

$\sqrt{242.7^2}$ - [(300 – 75)/2]^2= 215mm

- ✓ Lap angles determination

The angle of lap $\theta 1$ for driver pulley (motor) is given as;

$$\boldsymbol{\theta 1 = 180^O - 2sin^{-1}\left[\frac{D2-D1}{2C}\right]} \quad \ldots\ldots(\mathbf{91})$$

$$= 180^O - 2sin^{-1}\ {}^{-}\ [\frac{300-75}{2x242.7}]$$

$$= 180^0 - 2(55.23) = 124.7^0 = 2.17rad$$

The angle of lap $\theta 2$for driven pulley (motor) is given as;

$$\boldsymbol{\theta 2 = 180^{O} + 2sin^{-1}\left[\frac{D2-D1}{2C}\right]} \quad \text{..}(\mathbf{92})$$

$$= 180^{O} + 2sin^{-1}\left[\frac{300-75}{2x242.7}\right]$$

$$= 180^{0} + 2\ (55)$$

$$= 235.23^{0} = 4rad$$

- ✓ Determination of belt tension

$P = (T1 - T2)\ V$ (Akintude et al, 1983):

Where p is design power (kw) =2.24kw, $T_1$is tension on the tight side of the belt, $T_2$is tension on the slack side of the belt. From table, mass of belt is determined or as weight/gravity constant with W/g = mass = weight, where W = 0.2189N, g =9.81m/sec2

V speed =11m/s.

Using belt ratio;

$$\boldsymbol{2.3log\left(\frac{T1}{T2}\right) = \mu\theta cosec\beta} \quad \text{..}(\mathbf{93})$$

$$Where\ \mu\ is\ coefficient\ of\ friction = 0.3, \quad \theta, angle\ of\ contact\ in\ \frac{rad}{s} = 4rad,$$

$$\beta\ \ is\ groove\ angle = 180^{0}$$

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

$$2.3log\left(\frac{T1}{T2}\right) = 0.3x2.17xcosec180 = 0.651$$

$$log(T1/T2) = 0.651/2.3 = 0.283$$

$$(T1/T2) = 0.223 \quad (Taking\ antilog\ of\ )$$

$$T1 = 12.5T2$$

$$T1/12.5 = T2$$

$$P = (T1 - T1/12.5)V = 2.24KW = (0.92T1)11m/s$$

$$2.24KW = 10.12T1m/s$$

$$T_1 = 868.7\ N\&T_2 = 338N$$

Determining the unthreaded part of a shaft

The unthreaded end of the shaft is supported by two bearings and there is one pulley mounted on it that transmits power from the motor over it through belt. The shaft is subjected to combined bending and torsion load. So, the diameter of the shaft must be determined to with stand the stresses developed on it because of the above loads. The power source of its rotation is a 3hp electric motor having 1440 rpm. During the rotation of the screw side of the shaft ,the biomas moves through the helical grooves of the screw towards the chamber where it is compacted by high pressure of the screw and finally exit out of the barrel through the die opening. This screw shaft has been designed to have rotational speed of 360rpm.The shaft will be subjected to combined stress bending and twisting which is equivalent twisting moment.

Maximum twisting moment acting on the shaft:-

- ✓ Maximum bending moment acting on the shaft will be calculated.
- ✓ Find the load acting on the shaft due to the belt tension and the weight of the pulley.

The force of belt tension and weight of the pulleys and drum bend the shaft vertical plan.

Effective tension in the belt on the tight and slack sides,$T_1 = 868.7\ N \& T_2 = 338N$

respectively, Pulley weight Pw= 10N, V-belt tension T_b= 1196.7 N. Mild steel selected for the design of shaft, because the load that applies on the shaft twisting moment and bending moment that requires a material with high yield strength and the pulley is keyed into it.

Table 4.3 Material properties of mild steel

Material	yield strength of the material	ultimate tensile strength(MPa)
mild steel	345 N/mm2	521 N/mm^2

The standard value of factor of safety based on ultimate tensile strength for steel at dynamic load is 10(table 4.3).

$$\boldsymbol{WT} = (\boldsymbol{T1} + \boldsymbol{T2}) - \boldsymbol{Wp} \quad \ldots\ldots(\mathbf{94})$$

$$= (868.7 + 338) - 10$$

$$= 1196.7\ N$$

To determine the reaction Force on the Shaft use moment equation;

$$\sum \boldsymbol{MA} = \mathbf{0} \quad \ldots\ldots(\mathbf{95})$$

$$= 1197\ x76\ =\ RA\ x\ 100$$

$$RA = \frac{210672}{100} = 2106.72\ N$$

$$\sum \boldsymbol{F} \quad = \mathbf{0} \quad \text{.....} \ (\mathbf{96})$$

$$1197\ N\ +\ R_B\ =\ R_A$$

$$R_B\ =\ 909.72\ N$$

Maximum bending moment (M_{max})

Bending moments at the two ends are zero, but at bearing -1 it will be maximum. Therefore, the maximum bending moment (M) on the shaft is at 76 mm distance from the center of the pulley that is M_b = 1197 x 76 = 90,972Nmm that is,

$$\text{Mb at RA} = \ 1197 \text{ x } 76 \ = \ 90{,}972Nmm$$

$$\text{Mb at Rd} \ = 1197\text{x}176 - 2106\text{x}100 = -2{,}317.9Nmm$$

Therefore the maximum bending moment will be at RA=90,972Nmm

Bending Moment and Shear Force Diagram

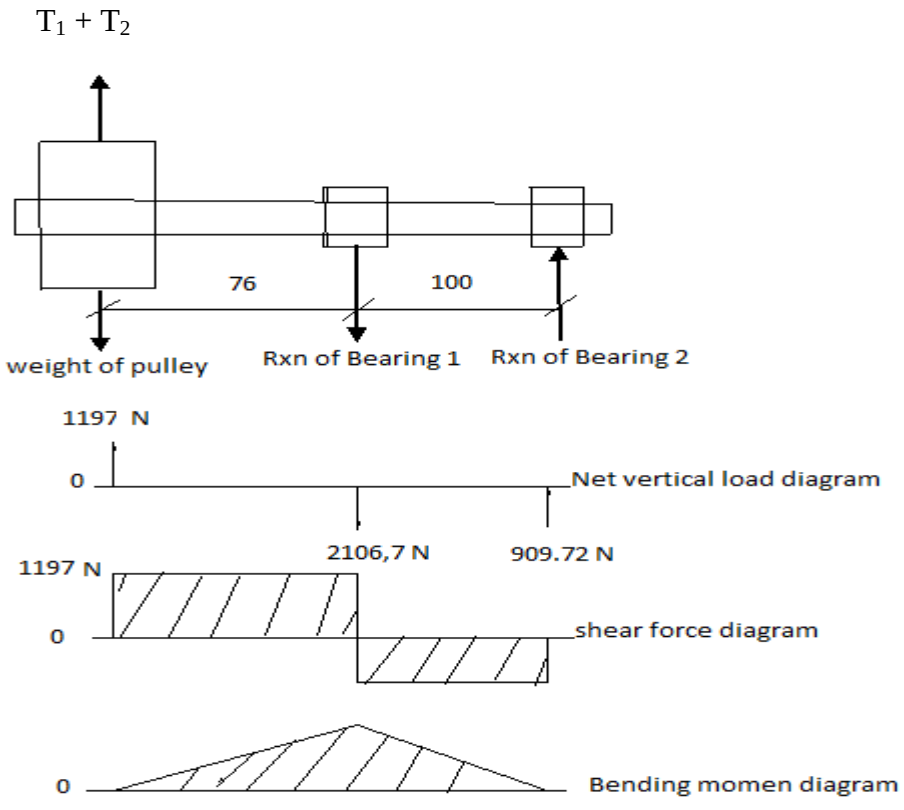


Figure 4.5 Shear and moment diagram

From the derivation of the maximum shear stress theory,

$$\boldsymbol{T_e} = \frac{\boldsymbol{\pi}}{\mathbf{16}}\boldsymbol{\tau d^3} \quad \ldots\ldots (\mathbf{97})$$

Where, $\tau is allowable shear stress$, =24.4MPa $T_e is equivalent twisting momen$ d, is diameter of the shaft

$$\boldsymbol{T_e} = \sqrt{(\mathbf{M})^2 + (\mathbf{T})^2} \quad \ldots\ldots (\mathbf{98})$$

Where, M= 90972 N-mm, T =79.6 x 10^3 N-mm

$$T_e = \sqrt{(\ 90972\ )^2 + \ (\ 79.6 \text{ x } 103\ )^2}$$

$$= 120880\ Nmm$$

$$\frac{\pi}{16}\tau d^3 = \mathrm{T_o} = 120880\ Nmm$$

$$\mathrm{d^3} = \frac{16 \times 120880}{\pi \times 24.4}$$

$$= 29.4 \text{ mm}$$

From the derivation of the maximum normal stress theory,

$$\boldsymbol{M_o} = \frac{\boldsymbol{\pi}}{\mathbf{32}}\boldsymbol{\sigma d^3} \quad \ldots\ldots (\mathbf{100})$$

Where, σ *is allowable bending strength*

$$\mathrm{M_o} = \frac{\mathbf{1}}{\mathbf{2}}\left(\boldsymbol{M} + \sqrt{\boldsymbol{T^2} + \boldsymbol{M^2}}\right) \quad \ldots\ldots (\mathbf{101})$$

$$\mathrm{M_o} = \frac{1}{2}\ (\ 90972 + \ T_o\ )$$

$$= \frac{1}{2}\ (\ 90972 + \ 120880\ )$$

$$= 105926\ Nmm$$

We know that,

$$\frac{\pi}{32}\sigma d^3 = M_o = 105926\ Nmm$$

$$\mathrm{d^3} = \frac{16 \times 120880}{\pi \times 24.4} = 28.9 \text{ mm}$$

Therefore 30 mm has been selected for diameter of the shaft as it is a larger value.

Determination of the diameter of the 212 mm length screw

The challenging work in this design is manufacturing of screw, because machines that can produce screw with such larger pitch and too much depth are not available. The method used to make the screw of this machine is by a careful welding of 6 rings prepared from 4 mm thickness

sheet metal. Except one ring for the first tooth, the rest 5 rings will have a cut that starts from one point on the outer circle up to the other point on the circumference the drilled hole for the purpose of making the helix of screw. See the figure below:

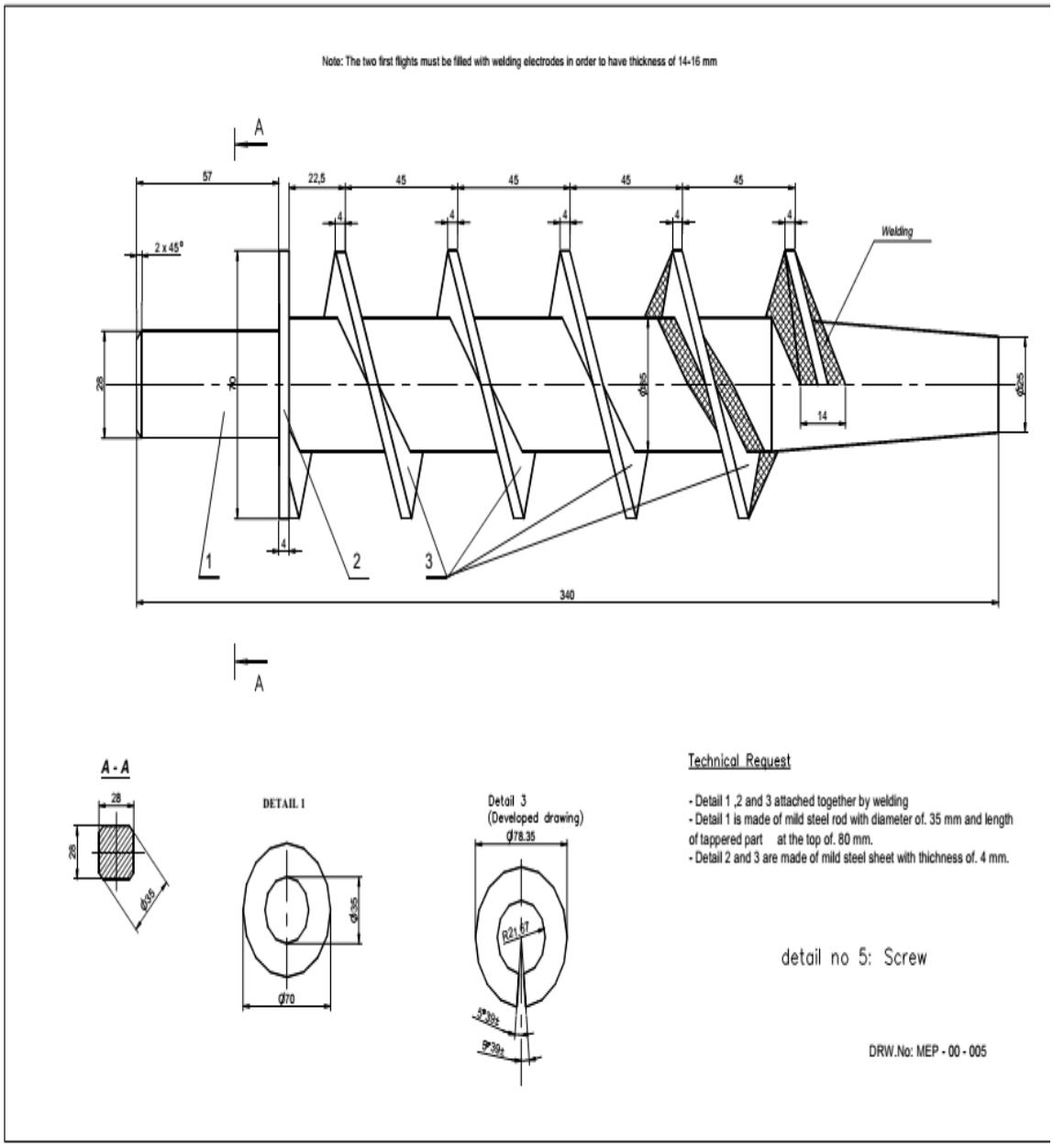


Figure 4.6 Extruding Screw profile

The screw is subjected to the reactionary axial load of the biomass to be densified during densification. This load is compressive force in nature and distributed throughout the length of the screw to cause the teeth of the screw around the core (root) diameter to shear. The core

diameter(d_c) , major diameter(d_o) , and the mean diameter(d_m) have to be calculated withstand the stress developed in it Steel with ultimate stress (σ_u) 448 Mpa and 10 factor of safety has been selected to manufacture the screw. Pre specified parameters of the screw in this design are:

- ✓ μ = 0.23, coefficient of friction between the biomass and the screw (Robert 1992)
- ✓ θ = 28.6 ^{0}, helix of the screw
- ✓ L = 90 mm = 2P, lead of the screw ,

$$\text{Tan } \boldsymbol{\theta} = \frac{\boldsymbol{L}}{\boldsymbol{\pi d_m}} \quad (\mathbf{102})$$

Where: d_m is mean diameter of screw

$$\boldsymbol{d_m} = \frac{\boldsymbol{L}}{\boldsymbol{\pi \tan \theta}} \quad (\mathbf{103})$$

$$= \frac{90}{3.14 \tan 28.6} = 52.5\ mm$$

$$\boldsymbol{d_o} = \boldsymbol{d_m} + \frac{\boldsymbol{p}}{\boldsymbol{2}} \quad (\mathbf{104})$$

$$= 52.5 + \frac{45}{2} = 75mm$$

$$\boldsymbol{d_m} = \frac{\boldsymbol{d_o + d_c}}{\boldsymbol{2}} \quad (\mathbf{105})$$

$$d_c = 2d_m - d_o$$

$$= 105 - 75 = 30mm$$

For pure compression (patel and panda,1968) an estimate of screw root diameter (d1)can also be computed from:

$$\boldsymbol{Wmax} = \frac{\boldsymbol{\pi d1^2 \sigma}}{\boldsymbol{4N}} \quad (\mathbf{106})$$

Where, N, rotational speed of the screw, 360 rpm, $Wmax$is maximum load on shaft 29 N $\sigma\ is\ allowable\ stress$, 44.8 Mpa

$$d_c^2 = \frac{4N\text{W max}}{\pi\sigma}$$

$$= \frac{4x360x29}{3.14x44.8}$$

$$= \sqrt{\frac{28800}{140}} = 17.3 \text{ mm},$$

As this value is smaller than the previous, $30\ mm, 52.5\ , mm, and\ 75\ mm$ have been selected for $d_c, d_m\ and\ d_o\ respectively.$

Design of Housing Barrel.

The barrel is a cylindrical steel tube in which the densification of biomass takes place by axial force of the screw rotating inside it .One end of the barrel is closed with a die through which a densified briquette is released.

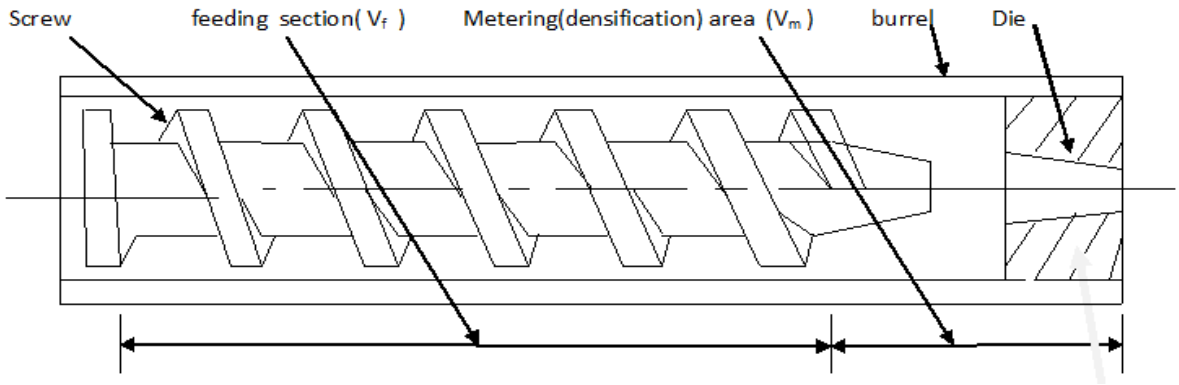


Figure 4.7 Sections of densification

The clearance between barrel and screw is 1 mm. The material used for a barrel is mild steel with a density of 7861.09 *kg* /*m*3.The weight of the barrel is calculated thus:

Weight = mass x gravitational force

$$\boldsymbol{Mass, m = \rho x v} \quad \ldots\ldots (\mathbf{107})$$

The material used is mild steel, $\rho_{steel\ mild} = 7861.09\, Kg\ /m^3$

Volume of the barrel = volume of cylinder + volume of the tapered end.

Volume of the cylinder

$$\boldsymbol{V = \tfrac{1}{4}\pi d^2 l} \quad \ldots\ldots (\mathbf{108})$$

Where, l = length of the barrel = 477 mm, d = diameter of the barrel = 76 mm, t= thickness of barrel.

Therefore, Volume of cylinder = $\frac{3.14 \times 76^2}{4} \times 477\ , mm^3$

= 1958757.12 mm^3 =1.96 $\times 10^{-3} m^3$

Design of a Die

Volume of tapered die = volume of big cone – volume of small cone The die is an opening of the densified briquette product. The size and shape of the briquette depends on it. It is cylindrical shape externally and a has internal taper section (frustum of a cone). The material selected for a die is the same material as that of the barrel. The internal taper volume of a die (Vd) through

which a briquette passes is a difference of full cone and the small cone. The die is a frustum of a cone and is designed, using similar triangles in figure 4.8.

$$\frac{60+x}{30} = \frac{x}{25}$$

$$25(60+x) = 30x$$

$$X = 300\ mm$$

So Volume of taper $(V_d) = \frac{1}{3}\pi\left[(60+x)(R^2) - X(r^2)\right]$

$$= \frac{1}{3}3.14\ [(60+300)(17.5)^2 - 300(12.5)^2]$$

$= 66332.5\ mm^3 = 6.6332 \times 10^{-5}\ m^3$

Total volume of the Barrel = volume of the cylinder+ volume of the tapered end

$$=1958757.12 \times 10^{-9} m^3 + 66332 \times 10^{-9}\ m^3$$

$$= 2.6 \times 10^{-4} m^3$$

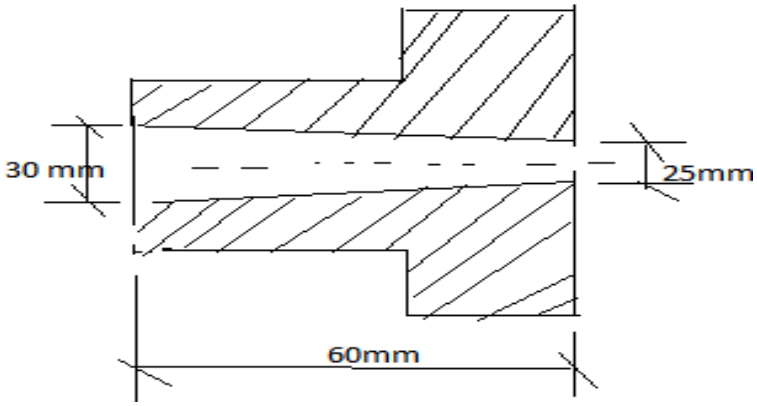


Figure 4.8 Section of die

Determination of production capacity of extruder per hour

To determine the rate of production, the mass of biomass in each section (volume) of the barrel must be calculated, that is feeding volume (Vf) and metering volume (Vm).

$$\boldsymbol{Vf = [V_b - (V_c + V_t)] + (V_b - V_o)} \quad \textbf{(109)}$$

$$\mathbf{V_m = (V_b - V_t) + V_d} \quad \textbf{(110)}$$

$$\boldsymbol{V_{Total} = Vf + Vm} \quad \textbf{(111)}$$

Where, Vcvolume of core diameter,Vb is volume of barrel, Vt is volume of taper of a die, Vd is volume of die, Vo is volume of outside diameter, $Vt$is volume of teeth profile of screw.

$$Vf = [V_b - (V_c + V_t)] + (V_b - V_o) = \left[\pi R_b^2 L - \left((\pi r_c^2 . l_c) + \left(\left(\pi . \frac{d_{1st}^2}{4} . l_{1st}\right) + \right.\right.\right.$$

$$5(\pi . dst24 . lst) + \pi Rb2\, L - \pi . do . 2lo$$

$$= \left[\pi x 38^2 x 432 - \left((\pi x 15^2 x\, 212) + \left(\pi x 4 \left(\frac{75^2 - 35^2}{4}\right) + 5x\pi x 4\left(\frac{83.35^2 - 43.34^2}{4}\right)\right)\right)\right] +$$

$$[(\pi x 38^2 x 432) - (\pi x 37.5^2 x 2)]$$

$$= \left[1958757 - \left((149778) + (13816 + 79581.2)\right)\right] + (1958757.12 - 936112.5)$$

$$= [1958757 - 243175.2] + 1022644.62$$

$$= 2738226.42\ mm^3$$

$$V_m = (V_b - V_{ts}) + V_d$$

$$= \left(\pi R_b^2 L - \frac{1}{3}\pi(L . R^2 - l . r^2)\right) + \frac{1}{3}\pi\lfloor(60 + 300)(R^2) - 300(r^2)\rfloor$$

$$= \left[(\pi x 38^2 x 432) - \frac{1}{3}\pi(240 \times 15^2 - 160 \times 10^2)\right] + \frac{1}{3}\pi\lfloor(360(17.5)^2 - 300(12.5)^2\rfloor$$

$$= (1958757 - 39773.3) + 66332.5 = 1985316.2\ mm^3$$

$$V_{Total} = Vf + Vm$$

$$= 2738226.42 + 1985316.2$$

$$= 4723542.62\ \text{mm}^3 = 4.75 \times 10^{-3}\ m^3$$

Total volume of the material is $4.75 \times 10^{-3}\ m^3$ with two different densities.The material in feeding section is a mixture of biomass, binder ,and water with a density of 173.6 kg/mm^3,where as in metering(compacting) section the material is a mixture of biomass and binder with little amount of moisture because the water drains out through holes drilled at the bottom of the barrel. So in this section the density of material is 1200 kg/mm^3.The mass of material in feeding section

$$\boldsymbol{(Mf) = Vf \times \rho_f} \quad \ldots\ldots(\mathbf{112})$$

$$= 2.74 \times 10^{-3} \times 173.6 \approx 0.5kg$$

$$\boldsymbol{Wf = m.g} \quad \ldots\ldots(\mathbf{113})$$

$$= 0.5kgx10\,m/s^2 \quad = 5N$$

Where, W is weight of material in feeding section, ρ is density of material in feeding section force of gravity=10 m/s^2.The mass in metering (densification) section

$$(\boldsymbol{Mm}) = \boldsymbol{Vm} \times \boldsymbol{\rho_m} \text{...} (\mathbf{114})$$

$$= 1.99 \times 10^{-3} \times 1200$$

=2.38Kg $\approx 2.4\,kg$

Weight of material in metering (densification) section, ρ is density of material in metering (densification) section, g force of gravity =10 m/s^2

$$\boldsymbol{Wm} = \boldsymbol{m.g} \text{ ....} (\mathbf{115})$$

= 2.4Kg $\times 10\,m/s^2$ =24 N

Total weight

$$W_{tot} = Wf + Wm$$

= 5 N + 24 N = 29 N

The briquette product will exit only when the entire volume of a barrel is filled by 3 kg biomass with high pressure of the screws. In one revolution $1.7 \times 10^{-4}\,m^3$ mass of biomass that is 2.93×10^{-2}kg with 173.6 kg/m^3, moves towards the metering section where it is densified. So, in 177 revolution of screw, the volume will be filled by 3 kg compacted biomass material, then starts to exit , that means in 360 rpm 6kg will be released out. But considering 3 kg biomass is still in the barrel for densification process, we should assume 3 kg is released in 360 rpm (in one minute). Therefore 3 kg is produced in one minute; the production rate will be 180 kg/hr.

CHAPTER FIVE

MANUFACTURING PROCESS OF MACHINE COMPONENT

5.1 Introduction

Manufacturing process is a part of the production process which is directly concerned with the change of form or dimensions of the part being produced. It does not include the transportation, handling or storage of parts, as they are not directly concerned with the changes into the form or dimensions of the part produced. The drawing for a component will be given along with a basic product design specification(PDS). The drawing and other available data will be analysed and interpreted. This will form the basis for the material evaluation and the subsequent selection of manufacturing processes, machies,tooling, workholding devices and the setting of appropriate processing parameters.

Documenting all of the decisions with regards to how the component is to be made is the next step. All of the above information will be used to produce a detailed routing sheet for the product.A detailed operation list will also be produced as will a tooling list. Finally, the cost component will be considered based on the documented process plan.

The aim of this chapter is to demonstrate the complete process planning from drawing interpretation to finished process planning documentation, that is, from design to manufacture.

5.2 Processes and materials

A wide variety of processes are employed in the production department. These are organized into four functional areas, which are a foundry workshop, a machine shop a fabrication shop and assembly and test area.

5.2.1 Foundry shop

There are two types of hot forging used in the foundry. These are impression and open die forging. The foundry also has the capability to carry out both sand casting and investment casting.

5.2.2 Machine shop

There is a wide selection of machining processes in the machine shop. These include turning, milling, drilling, shaping, planning, and grinding.

5.2.3 Fabrication shop

Within the fabrication shop there are a number of joining processes employed. These are tungsten inert gas (TIG) welding and manual metal arc (MMA)pipe work and metal inert gas (MIG) welding for general fabrication work and structural steelwork. There is also a number of other joining processes and sheet forming processes.

5.3 Material evaluation

As stated in chapter 4, the selection of a particular material for any product will strongly influence the manufacturing processes that can be used. Therefore, neither material nor process can be selected exclusive of the other. However, for this particular project the material selected first and therefore the processes selected to suit, as is normally the case. Different materials are specified in chapter 4, design and material selection part. From the PDS, there are a number of particularly important criteria to be considered for the material to be used.

5.4 Manufacturing considerations

The manufacturing considerations are basically the process parameters indicated within the drawing. In this instance the critical process parameters are: produce different component of the machine according to design specification and the given dimensions and material as previously identified.

5.5 Process selection and sequencing

In selecting a suitable manufacturing process or processes there is a number of considerations. The first is to ensure that the process selected can actually produce the part to the design specification with regards to both surface finish and dimensional accuracy. The next most important consideration is ensuring the process is capable of producing the part in the volume required economically. After this, the compatibility of the process with the material selected must be determined. Finally, the cost of each process must be considered

5.5.1 Critical processing factors

Correlating the above information, the initial process required must:

- ✓ Be suitable for use with the selected materials;
- ✓ Be able to meet the general dimensional tolerance;
- ✓ Be able to meet the general surface specification;
- ✓ Be able to economically produce;
- ✓ Be able to meet the specific dimensional and geometric tolerances stated on the drawing.

From the above list, it is important that the initial process meets these requirements. However the last requirement is less important as it has already been specified on the drawing that machining must be carried out. Therefore, some of the specific dimensional and geometric tolerances will be met through secondary processing.

5.6 Machine selection and operations sequencing

The selection of a suitable machine for a given job is a simpler task than the initial process selection. The systematic approach to machine selection outlined, based on a preliminary machine selection method developed by Halevi and Weill(1995) will be used. First cut selection, power or force analysis, capability analysis and operational analysis are taken to account for the operation.

5.7 Tooling selection

The processes to be used are casting, turning, drilling and grinding as detailed in the table below. In terms of tooling casting will not be considered further as the tooling in this instance will be the moulds that will be unique to the component. However, the selection of tools for the other processes and operations will be considered further. Analysis of machining operations, analysis of work piece characteristics and tooling analysis are considered.

5.8 Setting the process parameters

The process parameters to be calculated are the speeds, feeds and times for all operations. These will be calculated using the formulae and guidelines provided. Therefore, in general there will be lower cutting speeds and higher feeds used for roughing cuts and vice versa for finishing cuts. Finally, all calculations will be made on the basis that carbide tooling is being used in line with the general recommendation.

5.9 Determining work holding requirements

The determining work holding requirements are focused on the machining processes to be carried out namely, the turning, drilling and grinding. The work holding for the turning and grinding will be relatively straightforward and as such can be classified as general work holding. However, the drilling process will require a jig to ensure repeatability and interchangeability.

5.10 Selection of quality assurance methods

Based on the process sequence outlined, there are a number of basic decisions to be made with regards to the inspection required for the manufacture of the component. These are primarily:

- ✓ the type of inspection;
- ✓ the inspection location;
- ✓ the inspection methods;
- ✓ the measurement instruments or methods required.

Although the process plan will specify the above, ultimately the detail design of the quality assurance regime will be the responsibility of the quality engineer.

5.11 Documenting the process plan

Using the information generated in the various stages detailed in above, the process plan can be fully documented. The documentation in this instance will consist of a routing sheet, an operations list and tooling list it may also be the case that the speeds per feeds calculation sheet forms part of the total process planning documentation package. However, in this case specifying the speeds and feeds in the operations list is sufficient.

5.11.1 Routing sheet

The routing sheet in this instance is a basic document. The header contains basic product or component part information. The main body of the routing sheet list of the operation number in increments of 100(for the reasons that will become obvious when considering the operations list) and provides a description of the process. It then identifies the work centre and the machine tool to be used.

5.11.2 Operations list

The operations list for this case lists all operations for all processes, as opposed to having a separate operations list for all processes listed in the routing sheet. Again, the header consists of product or component part information.

5.11.3 Tooling list

Although the operations list identifies the tooling to be used, it provides very little in the way of detail for tooling. Therefore, a tooling list is used for fully specifying the tooling for all operations and can be used for preparing the tooling required for the batch. The operation numbers on the tooling sheet relate to those in the operations list.

A detail operation of the above discussed are listed in the table below from tables (5.1 to 5.25) for the component of the machine.

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.
- ✓ Polishing the assembled component to recommended final finishing
- ✓ Painting if it is necessary
- ✓ Make ready the component for assembly.

5.12 Manufacturing process of the basic components of new machine.

5.12.1 Manufacturing process of the basic components of biomass thrasher.

Table 5.1 Operation sheet for thrasher shaft

Material: - mild steel

Blank size: - ø35mmx450mm

Quantity: -one

Operation№	Descriptions	Feed In mm/min	Cutting speed m/min	Depth of Cut mm	Machine	tools	coolant
01	Measuring and laying out to 450mm*ø30mm	_	_	_	Steel rule, scriber	v-caliper Scriber	_
02	Cutting 450mm length of stock	_	_	_	Power hacksaw	Hacksaw blade	_
03	Clamping stock on lathe machine	_	_	_	Lathe	Lath chuck	
04	Turning to 450mm	0.5	Forturning= 600 For	Forturning=0.5	Lathe machine	Cutting tool	Used

			finishing=1200	For finishing =0.2			
05	Facing 25mm from both side	0.2	600	10	Lathe machine	Cutting tool	Used
06	Grooving for key way 47*7.5*2.5mm	0.1	200	2.5mm	Milling m/ne	End mill	_

Table 5.2 Operation sheet for key

Material: mild steel

Blank size: 40mmx8mm, and 6mm thick

Quantity: one

Opera №	Descriptions	Feed in mm/min	Cutting speed m/min	Depth of Cut mm	Machine	Tools	coolant
01	Measuring and laying out 45mm*7.5mm*4.2mm	_	_	_	_	Tape rule Scriber Steel rule	_
02	Cutting rectangular bar 45mm*8mm*5mm	_	_	_	_	Hacksaw Blade Tri Square	_
03	Facing both sides on lathe machine 39mm	0.1	200	3	lathe machine	Vice Sleeve	Used
04	Turning four sides to 39mm*7.5mm*4.2mm	0.1	150	3	Milling machine	End mill Vice	Used

Table 5.3 Operation sheet for thrasher shaft pulley

Material: - Al ingot

Blank size: - for shaft pulley external diameter ø150mm, width 55mm

Quantity: - one

Operation №	Descriptions	Feed in mm/min	Cutting speed m/min	Depth of Cut mm	Machine	Tools	Coolant
01	Measuring and laying to width	_	_	_	_	V-caliper Scriber	_

	45mm, ø140mm,					Tape rule	
02	Clamping in power hacksaw	_	_	_	_	Vice	_
03	Sawing to 45mm			Full cut	Power hack saw	Saw blade vice	03
04	Facing both side to 40mm	0.2	600	5	Lathe machine	v-caliper	04
05	Turning to 78mm	0.2	600	2	Lathe machine	v-caliper	05
06	Boring center to make hole ø25mm		200	_	lathe machine	Boring Tool v-caliper	06
07	Grooving the top for the v-belt 20mm and 34^{o}	0.2	200	20	lathe machine	Grooving tool v-caliper	07
08	Finish turning to 76mm	0.15	600	2	Lathe machine	v-caliper vice	08
09	Finishing groove 25mm and 36^{o}	0.2	300	5	Lathe machine	v-caliper	09

Table 5.4 Operation sheet for rotor

Material: - mild steel

Blank size: - ø210mm*4mm

Quantity: - two

Oper. №	Descriptions	Machine	Tools
01	Measuring and laying out ø200mm and ø25mm	_	Tape rule Scriber Steel rule
02	Cutting circular to 202mm and making hole of ø25mm at the center	Portable grinding machine	Cutting disk
03	Grinding to ø200mm	Portable grinding machine	Grinder disk
04	Cutting four places 5*5mm on the top of the rotor at opposite side for fixing the blades	_	Hacksaw Vice chisel

Table 5.5 Operation sheet for crushing blade

Material: - mild steel

Blank size: -305mm*45mm*5mm thick

Quantity: - four

Oper. №	Descriptions	Machine	Tools
01	Measuring and laying out 300mm*40mm	_	Tape rule, Scriber, Steel rule
02	Cutting to 302mm*42mm	Portable grinding m/ne	Cutter disk
03	Grinding to 301*41mm	_	File
04	Surface Finishing 300*40mm	_	Try square file
05	Joining blade to the hub	Welding machine	Try square, Shielding, chipping hammer

Table 5.6 Operation sheet for hopper.

Material: - mild steel

Blank size: taper (165 to 65)mmx225, 2mm

Quantity: - 0ne

Oper. №	Description	Machine	Tools
01	Measuring and laying out four sheets of 160x60x220mm	_	Tape rule, Scriber Steel rule
02	Cutting the measured four sheets 160x60x220mm (four pieces)	Shearing machine, portable grinder	Cutting disk
03	Joining the sheets together. And assemble to the rectangular box on the crusher.	Welding machine	Try square Shielding, chipping hammer

Table 5.7 Operation sheet for container Upper box

Material: - mild steel

Blank size: $1900x400mm$, 2mm thick

Quantity: - one

Oper.№	Description	Machine	Tools
01	Measuring and laying out five sheets 500mmx400mm (three pieces) 400x400mm(two pieces)	Shearing machine, portable grinder	Tape rule Scriber Steel rule
02	Cutting the measured five sheets 500mmx400mm (three pieces) 400x400mm(two pieces)	Shearing machine	-
03	Joining the sheets. So that only at the bottom making the feeding slot.	Welding machine Grinding machine	Try square, grinding disk, Shielding, chipping hammer

Table 5.8 Operation sheet for outer drum

Material: - mild steel

Blank size: $650x410mm$, 2mm thick

Quantity: - one

Oper.№.	Description	Machine	Tools
01	Measuring and laying out one sheets 630mmx400mm	-	Tape rule Scriber Steel rule
02	Cutting the measured sheets 630mmx400mm	Shearing machine	-
03	Folding the sheets, then welding the hem edge.	Welding machine Grinding machine	Try square, grinding disk, Shielding, chipping hammer

Table 5.9 Operation sheet for Charcoal fine chamber

Material: - mild steel sheet

Blank size: 510mmx450mmx400mm,1.5mm thick

Quantity: - one

Oper.№	Description	Machine	Tools
01	Measuring and laying out five sheets 500mmx400mm (three pieces) 400x400mm(one pieces)	-	Tape rule Scriber Steel rule
02	Cutting the measured five sheets 500mmx400mm (three pieces) 400x400mm(two pieces)	Shearing machine	
03	Joining the sheets. So that only at the bottom making the feeding slot.	Welding machine Grinding machine	Try square, grinding disk, Shielding, chipping hammer

Table 5.10 Operation sheet for outlet sheet

Material: - mild steel sheet

Blank size: - 610mm*450mm*200mm 1.5mm thick

Quantity: - one

Oper.№	Description	Machine	Tools
01	Measuring and laying out five sheets 500mmx400mm (three pieces) 400x400mm(one pieces)	-	Tape rule Scriber Steel rule

02	Cutting the measured five sheets 500mmx400mm (three pieces) 400x400mm(two pieces)	Shearing machine	-
03	Joining the sheets. So that only at the bottom making the feeding slot.	Welding machine Grinding machine	Try square, grinding disk, Shielding, chipping hammer

Table 5.11 Operation sheet for main frame

Material: - mild steel (angle iron bar)

Blank size: - 790mm*600mm*450mm, 4mm thick

Quantity: - one

Oper.№	Descriptions	Machine	Tools
01	Measuring and laying out to 630*850mm,	-	Tape rule, Scriber, Steel rule
02	Dividing to three sections i.e 200mm, 450mm, 200mm,	-	Scriber, Steel rule
03	Connecting both side sections to the middle sections by diagonal line,	-	Scriber, Steel rule
04	Cutting the diagonal Line	Shearing machine	-
05	Bending both side sections to 90^{o}	Bending machine	-
06	Drilling for the rivet	Portable drilling machine	Chuck key Drill bit
06	Joining the developed out let under the sieve to the frame	Riveting gun, welding,	Rivets Rivet gun Try square

5.12.2 Manufacturing process of the basic components of biomass Mixer.

Table 5.12 Operation sheet for mixer shaft

Material: mild steel

Blank size: - Ø35mmx450mm

Quantity: - one

Oper.№	Descriptions	Machine	Tools
01	Measuring and laying out angle iron six 802mm for legs, four 602mm and four 1300mm for thresher and mix place frame	-	Tape rule, Scriber Steel rule
02	Cutting to 802mm,602mm,1302mm for thresher and mixer can place frame	-	Hand hacksaw Vice, Blade
03	Cutting angle iron 447mm (six), 542mm(six) for	-	Hand hacksaw,

	briquetting machine frame		Vice, Blade Try square
03	Filing 2mm from all angle bars	-	File , Vice, Try square
04	Joining the angle bar 1300mm and 447mm to rectangular form for top frame	Welding machine	Try square Shielding, chipping hammer
05	Sectioning the top for thresher work space, mix can, 450mm, 200mm,450mm,200mm all partitions are by angle iron	Welding machine	Try square, Shielding, chipping hammer
06	Joining four legs to the edges of the top at right angle	Welding machine	Try square, Shielding, chipping hammer
07	Joining two 447mm and two 542mm at rectangular form for top briquetting machine	Welding machine	Try square, Shielding, chipping hammer
08	Join the briquetting top to the top of the main frame and join the left two legs to the edge of the briquetting	Welding machine	Try square, Shielding, chipping hammer
09	Making partition for die box and compaction chamber and for hydraulic jack 290mm, 300mm and 200mm respectively	Welding machine	Try square, Shielding, chipping hammer
10	Joining supporters x and y-axis to the four legs starting from the second partition.	Welding machine	Shielding, chipping hammer

Table 5.13 Operation sheet for key

Material: mild steel

Blank size: 40mmx8mm, and 6mm thick

Quantity: one

Opera №	Descriptions	Feed in mm/min	Cutting speed m/min	Depth of Cut mm	Machine	Tools	coolant
01	Measuring and laying out 45mm*7.5mm*4.2mm	-	-	-	-	Tape rule Scriber Steel rule	-
02	Cutting rectangular bar 45mm*8mm*5mm	-	-	-	-	Hacksaw Blade Tri Square	-
03	Facing both sides on lathe machine	0.1	200	3	lathe machine	Vice Sleeve	-

	39mm						
04	Turning four sides to 39mm*7.5mm*4.2mm	0.1	150	3	Milling machine	End mill Vice	-

-

Table 5.14 Operation sheet of pulley for mixing shaft

Material: - Al ingot

Blank size: - for shaft pulley external diameter ø150mm, width 50mm

Quantity: - one

Operation №	Descriptions	Feed in mm/min	Cutting speed m/min	Depth of Cut mm	Machine	Tools	Coolant
01	Measuring and laying to width 45mm, ø140mm,	-	-	-	-	V-caliper Scriber Tape rule	-
02	Clamping in power hacksaw	-	-	-	-	Vice	-
03	Sawing to 45mm			Full cut	Power hack saw	Sawblade vice	-
04	Facing both side to 40mm	0.2	600	5	Lathe machine	v-caliper	used
05	Turning to 78mm	0.2	600	2	Lathe machine	v-caliper	used
06	Boring center to make hole ø25mm		200		lathe machine	Boring tool v-caliper	used
07	Grooving the top for the v-belt 20mm and 34^{o}	0.2	200	20	lathe machine	Grooving tool v-caliper	used
08	Finish turning to 76mm	0.15	600	2	Lathe machine	v-caliper vice	used
09	Finishing groove 25mm and 36^{o}	0.2	300	5	Lathe machine	v-caliper	used

Table 5.15 Operation sheet for both side of outer drum

Material: - mild steel

Blank size: - ø210mm*4mm

Oper. . №	Descriptions	Machine	Tools
01	Measuring and laying out ø200mm and ø30mm	-	Tape rule Scriber Steel rule
02	Cutting circular to 202mm and making hole of ø29mm at the center	Portable grinding and drilling machine	Cutting disk Drill bit
03	Grinding to ø200mm and ø30	Portable grinding machine	Grinder disk

Table 65.16 Operation sheet for mixing impeller

Material: mild steel

Blank size: taper (100 to 50)x80x4mm

Quantity: - 0ne

Oper.№	Description	Machine	Tools
01	Measuring and laying out four taper plate (90 to 50)x75mm	-	Tape rule Scriber Steel rule
02	Cutting the measured four sheets (90 to 50)x75mm	Shearing machine	-
03	Joining the plate on the shaft in 45° at equal distance from each other.	Welding machine	Try square Shielding, chipping hammer

Table 75.17 Operation sheet for outer drum

Material: mild steel

Blank size: 650mmx410mmx2mm

Quantity: - one

Oper.№	Description	Machine	Tools
01	Measuring and laying out one sheets 630mmx400mm	-	Tape rule Scriber Steel rule
02	Cutting the measured sheets	Shearing machine	

	630mmx400mm		
03	Folding the sheets, and then welding the hem edge.	Welding machine Grinding machine	Try square, grinding disk, Shielding, chipping hammer

5.12.3 Manufacturing process of the basic components of biomass screw press extruder machine

Table 5.18 Operation sheet for screw press extruder shaft

Material: mild steel

Blank size: Ø35mmx600mm

Quantity: - one

Oper. №	Descriptions	Feed In mm/min	Cutting speed m/min	Depth of Cut mm	Machine	tools	coolant
01	Measuring and laying out to ø30mmx550mm	_	_	_	_	v-caliper Scriber	-
02	Cutting 600mm length from the stock	_	_	_	Power hacksaw	Saw blade	Used
03	Clamping on lathe machine	_	_	_	Lathe	Lath chuck	-
04	Turning ø30mmx550mm and offsetting 80mm length to the screw side of the shaft	0.5	For turning=600 For finishing=1200	For turning=0.5 For finishing=0.2	Lathe machine	Cutting tool	Used
05	Facing 25mm from both side	0.2	600	10	Lathe machine	Cutting tool	Used
06	Careful layout the place where helical mild steel rod of ø35mm welded for making the screw thread	-	-	-	-	v-caliper Scriber, hammer	-

Table 5.19 Operation sheet for key

Material: mild steel

Blank size: 40mmx8mm, and 6mm thick

Quantity: one

Opera №	Descriptions	Feed in mm/min	Cutting speed m/min	Depth of Cut mm	Machine	Tools	coolant
01	Measuring and laying out 45mm*7.5mm*4.2mm	-	-	-	-	Tape rule Scriber Steel rule	-
02	Cutting rectangular bar 45mm*8mm*5mm	-	-	-	-	Hacksaw Blade Tri Square	-
03	Facing both sides on lathe machine 39mm	0.1	200	3	lathe machine	Vice Sleeve	Used
04	Turning four sides to 39mm*7.5mm*4.2mm	0.1	150	3	Milling machine	End mill Vice	Used

Table5.20 Operation sheet for screw press extruder shaft pulley

Material: - Al ingot

Blank size: - for shaft pulley external diameter ø310mm, width 50mm

Quantity: - one

Operation №.	Descriptions	Feed in mm/min	Cutting speed m/min	Depth of Cut mm	Machine	Tools	Coolant
01	Measuring and laying to width 45mm, ø300mm,	-	-	-	-	V-caliper Scriber Tape rule	-
02	Clamping in power hacksaw	-	-	-	-	Vice	-
03	Sawing to 45mm			Full cut	Power hack saw	Saw blade vice	-
04	Facing both side to 40mm	0.2	600	5	Lathe machine	v-caliper	Used
05	Turning to 302mm	0.2	600	2	Lathe machine	v-caliper	Used
06	Boring center to make hole ø30mm		200		lathe machine	Boring tool v-caliper	Used

07	Grooving the top for the v-belt 20mm and 34^{o}	0.2	200	20	lathe machine	Grooving tool v-caliper	Used
08	Finish turning to 300mm	0.15	600	2	Lathe machine	v-caliper vice	Used
09	Finishing groove ø30mm and 36^{o}	0.2	300	5	Lathe machine	v-caliper	Used

Table 5.21 Operation sheet for barrel

Material: mild steel

Blank size:ø80mmx510mmx2mm

Quantity: - one

Oper.№.	Description	Machine	Tools
01	Measuring and laying out one sheets 630mmx400mm	-	Tape rule Scriber Steel rule
02	Cutting the measured sheets 630mmx400mm	Shearing machine	-
03	Folding the sheets, and then welding the hem edge.	Welding machine Grinding machine	Try square, grinding disk, Shielding, chipping hammer

Table 5.22 Operation sheet for one side of barrel

Material: - mild steel

Blank size: - ø80mm*2mm

Quantity: - one

Oper. №.	Descriptions	Machine	Tools
01	Measuring and laying out ø76mm and ø30mm	-	Tape rule Scriber Steel rule
02	Cutting circular to 77mm and making hole of ø29mm at the center	Portable grinding and drilling machine	Cutting disk Drill bit
03	Grinding to ø76mm and ø30	Portable grinding machine	Grinder disk

Table 5.23 Operation sheet for screw plate

Material: mild steel

Blank size: 85mm*85mm*5mm thick plate

Quantity: six

Oper. №.	Descriptions	Machine	Tools
01	Measuring and laying out ø75mm and ø30mm to make thread for screw	-	Tape rule Scriber Steel rule
02	Cutting circular to 76mm and making hole of ø29mm at the center	Portable grinding and drilling machine	Cutting disk Drill bit
03	Grinding to ø75mm and ø30	Portable grinding machine	Grinder disk
04	Cutting one side circle to stretch the circle	Hacksaw	Hacksaw blade
05	Careful weld on the shaft	Welding machine Grinding machine	Try square, grinding disk, Shielding, chipping hammer

Table 5.24 Operation sheet for hopper.

Material: - mild steel

Blank size: taper of (165 to 65)$x225$, 2mm thick

Quantity: - 0ne

Oper. №	Description	Machine	Tools
01	Measuring and laying out four sheets of 160x60x220mm (four pieces)	-	Tape rule Scriber Steel rule
02	Cutting the measured four sheets 160x60x220mm (four pieces)	Shearing machine	-
03	Joining the for sheets together. And assemble to the rectangular box on the crusher.	Welding machine	Try square Shielding, chipping hammer

Table 5.25 Operation sheet for cylindrical die.

Material: - mild steel

Blank size: ø85mm$x110mm$

Quantity: - one

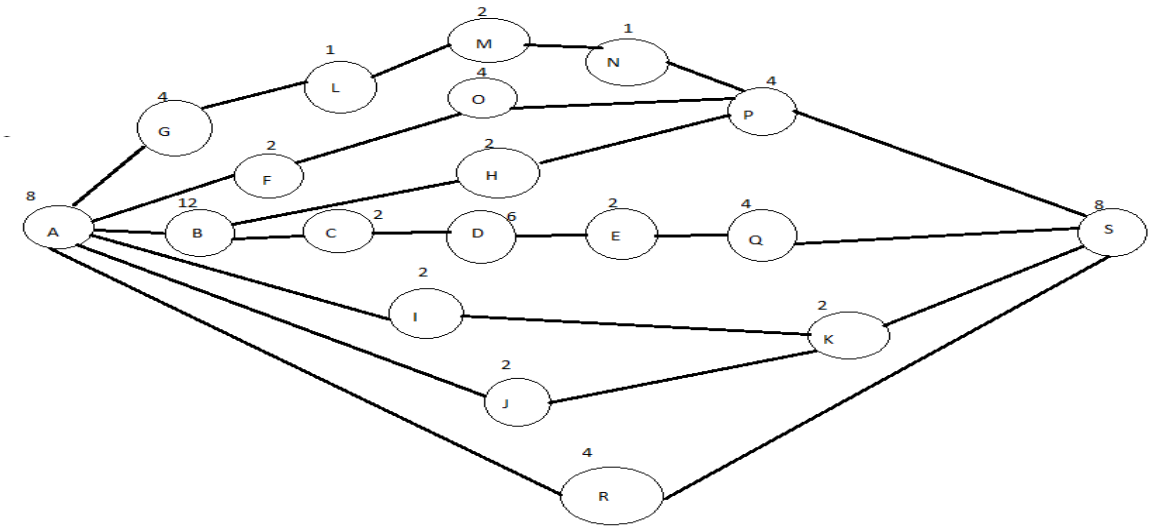
Oper. №	Description	Machine	Tools

01	Measuring and laying out internal taper ø30mm toø25mm of 60mm length	-	Tape rule, Scriber Steel rule
02	Holing accordingly the measured diameter and length	milling machine	Milling vice
03	Joining the die with the right side of outer drum of the barrel.	Welding machine	Try square Shielding, chipping hammer

5.13 Sequence of manufacturing process

Table 5.26 Critical Path Method (CPM)

Activities	Description	Predecessor Activities	Successor activities	Duration (hr)
A	Prepare material	None	B,C,D,E,F,G,H,I,J,L,M,N,R	8
B	Prepare Shaftand pulley	A	C,D,H,O,P,Q	12
C	Prepare Housing barrel(cylinder)	B	D,E,Q	2
D	Prepare Extruder	C	E,Q	6
E	Prepare extruder die	D	Q	2
F	Prepare hopper	E	O	2
G	Prepare Outside drum	F	L,Q,P	4
H	Prepare impeller	G	P	2
I	Prepare blade	H	K	2
J	Prepare hub	I	K	2
K	Assembly rotor drum	J	Q	2
L	Prepare Grinding screen	K	M	1
M	Prepare Fine chamber box	L	N,P	2
N	Prepare outlet for mixing system	M	P	1
O	Subassembly crushing	N	S	4
P	Subassembly mixer	O	S	4
Q	Subassembly screw press extruder	P	S	4
R	Prepare structure	R	S	4
S	Full assembly			8
Total				80



Path 1: A ⟶ G ⟶ L ⟶ M ⟶ N ⟶ P ⟶ S

8 + 4 + 1 + 2 + 1 + 4 + 5 = 25

Path 2: A ⟶ F ⟶ O ⟶ P ⟶ S

8 + 2 + 0 + 4 + 5 = 19

Path 3: A ⟶ B ⟶ H ⟶ P ⟶ S

8 + 12 + 2 + 4 + 5 = 31

Path 4: A ⟶ B ⟶ C ⟶ D ⟶ E ⟶ Q ⟶ S

8 + 12 + 2 + 6 + 2 + 4 + 5 = 39

Path 5: A ⟶ I ⟶ K ⟶ S

8 + 2 + 2 + 5 = 17

Path 6: A ⟶ J ⟶ K ⟶ S

8 + 2 + 2 + 5 = 17

Path 7: A ⟶ R ⟶ S

8 + 4 + 5 = 17

The maximum duration of accomplishing for this project is 39 hours which path 4 of:

Critical path 4: A ⟶ B ⟶ C ⟶ D ⟶ E ⟶ Q ⟶ S

8 + 12 + 2 + 6 + 2 + 4 + 5 = 39

Subassembly and full assembly procedures:

1. Rotor drum is fixed on the shaft
2. Outside drum and grinding screen are joined together
3. Following subassembly will be taken place.
4. Preparing Container
5. Stirrer fixed on the shaft
6. Following subassembly will be taken place.
7. Weld the twist plate on shaft to make screw Press
8. Insert the die and the screw press in to the barrel
9. Following subassembly will be taken place.
10. Finally full assembly will be taken place then finishing.

CHAPTER SIX

PART ASSEMBLY AND COST ANALYSIS

6.1 Introduction

The previous chapters five have focused on processes that primarily change the shape of individual components. Assembling processes differ in that at least two components are joined together, thereby allowing more complicated or larger structures to be fabricated. A wide range of assembling techniques is used in various manufacturing operations, including different mechanical fasteners, adhesives, welding, brazing and soldering. Several joining operations are more akin to assembly than to metal processing. The major metal processing techniques used in the assembly of this project is welding, riveting, and using bolt and nuts are the foremost.

6.2 Assembly of the components

The present project, which is re-designing and manufacturing of the existing lever arm and hydraulic briquetting presses to replace by improved automated screw press extruder machine have synchronized three system, that is crushing, mixing and briquetting in a single unit and each system have subassembly components. The following section is described how each components of the system is assembled.

6.2.1 Crushing system: hammer mill (see in Fig. 6.1) is used to crush carbonized material into carbonized powder. Carbonized powder is then sieved during grinding, at 1.13 kg/min. Size of carbonized powder obtained from this system is less than 2 mm.

Crushing system Procedure/Assembly

- Required Equipment and Materials
  - ✓ Materials: Cover and hopper, Sieves, Blade, Shaft. Rotor
  - ✓ Equipment/Tools: Drilling machine, milling machine lever shear, Screw driver, Hammer, measurement, rolling machine, tools, Welding machine, etc.
- Procedure/Steps

✓ Prepare Container with hopper.

I. Container will need to be hold the rotor, crushed saw dust and the hopper used for feeding mechanism.

II. Prepare Container with hopper with the given dimension.

- ✓ Prepare Blades
  - I. Blades will need to be cut from the mild steel sheet metal.
  - II. Measure container to determine length of container.
  - III. These will determine how long your blades will be.
  - IV. Cut out a section of the post 20mm deep from the end that over hangs.
  - V. Attach blade to rotor in the required dimension.
- ✓ Prepare Rotor
  - I. Rotor will need to be hold the blades on its circumference.
  - II. Measure container to determine radius at the, middle, both sides of container. These will determine how long you're the radius of your rotor.
  - III. Prepared rotor will grooved with equal size of blade width and Attach rotor to the shaft in required dimension and place rotor into container so that the end of the shaft is centered and not touching the bottom of the container.
- ✓ Prepare sieves
  - I. Sieves will need to be filter the crushed charcoal and passes to the fine chamber.
  - VI. Prepare sieves according the given dimension.
  - VII. Tighten the sieves to container.
- ✓ Prepare fine chamber.
  - I. Fine chamber will need to be temporary fine charcoal storage and as the out let for crushing system.
  - II. Prepare fine chamber according the given dimension.
  - III. Joining the fine chamber to the sieves.
- ✓ Finally Set the crusher to assembly on the structure(body frame)

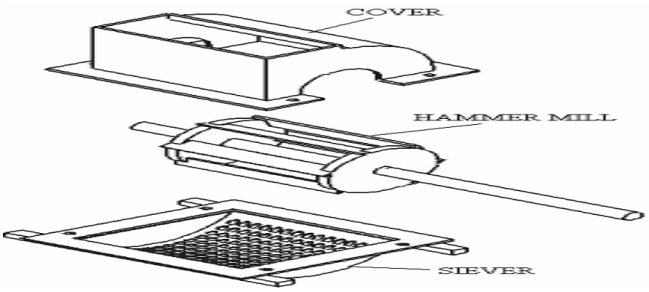


Figure 6.1 Crushing system

6.2.2 Mixing system: Carbonized powder and cassava starch as a binder in this study are mixed homogeneously by rotating stirrer in a container (See Fig. 6.2). After that, the mixed material is then sent into a briquetting process.

Mixing system: Procedure/Assembly

- Required Equipment and Materials
  - ✓ Materials: Container, stirrer (impeller), Shaft.
  - ✓ Equipment/Tools: Drilling machine, milling machine, lever shear, Screw driver, Hammer, measurement, rolling machine, tools, Welding machine, etc.
- Procedure/Steps

✓ Prepare Container.

I. Container will need to be hold the mixture and the shaft with stirrer(impeller)
II. Prepare the Container diameter of 200mmm and length of 400mm.
III. Cutout on the top of Container with the dimension of 200mmx100mm of inlets of the fine charcoal or sawdust from fine chamber as shown below figure 6.2

✓ Prepare stirrer(impeller)

I. Stirrer (impeller) will need to be mixed mixture.
II. Prepare stirrer (impeller) with the given dimension, ø 6mmx70mm and the u-shape 80mmx300mm of steel rod.
III. Weld the stirrer (impeller) on the shaft in the given dimension.

✓ Finally set the mixer to assembly on the structure (body frame).

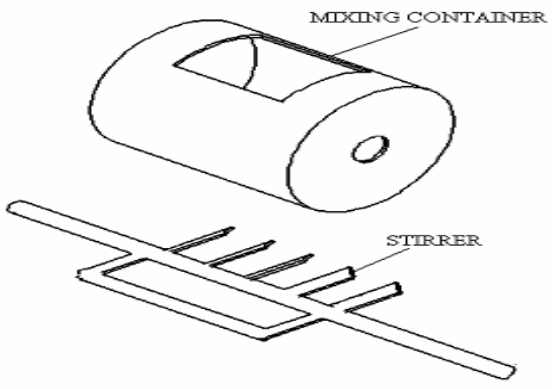


Figure 6.2 Mixing System

6.2.3 Extrusion system: In a briquetting process, the mixed material is extruded by a screw extruder which acts as a continuous feeder and driven by motor. The volume of the material is decreased as it is transferred from the hopper to the die exit. This is achieved by decreasing the diameter of the threaded shaft and cylinder gradually starting with a uniform diameter at the feeding position and decrease gradually to a minimum value at the die position. Figure 3.4 shows the design of the screw.

Screw press extruder system: Procedure/Assembly

- Required Equipment and Materials
  - ✓ Materials barrel, die, plate, Shaft, hopper
  - ✓ Equipment/Tools: Drilling machine, milling machine, lever shear, Screw driver, Hammer, measurement tools, rolling machine, tools, Welding machine, etc.
- Procedure/Steps

✓ Prepare barrel.

I. The barrel will need to be hold the the screw, die, hopper together.

II. Prepare the barrel with ø80mmx500mm.

✓ Prepare plate

I. The plate will need to be for prepare screw threads.

II. Prepare circular plate with outer diameter of 75mm and inner diameter of 30mm

III. Cutting at one edge twisting to form helical screw thread and then careful welded on the screw shaft.

✓ Prepare die

IV. The die will need to be for compressed biomass mixture with barrel wall and screw press.

V. Prepare cylindrical die with inlet diameter of 30mm and outlet diameter of 25mm and the outer diameter 78mm.

VI. Tighten on the barrel.

✓ Finally set the screw press to assembly on the structure (body frame).

✓

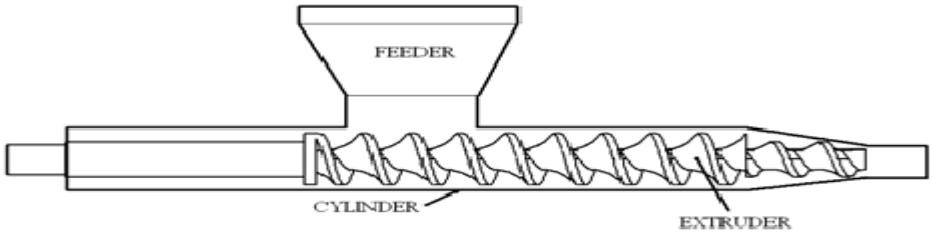


Figure 6.3 Extrusion systems

General assembly of the new system: Procedure/Assembly

- Required Equipment and Materials
  - ✓ Materials: Materials: sub assembly of crushing system, sub assembly of mixing system, sub assembly of extruder system pulley, bearing with house, angular iron of 50mmx50mmx4mm with appropriate length, barrel supporter, motor, and belt.
  - ✓ Equipment/Tools: Drilling machine, lever shear, Screw driver, Hammer, measurement tools, rolling machine, tools, Welding machine, etc.
- Procedure/Steps
  - ✓ Prepare Structure
    - I. The Structure will need to be support all the sub assembly and components together.
    - II. The Structure will be prepared with appropriate dimension
    - III. Fix the bearing house on the Structure
    - IV. Fix barrel support on Structure.
    - V. Fix mixture inlet on the Structure
    - VI. Fix binder inlet on the Structure
    - VII. Finally set the crusher to assembly on the structure(body frame)
    - VIII. Finally set the mixer to assembly on the structure (body frame).
    - IX. Finally set the screw press to assembly on the structure (body frame).
    - X. Final assemblies of the machine will accomplish.

Table 6.1 Part of the machine

Item №	Part Name	Amount
1	Structure	1
2	Crushing System	1
3	Bearing	6
4	Charcoal fine chamber	1
5	Mixing cover	1
6	Cylinder	1
7	Feeder	1
8	Extruder	1
9	Mixing handle	1
10	Motor	1
11	Mixing container	1
12	Crushing pulley size 140mm	1
13	Mixing pulley size 140mm	1
14	Extruder pulley size 300mm	1

See on appendix A each detail drawing of assembly parts.

After finishing the development of such a machine, the capacity and functional testing of the machine are performed. In testing, the briquettes are produced continually by the machine fabricated at full capacity and an appropriate ingredient ratio of the mixture is 50% carbonized powder, 40% cassava starch and 10% water. It is found that the machine can produce the briquettes at production rate of 180 kg/hr, the energy consumption is 60 kWh/Tone. It is also found that the machine can work appropriately as designed.

6.3 Cost analysis

The detailed cost estimating process, like the manufacture of a product, is comprised of parallel and sequential steps that flow together and interact to culminate in a completed estimate. Man-hour estimates of each basic skill required to accomplish the job are combined with the labor rates for these basic skills to derive labor birr estimates. In the mean time, material quantities are estimated in terms of the units by which they are measured or purchased, and these material are combined with their costs per unit to develop detailed direct material birr estimates. Labor over head or burden is applied to direct material costs. Then travel costs and other direct costs are added to produce total costs; general and administrative expenses and fee or profit are added to derive the "price "of the final estimate. The cost analysis is used to determine the overall cost of the machine after manufacturing.

The total cost the produced machine can be the summation of the following components.

- ✓ The cost of raw material
- ✓ Operation process cost(direct cost)
- ✓ Labor cost
- ✓ Machine depreciation cost and
- ✓ The cost of electrical power consumption and consumable material.

6.3.1 The cost of raw materials

The material cost refers to the sum of all raw materials which are consumed or used to the produce the screw press extruder, Biomass thresher and mixing system as single unit. Those raw materials (bulk and standard item) needed to produce this project are list in the table 6.2 below.

Table 6.2 List of Raw Materials needed

№	Items Needed	Specification Of material	Unit	Qty	Unit price		Total price		Remark
					Birr	cent	birr	cent	
1	Mild steel sheet metal	2 mm thick	Pcs	1.5	500	00	750	00	
2	Mild steel plate	40x4x6m	Pcs	1	500	00	500	00	
3	Angle iron	40x40x6m	Pcs	1	600	00	600	00	
4	Angle iron	30x30x6m	Pcs	1	450	00	450	00	
5	Bolt and nut	M6x60 mm	Pcs	20	6	00	120	00	
6	Bolt and nut	M8x60 mm	Pcs	10	8	00	80	00	
7	Bolt and nut	M10x40mm	Pcs	12	10	00	120	00	
8	Aluminum bar	Ø50x60 mm	Pcs	2	300	00	600	00	
9	Aluminum bar	Ø300x50 mm	Pcs	1	400	00	400	00	
10	Mild steel shaft	Ø30x400 mm	Pcs	3	375	00	1125	00	
10	Single phase motor	3 KW	Pcs	1	4000	00	4000	00	
11	Electrical switch	Single phase	Pcs	1	150	00	150	00	
12	Vee-belt	A43	Pcs	2	100	00	200	00	
13	Ball bearing	Standard	Pcs	6	100	00	600	00	
14	Electric wire	3 in one	M	5	40	00	200	00	
15	Mild steel electrode	Ø3.2mm, Mt 12	Pack	1	150	00	150	00	
16	Mild steel electrode	Ø2.5mm, Mt 12	Pack	1	120	00	120	00	
17	Paint brush	D/t size	Pcs	2	12	00	24	00	
18	Grinding disc	Standard	Pcs	1	30	00	30	00	Germany
19	Cutting disc	Standard	Pcs	1	30	00	30	00	Germany
20	Carbide cutter	20x20x100 mm	Pcs	1	150	00	150	00	Germany
21	Drill bit	HSS Ø 1.5-13	Set	1	250	00	250	00	Germany

22	Drill bit	Ø 14,16,18	Pcs	3	20	00	60	00	Germany
23	Hack saw blade		Pcs	5	20	00	100	00	Sweden
24	Paint		Gallon	1	120	00	120	00	
25	Anti rust		Kg	1	120	00	120	120	
Total Raw material needed cost for project one							10,929	00	

Calculation for shaft cost

The cost of the shaft is 150birr per mass of the stock. To determine the total cost of the shaft the mass of the stock must be determined as follows:

$$\boldsymbol{V = AxL} \quad \ldots\ldots(\mathbf{1})$$

Where, v is volume of the stock, A is area of the stock L is length of the stock.

$$\boldsymbol{V = \pi r^2 xl} \quad \ldots\ldots(\mathbf{2})$$

$$= (\pi x 15^2 x 450)\, mm = 3.18x10^{-4}m3$$

ρ= 7850kg/m3 for mild steel

$$\boldsymbol{m = \rho xv} \quad \ldots\ldots(\mathbf{3})$$

$$7850x3.18x10^{-4}m3 = 2.5kg$$

The total cost of shaft for this project will be, 3x150x2.5=1,125birr.

6.3.2 Operational process cost

Operation process costs can be clearly allocated to the product and they are proportional to the number of units produced. It is the cost of machine which is used to produce overall parts of the screw press extruder, biomass crusher and mixing system and it includes:-

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

Table 6.3 Machine operation time and associated overheads.

№	Type of machine	Total working hr. to produce the components of the machine	Machine cost per hours		The total cost of each machine.	
			Birr	cent	Birr	Cent
2	Lathe machine	6	45	00	270	00

3	Milling machine	3	50	00	150	00
5	Shielded metal Arc welding machine	24	15	00	360	00
6	Sheet metal shear machine	3	10	00	30	00
7	Portable grinder machine	5	10	00	50	00
8	Rolling machine	1	10	00	10	00
Production overhead					870	00

Table 6.4 Estimated lab our hours and cost incurred.

Part Name	Operation	Estimated Time (hr)	cost incurred per hour			
			Cost per hour		Total	
			Birr	Cent	Birr	Cent
Main Frame	Cutting	3	15	00	45	00
	Welding	4	15	00	60	00
Screw press extruder	Cutting	6	15	00	150	00
	Welding	10	15	00	150	00
Rotor and threshing drum	Cutting	8	15	00	120	00
	Rolling and bending	6	15	00	90	00
	Welding	10	15	00	150	00
Mixer machine	Cutting	4	15	00	60	00
	Bending	4	15	00	60	00
	Welding	5	15	00	75	00
Shaft and Pulley	Cutting	4	15	00	60	00
	Machining	8	15	00	120	00
All parts	Painting	3	15	00	45	00
	Assembly	16	15	00	240	00
Total production cost					**1330.00**	

6.3.3 Machine Deprecation Cost

Depreciation is defined as the reduction in value of the machine over time as it is working at a specific task. Depreciation occurs due to wear that gradually declines the capacity of the piece of equipment to perform its function. The objective of the depreciation schedule is to recover the initial investment cost of equipment each year over its economic life. Straight-line method assumes that the value of the equipment reduces at a constant rate for each year over its economic life. The straight-line method is the simplest way for estimating depreciation costs and

may be most preferable method to calculate equipment cost per unit of time. The mathematical formula for the yearly depreciation charge using the straight-line method is:

$$\boldsymbol{D = \frac{P-S}{N}} \quad \text{.....(4)}$$

Where:

D = depreciation charge

P = Initial purchase price (actual price)

S = Salvage value (percent of initial price; P) (take average 30% salvage rate

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

If the estimated scheduled machine hours are 1,600 (200 x 8-hours shifts per year), depreciation cost per scheduled machine hours is:

Depreciation charge per hour (D) = Depreciation charge per year divided by 1,600 hr./yr.

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

Table 6.5 Depreciation cost of different machines

№	Machine type	Life span	Machine Price		Depreciation values per hour	
			Birr	Cents	Birr	Cents
2	Arc welding machine	5 year	30,000	00	2	60
3	Potable grinder	3 year	2,000	00	00	30
4	Lathe machine	10 year	150,000	00	6	5
6	Milling machine	10year	300,000	00	13	10
7	Rolling machine	8year	30,000	00	1	64
9	Shearing machine	8 year	30,000	00	1	64

Therefore by summing up all the time for machining from the operation sheet we can calculate the total depreciation of these machines by multiplying the time we operated them and the hourly depreciation. Thus the total depreciation cost=161.36

Finally the cost is:-

1. The cost of raw material and the cost of standard items =10,929.00
2. Total Operation process cost(Direct cost)=870
3. Labor cost =555
4. Machine depreciation cost=161.36
5. The cost of electrical power consumption and consumable material=150

$$p_{c} = m_c + d_l + d_e \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where, p_c m_c, d_l, d_e is prime cost, direct material cost, direct lab our cost, direct expense respectively.

= 10,929.00 +555=11484

Production overhead = Machine Hours × Hourly rate

= 870birr

Production cost = prime cost + production overhead

= 11484 +870 =12354

Total cost = production cost + All other overhead cost.

=12,665.36 birr.

Therefore total cost of producing the machine before establishing the profit is 12,665.36 birr. In cost analysis, charcoal is used as raw material which is available in dry form and does not require drying but needs grinding prior to briquetting. In cost analysis for charcoal briquette production by using a new compact briquetting machine and one labor, it is assumed that the compact briquetting machine have a useful life expectancy of 5 years, the operating time at 8 hours a day, 250 days in a year, direct labor cost per day is 400 /labor, electricity cost of 5 birr/kWh, total electrical input power is 3kW, briquette price is 4 birr/kg, raw material cost and transportation cost is 2 birr/kg. Price of the compact briquetting machine is approximately 20.000 Birr. The first investment is 120,000 birr including the storehouse and machines. The machine capability is approximately 180 kg/hr. Results from the analysis show that, payback period for the production is approximately 1.5years and the Internal Rate of Return (IRR) is 455%.

CHAPTER SEVEN

MAINTENANCE AND ITS USES

7.1 Introduction

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

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

7.2 The need for maintenance

Maintenance is "the work of keeping something in proper condition; upkeep." This would imply that maintenance should be actions taken to prevent a device or component from failing or to repair normal equipment degradation experienced with the operation of the device to keep it in proper working order. 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.

7.3 Types of maintenance

There are four main types to maintain for our machine.

Reactive Maintenance:- This is also referred as breakdown or run-to-failure maintenance. It is basically the "run it till it breaks" maintenance mode. No actions or efforts are taken to maintain the equipment as the designer originally intended to ensure design life is reached.

Preventive Maintenance (Time-Based Maintenance):- can be defined as actions performed on a time- or machine-run-based schedule that detect, prevent, or alleviate degradation of a component or system with the aim of sustaining or extending its useful life through controlling degradation to an acceptable level.

Predictive Maintenance (Condition-Based Maintenance):- can be defined as measurements that detect the onset of system degradation (lower functional state), thereby allowing causal stressors to be eliminated or controlled prior to any significant deterioration in the component

Physical state. Basically, predictive maintenance differs from preventive maintenance by basing maintenance need on the actual condition of the machine rather than on some preset schedule. "Scientific application of proven predictive techniques increases equipment reliability and decreases the costs of unexpected failures." You will recall that preventive maintenance is time-based. Activities such as changing lubricant are based on time, like calendar time or equipment run time.

The proactive maintenance:-Monitoring and correcting of failing root cause. This department does not wait for the breakdown, but goes out onto the plant floor looking for future problems. Understood in proactive approach is the will to take equipment out of service for repair before the breakdown. The reactive approach says, "don't fix it if it isn't broke." The proactive approach says, "don't let it break down-period!"

Examples of proactively include inspection, cleaning, tightening, lubrication (all PM activity), complete testing of new equipment, operator certification programs, continuous training programs, reviewing designs before construction for maintainability, etc.

7.4 Maintenance and their functions

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

- ✓ Inspection or checkups.
- ✓ Lubrication.
- ✓ Planning and Scheduling.
- ✓ Records and analysis.
- ✓ Storage of Spare Parts

7.4.1 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, crushing blade and piston, tolerances in the parts 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 lab our productivity. Hence frequency inspection should be decided on the basis of past experiences and scheduled program for inspection.

7.4.2 Lubrication.

All moving parts and wearing parts (rollers, screw press and roller guide on frame) should be well lubricated with heavy oil or grease to insure smooth operation and cut down on wears.

7.4.3 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.

7.5 Maintenance of the biomass crusher, mixer and Screw Press Extruder Machine.

There are a few basic maintenance techniques to help ensure that the biomass crusher, mixer and Screw Press Extruder machine is well taken care of and will last a long time. Due to corrosion and wear on drum, blade, pulley, shaft, bearing, impeller, screw, die, barrel wall and different components of the machine; those components may fall before the optimum service time. Thus some prevent preventive maintenance recommended are follows:

1) **Belts**: Weekly inspect belt for wear. If wear is excessive then it should be replaced, clean belt, Keep dust and chemicals off of belt, Never clean the belt with oils or chemicals.
2) **tension belt**

Adjust the idler pulley until the belts appear fairly taut. When struck with the hand, belts will bounce back with a springy motion. Run the drive for about 15 minutes to seat the belts, and apply full load. If the belts slip or Squeal, apply more tension. When the drive is in motion, slight sag on the slack side is normal. An alternate method of tensioning is to use the simplified force/deflection method, as follows (as described by belt manufacture Bando USA):

- ✓ Measure the span length, L of the belt drive.
- ✓ At the center of the span, apply a force perpendicular to the belt.
- ✓ Measure the force required to deflect the belt 1/64” per inch of span length. For example, for a 100” span ,the deflection would be 100/64, or approximately 1 1/2” inches.
- ✓ Tighten or loosen the belt to bring it into the correct range.
- ✓ When you install new belts, tighten them to “initial tension” forces shown in the tables.

This tension will drop during the run-in period.

3) **Bearings:** Daily/Weekly inspect bearings make sure they are not making excessive noise and the drum spins freely with the belt is not attached. Bearings are self contained and do not need lubricated.

4) **Paint condition/Rust:** Weekly/Monthly; inspect all painted surfaces inside and out. Surface rust can be removed and repainted.

7.6 Troubleshooting and its solution.

- **Problem: Excessive vibration**
- **Solution**

✓ Check security belt tension and ensure that they are all tightened.

✓ Ensure that the crusher and mixer, screw press extruder and all parts are assembled correctly.

✓ Check motor seat, Strength it with additional supporter.

✓ Check pulleys and belt system.

✓ Check drum and bearings.

- **Problem: Hot Bearings**
- **Solution**

✓ Drive under tensioned and belts are slipping causing heat build-up then re-tension belt.

✓ The drive is over tensioned with belts bottoming out then the pulleys are worn and should be replaced.

✓ Bad bearings because of poor maintenance or under-design. Replace bearings and evaluate maintenance or bearing might need redesigned.

✓ Pulleys too far out on shaft pull them in as far as possible.

- **Problem: Belt deterioration or breaking prematurely**
- **Solution**

✓ Check belt or pulley manufacture's catalog for full detailed list.

✓ Check for foreign objects in the drive, make sure that the guard is installed or make sure that the belt drive is protected.

✓ Check for oil or grease on belts. Clean belts and sheaves with a degreasing agent or detergent and water and remove the source of oil or grease

✓ Excessive slippage, re-tension belt.

✓ Check sheave or pulley grooves for wear of damage, replace pulley if needed.

- **Problem: Threshing drum, mixing and screw press extruder is not crushing, mixing and extruded or rotating correctly.**
- **Solution**

✓ Check belt drive and ensure that the belt is correctly tensioned and not slipping.
✓ Check the drum and rotor and make sure that the shear blades are not broken.
✓ Check the mixer impeller and make sure that the impellers are correctly welded on the shaft.
✓ Check the screw groove and make sure that the threads of the screw are not wear out.
✓ Check that pulley is tightly connected to the shaft and the keys are not broken.
✓ Check the motor and ensure that is not broken and is transmitting power.

- **Short life of screw**

The main player of the densification system is the screw. The main role of this screw is to convey and compress the raw material into the die barrel. The problem is the rapid worn out of tip of the screw. The rice husk contains about 15-20 percent silica (RWEDP 1996b, p.28) which is abrasive in nature and it wears out the screw easily. The nominal life of the screw varied from 6 to 14 hours, depending on the quality of repairing and as well as quality of raw material. The higher dust contained in the raw material causes the rapid worn out of the screw.

- **Short life of die barrel**

The die barrel is that wherein the densification of loose biomass is occurred. The die barrel is made of cast iron. There is 4 or 5 number of edge inner sides of the barrel which guides the delivery of densified biomass. If the depth of these edges is reduced then it is needed to repair the barrel in a lathe shop. If the barrel once is broken there is no way to repair it, people need to buy a new one. The life of the die barrel varied from 15 day to 4 months.

- **Main bearing problem**

The main bearing is damaged due to the overheating the machine because the hot screw is coupled with the bearing shaft. Since new main bearing is costly, to replace suddenly use old rejected bearing from bus or truck engine. To change the main bearing the whole machine has to be dismantled and it is time consuming and laborious works.

CHAPTER EIGHT

RESULT AND DISCUSSION

According to design and development of the compact briquetting machine and the results of the functional and capacity testing, it found that the compact briquetting machine can work functionally and properly with the obtained briquette quality is in an acceptable range. The popular known CINVA-RAM press use in making earth ram bricks and a hydraulic press was considered and modified to a suitable screw press briquette machine.

The comparison between the new and the existing system shows that a lot of improvement occurred in the new system such as the process time, worker and production area required, operating cost, and productivity. It is so because combining three functions in a single unit and the machine can operate continually can help to reduce the transfer time and distance, and material. The new system just needs one worker to operate the compact machine and convey the material. That leads to reduce cost and improve the productivity of the system. The new compact machine has potential to replace the individual traditional machines in the biomass briquetting industry due to the lower price of the compact machine.

Comparison between the Existing and the New System

Comparison of the production results between the existing/traditional system (three individual machines working together and three workers) and the new system (a compact machine and a worker) at the same conditions such as using a 3hp electrical motor and using screw-press technology. (See Table. 8.1)

Table 8.1 Comparison between the existing and the new system

№	Activities	The Existing System	The New System
1	Worker required (man/day)	3	1
2	Productivity(ton/day)	0.114	0.144
3	Operating cost(birr/ton)	3,554	2,782
4	Area required(m^2)	48	16

CHAPTER NINE

CONCLUSION AND RECOMMENDATION

9.1 Conclusion

The compact biomass briquetting machine fabricated for this study is a prototype unit which manufactured locally in Ethiopia. The compact machine which combines three functions including crushing, mixing and briquetting in a single unit is able to improve the production cost and productivity. This machine has the capacity to produce 180kg of briquette in one hour. It can be easily fabricated with materials sourced locally. From comparison between the new and the existing/traditional briquetting system, it was found that when using the compact briquetting machine, the required production area, production time and operating cost are reduced by 67, 16, and 22% respectively when using the compact machine. The cost of the machine is within the reach of a lot of families in the rural communities and if commercialized the cost could go for far less the price of production in this project.

Furthermore, the investment in producing biomass briquette by using the compact briquetting machine, based on mentioned conditions, is economically attractive and will provide job opportunity to the unemployed graduates, and small-scale entrepreneurs can be empowered by the government by making briquette from carbonized agricultural waste for household fuel production. This will reduce unemployment rate in Ethiopia and dependence on petroleum products for heating and cooking and also utilize waste generated by the sawmill industries thereby reducing open air burning and attendant environmental pollution beside address the issue of deforestation in the country.

9.2 Recommendation

This machine can easy be implemented in real life situation. Even though the synchronized machine is functioning as expected, the following recommendations are suggested:

1) Designing a more effective way of cutting the briquettes in the appropriate length from the die exit instead of simple scratch by itself.
2) Designing the die with a multiple number of exit.
3) Designing the new machine with a preheating system of the biomass.

4) It is needed to give emphasis on extension research for dissemination of this technology throughout the country.
5) Policy or government body should come forward for development, promote and commercialization of densified biofuel

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Appendix

Appendix. A Dimensions of standard V belts according to IS: 2494 – 1974

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

Appendix. B Dimensions of standard V grooved pulleys according to IS: 2494 – 1974 (All dimensions are in mm).

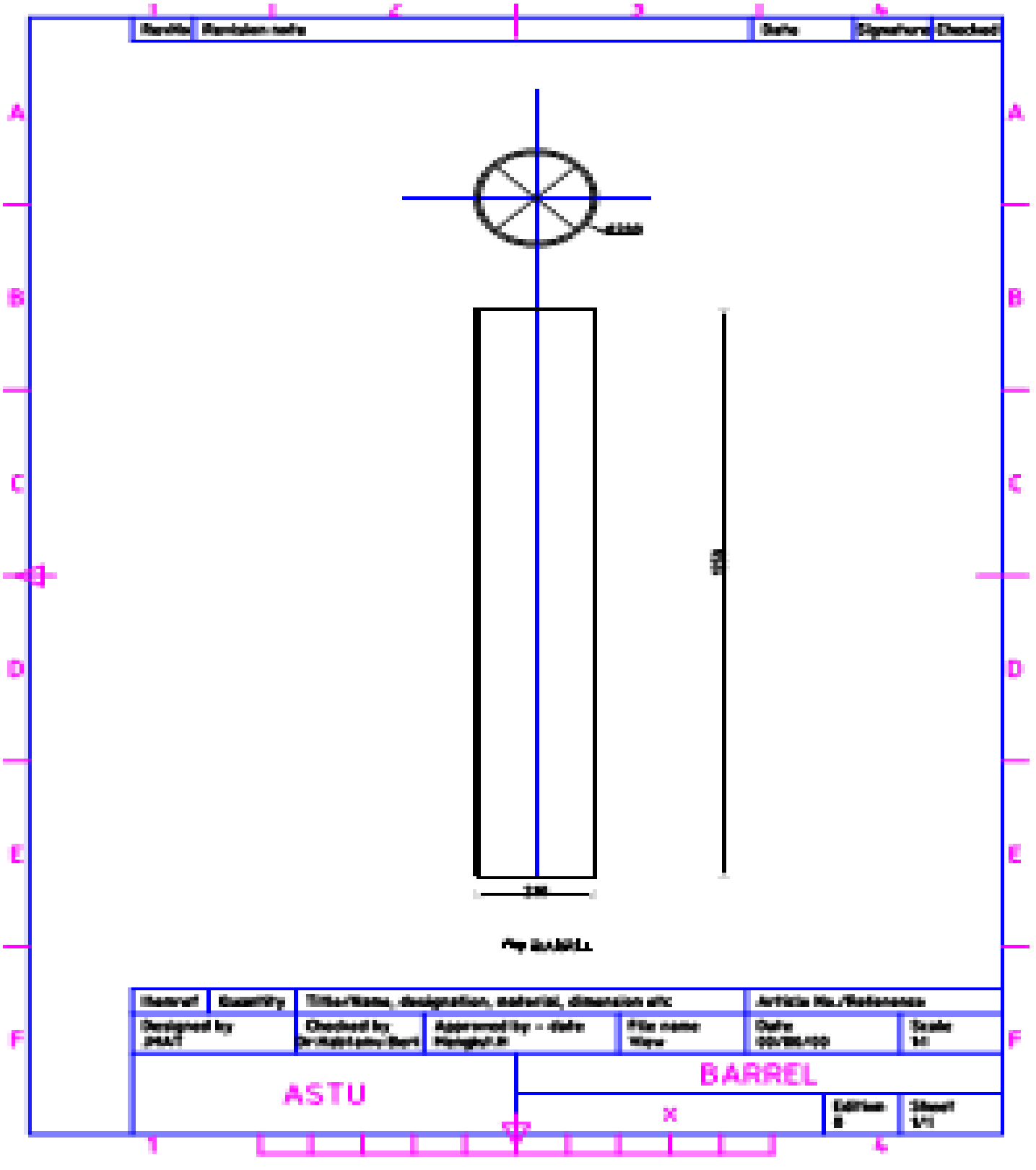
Type of belt	*w*	*d*	*a*	*c*	*f*	*e*	*No. of sheave grooves (n)*	*Groove angle (2β) in degrees*
A	11	12	3.3	8.7	10	15	6	32, 34, 38
B	14	15	4.2	10.8	12.5	19	9	32, 34, 38
C	19	20	5.7	14.3	17	25.5	14	34, 36, 38
D	27	28	8.1	19.9	24	37	14	34, 36, 38
E	32	33	9.6	23.4	29	44.5	20	–

Note: - Face width (B) = (n-1) e + 2f

Apendx.C Standard pitch lengths of V belt 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. D Each detail drawing of machine components



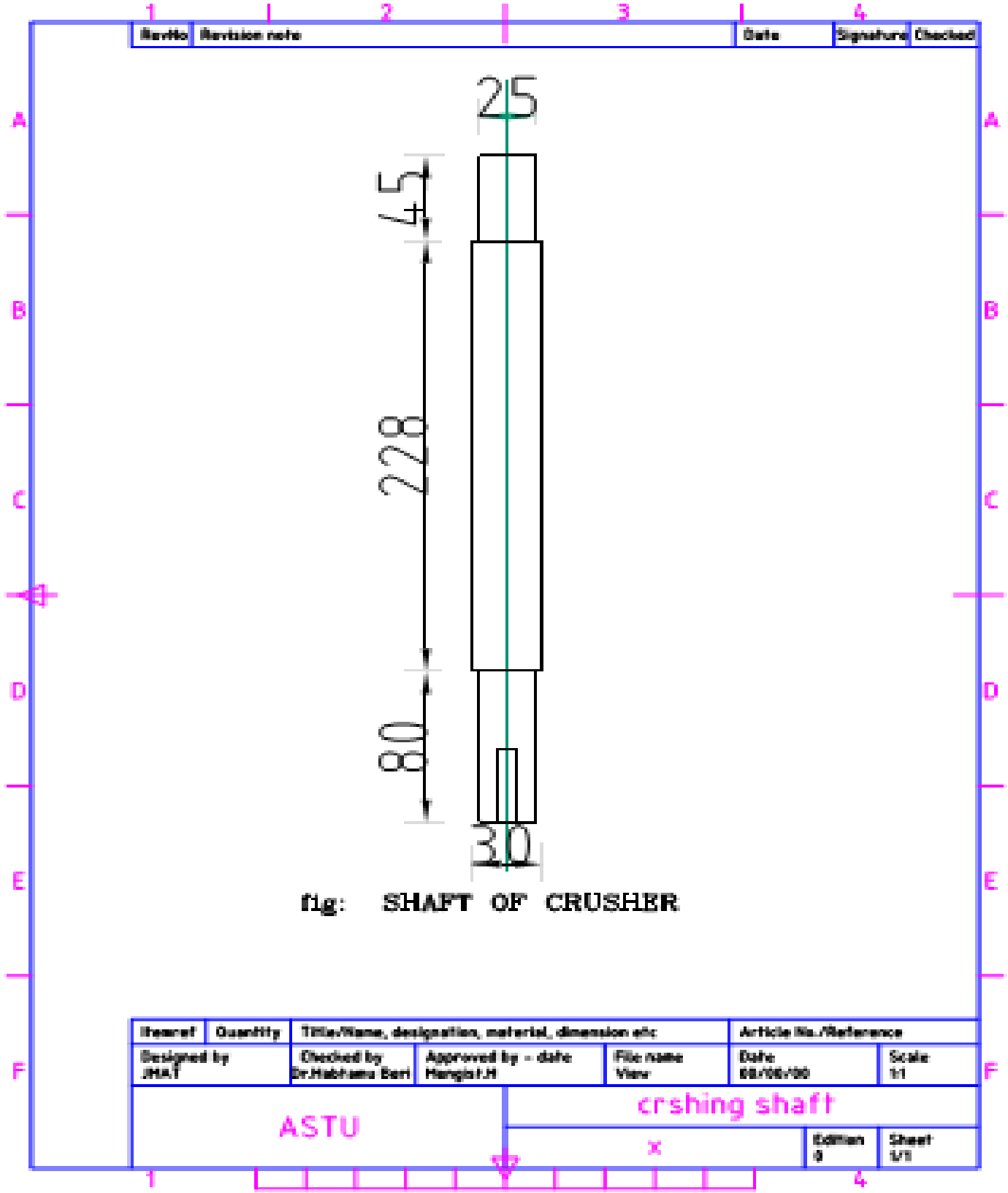
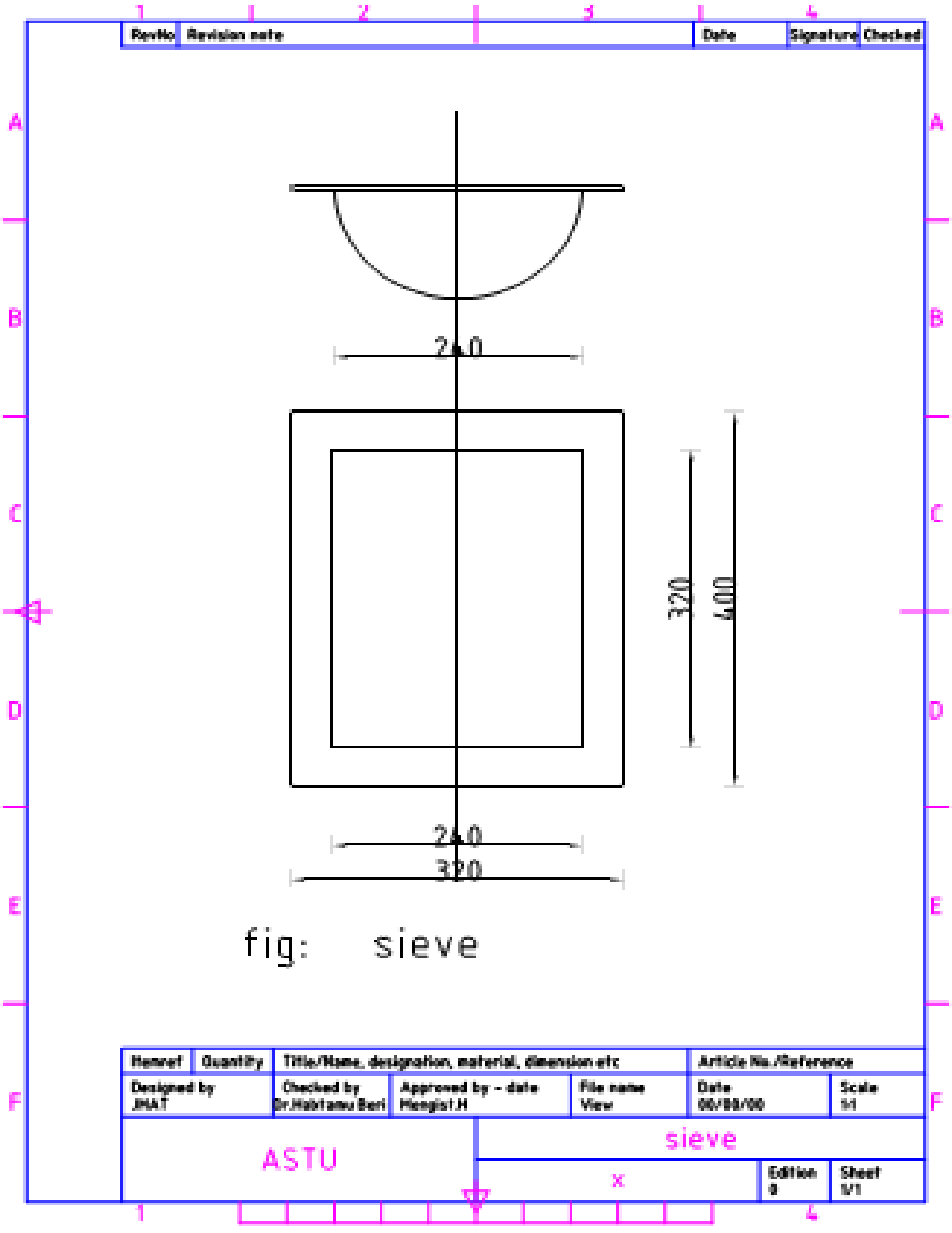


fig: SHAFT OF CRUSHER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240
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Item ref
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Article No./Reference
Designed by
JHAT
Checked by
Dr.Habtamu Beri
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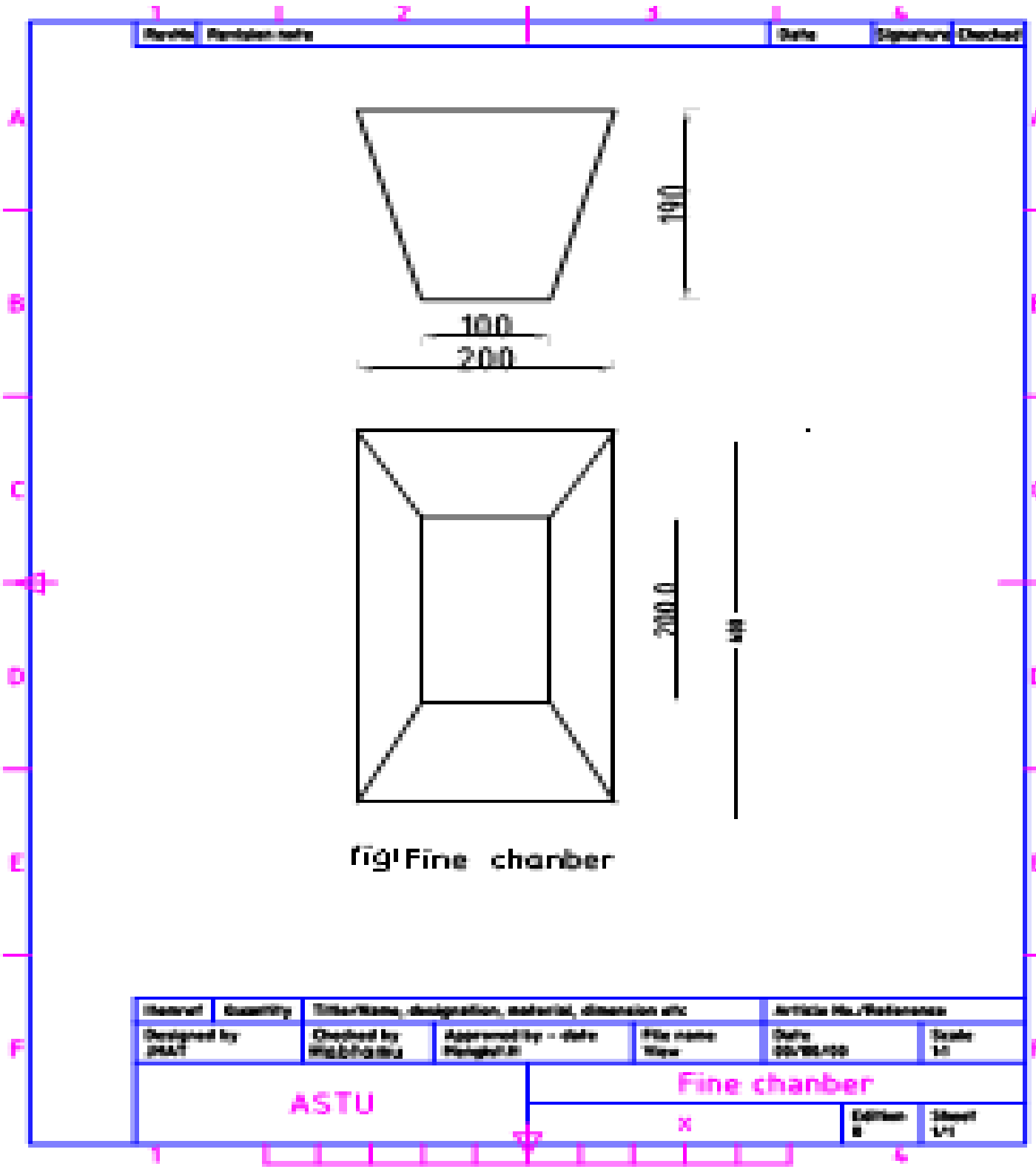
fig: sieve



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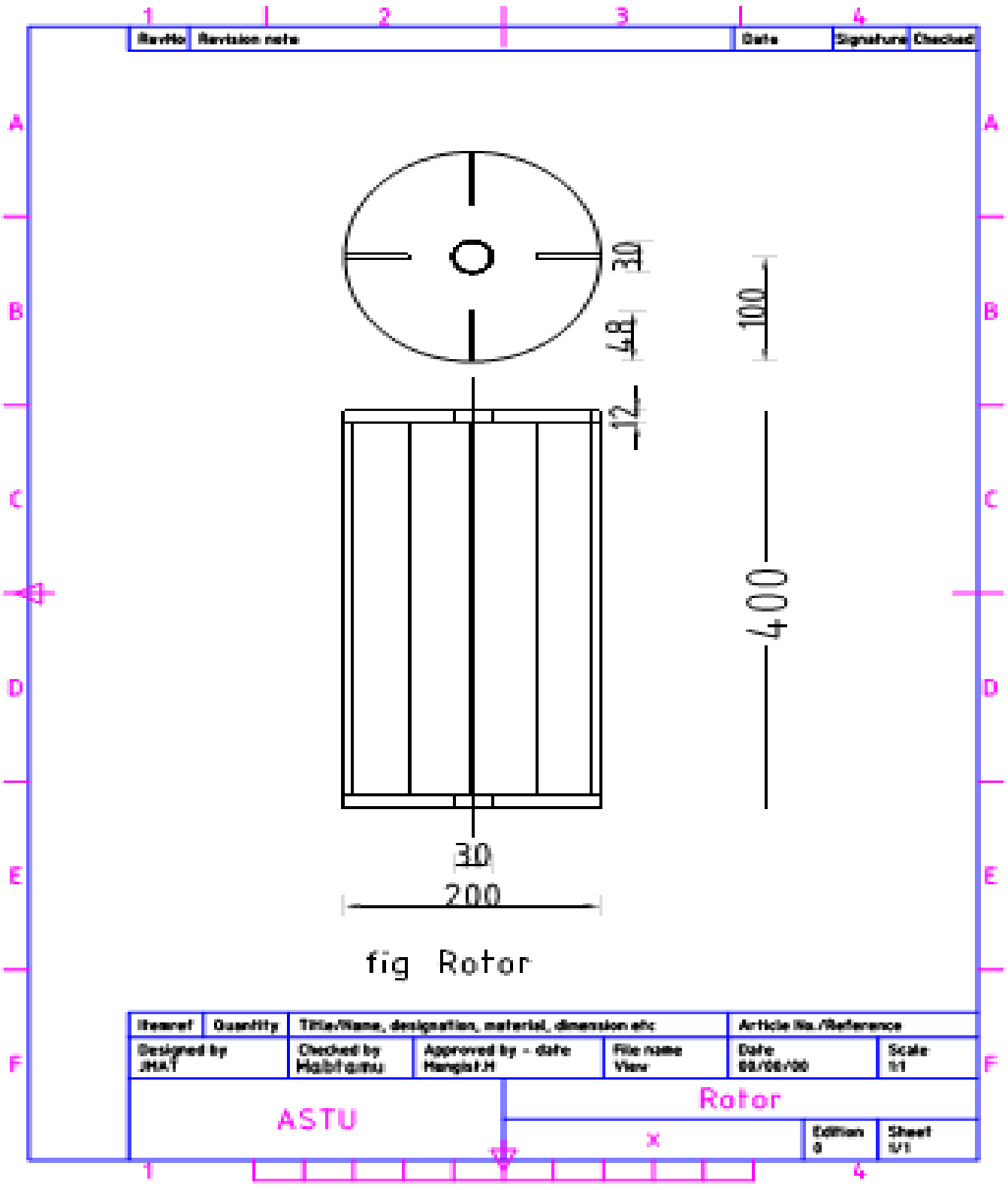
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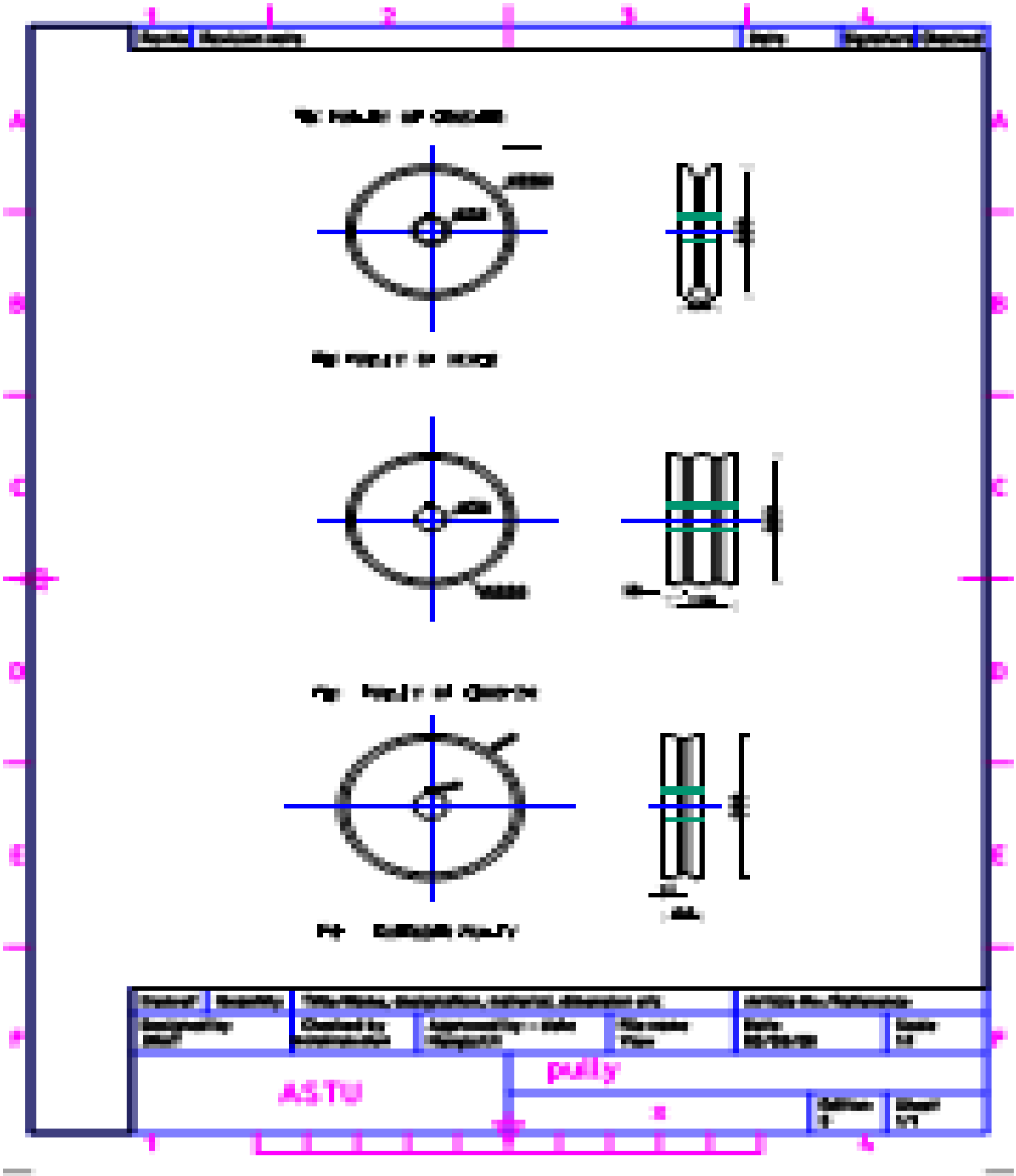
fig Rotor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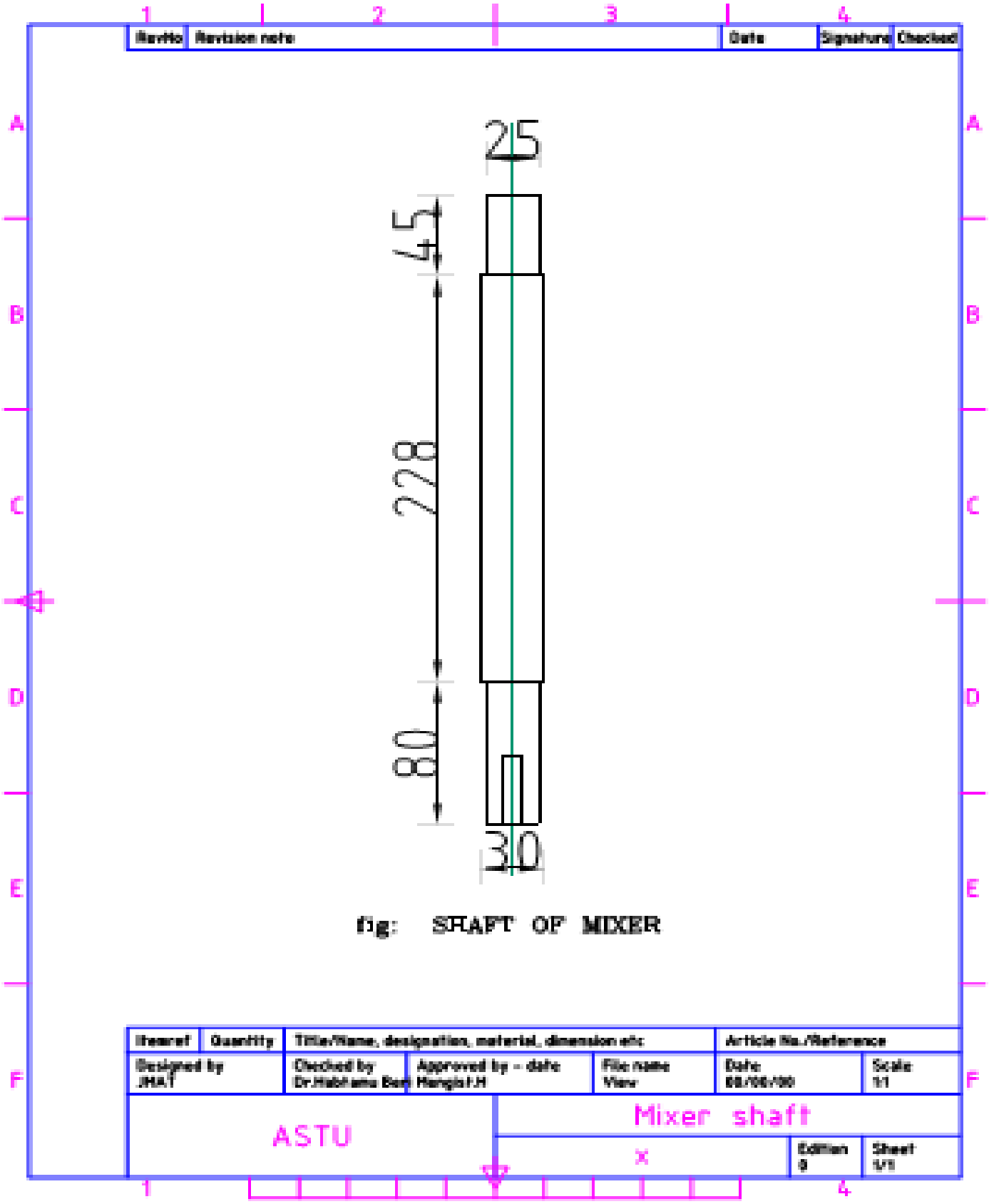

fig: SHAFT OF MIXER

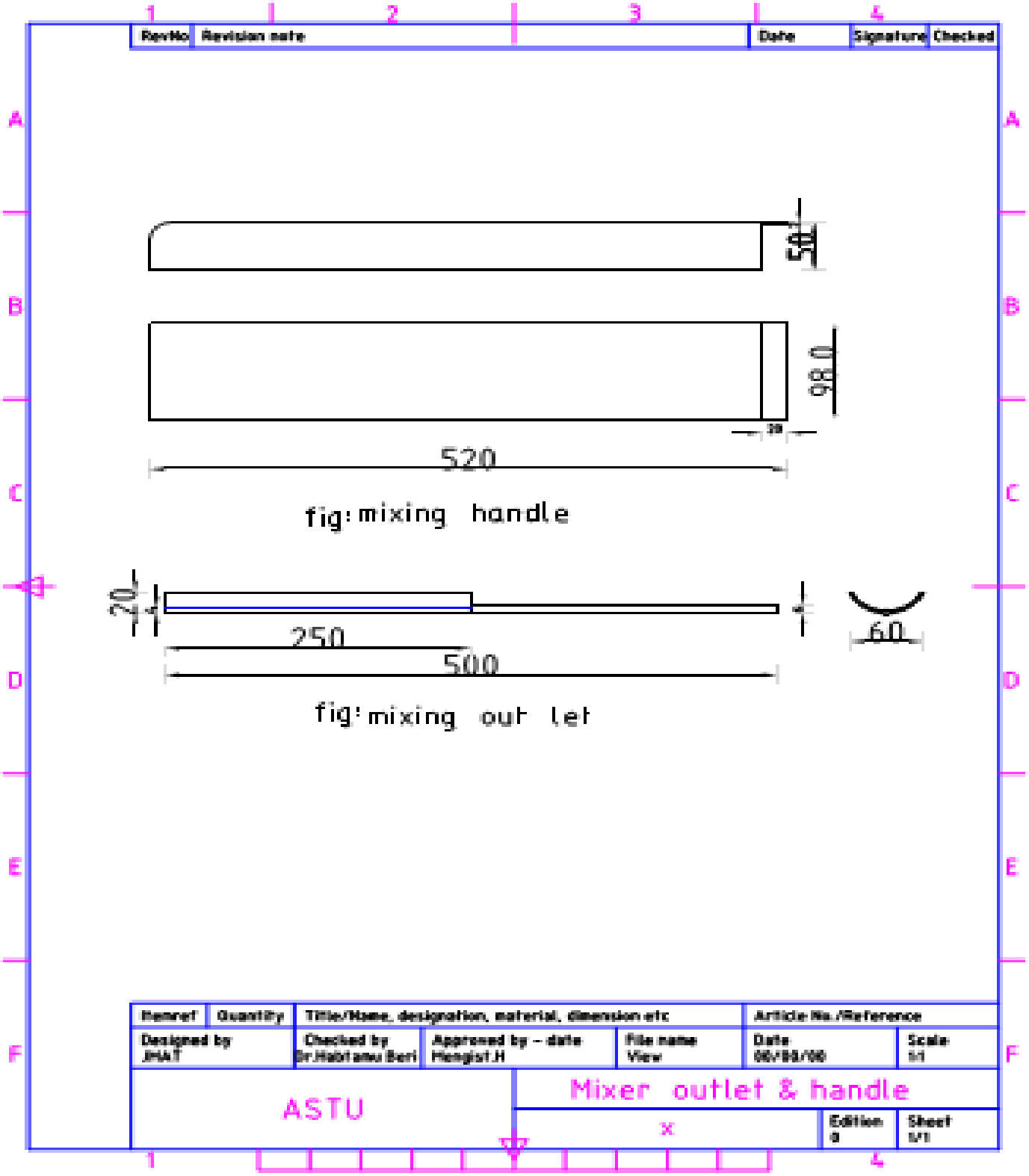
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fig: mixing handle
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fig: mixing out let
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Article No./Reference
Designed by
JHAT
Checked by
Dr.Habtamu Beri
Approved by – date
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File name
View
Date
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Mixer outlet & handle
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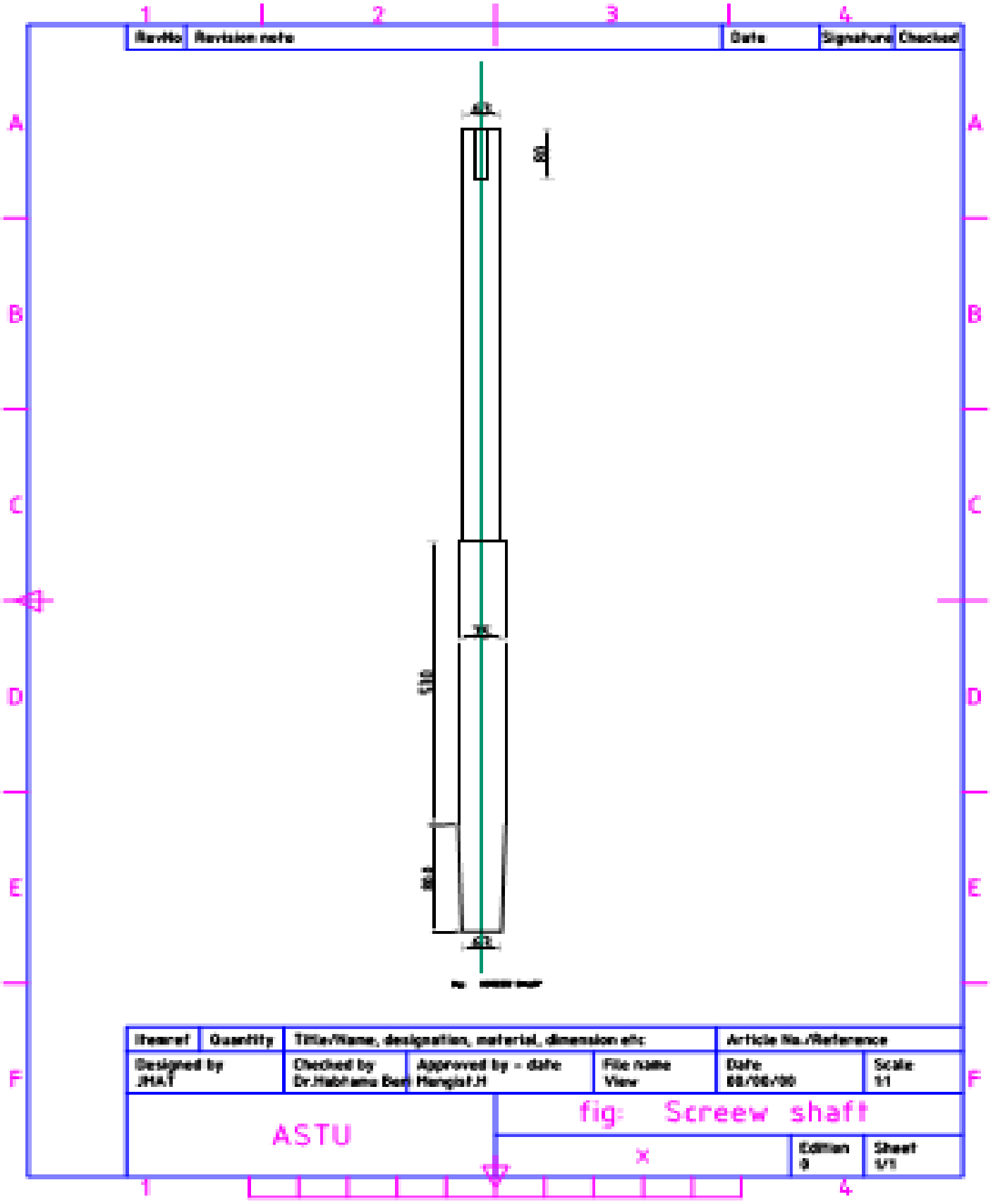
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fig: Screew shaft
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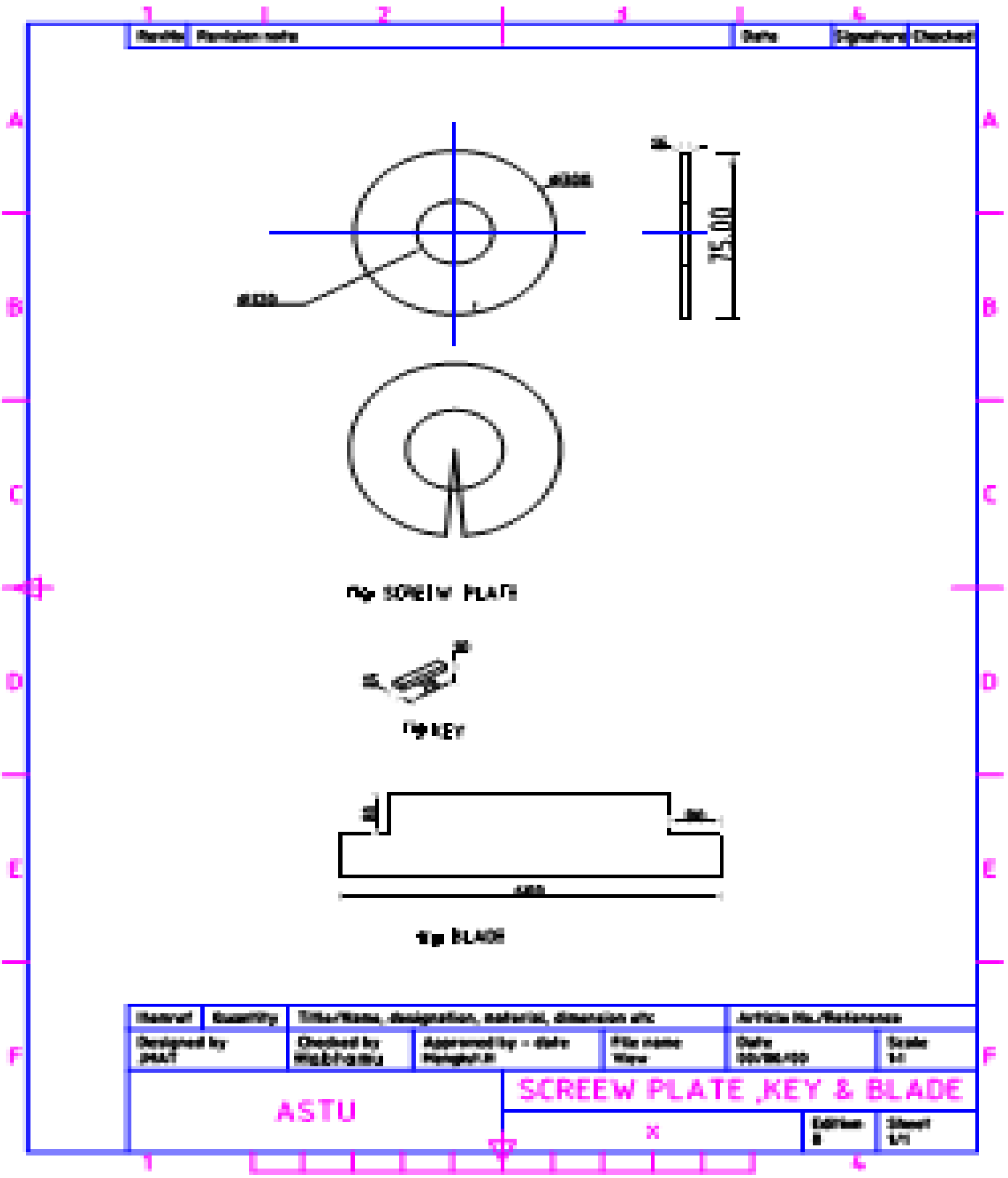
75.00
SCREEW PLATE ,KEY & BLADE
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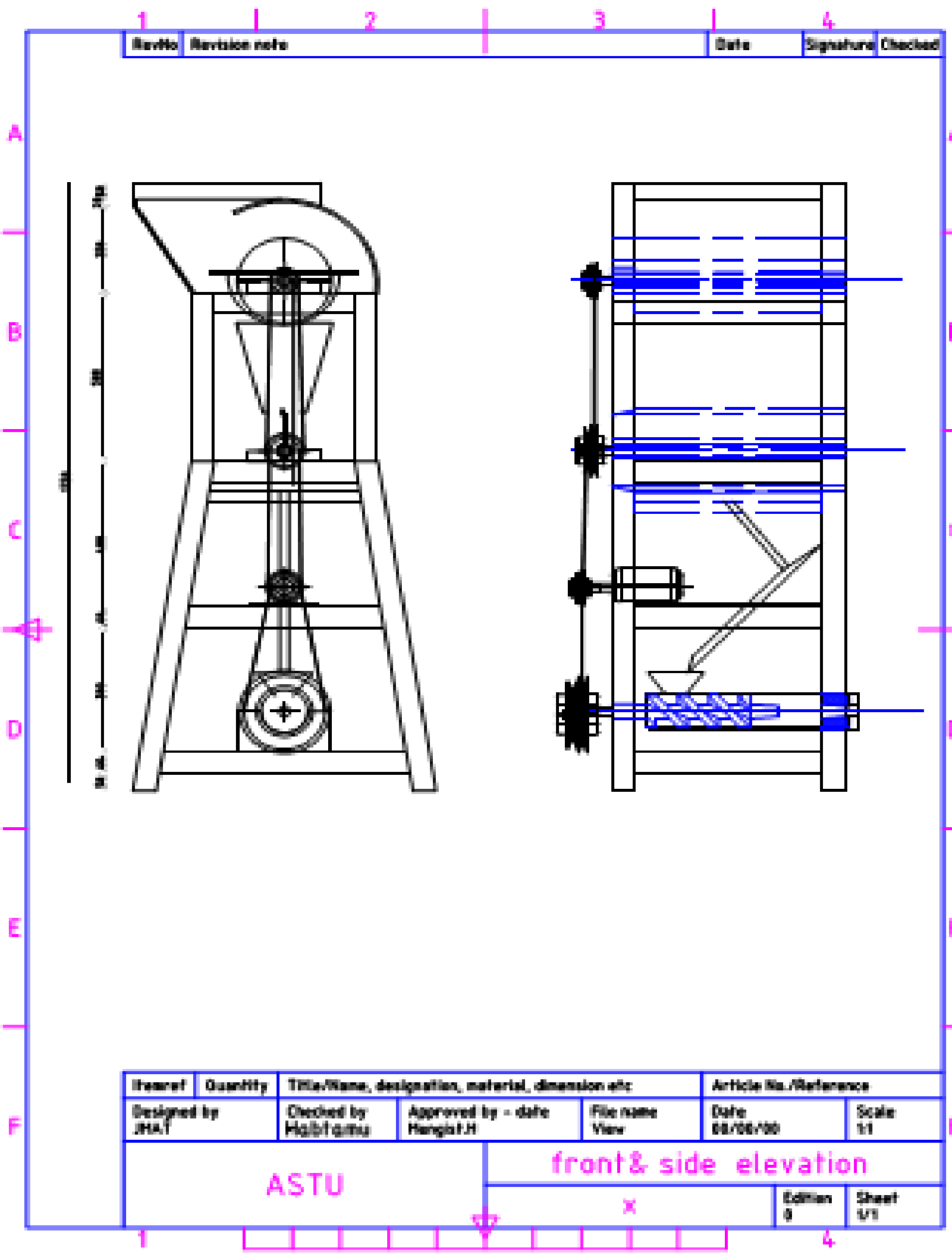
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Itemref
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Title/Name, designation, material, dimension etc
Article No./Reference
Designed by
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front& side elevation
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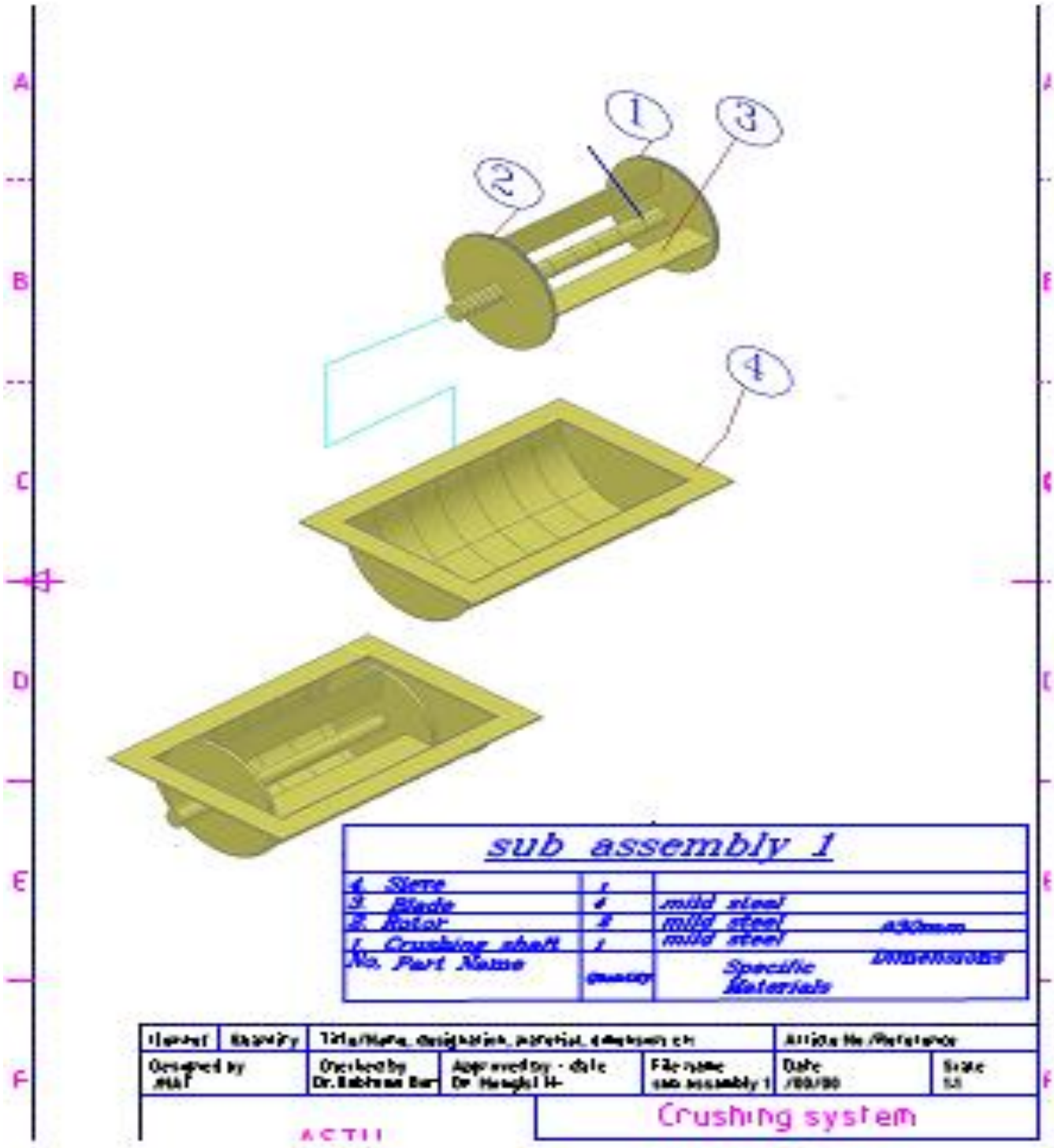
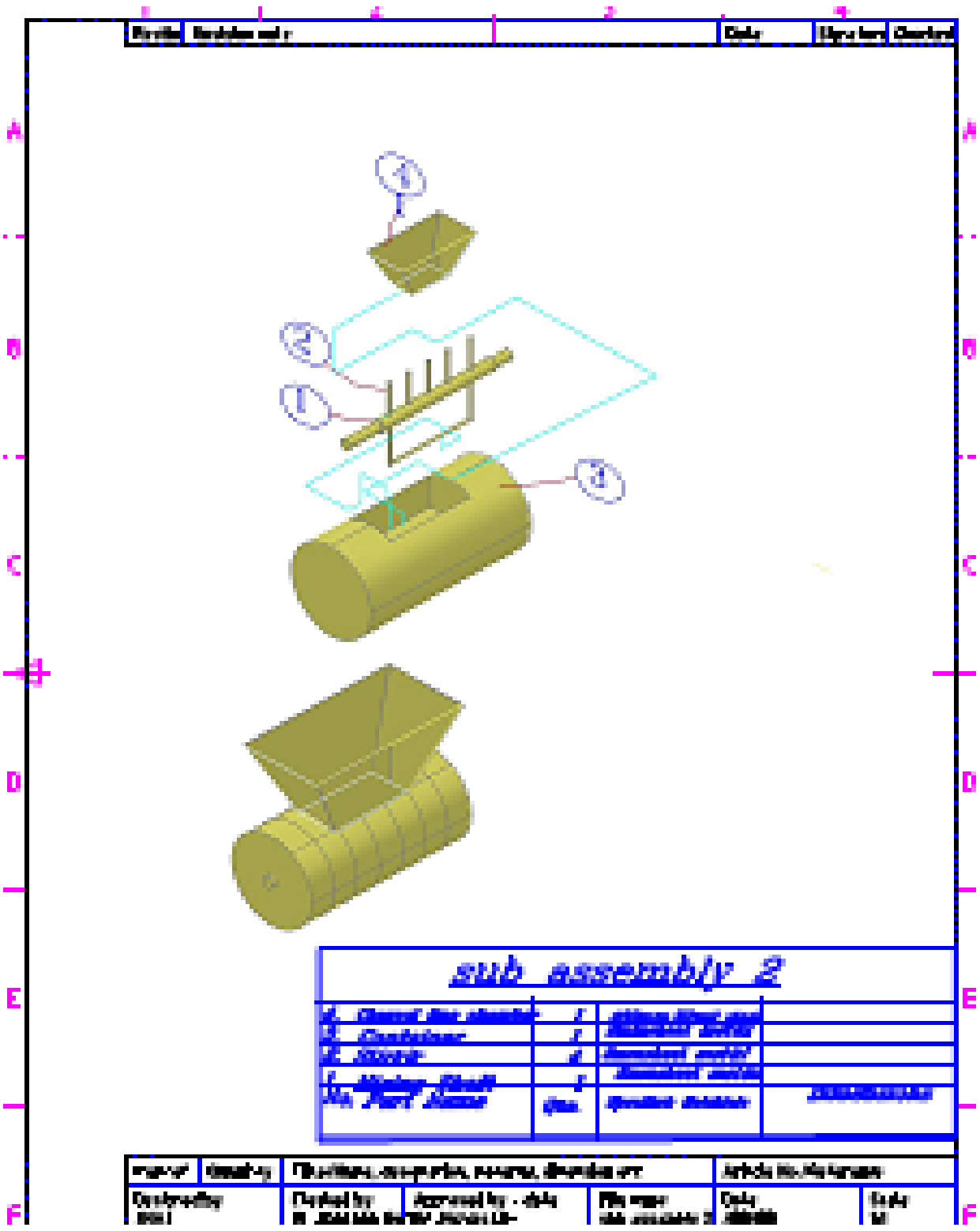
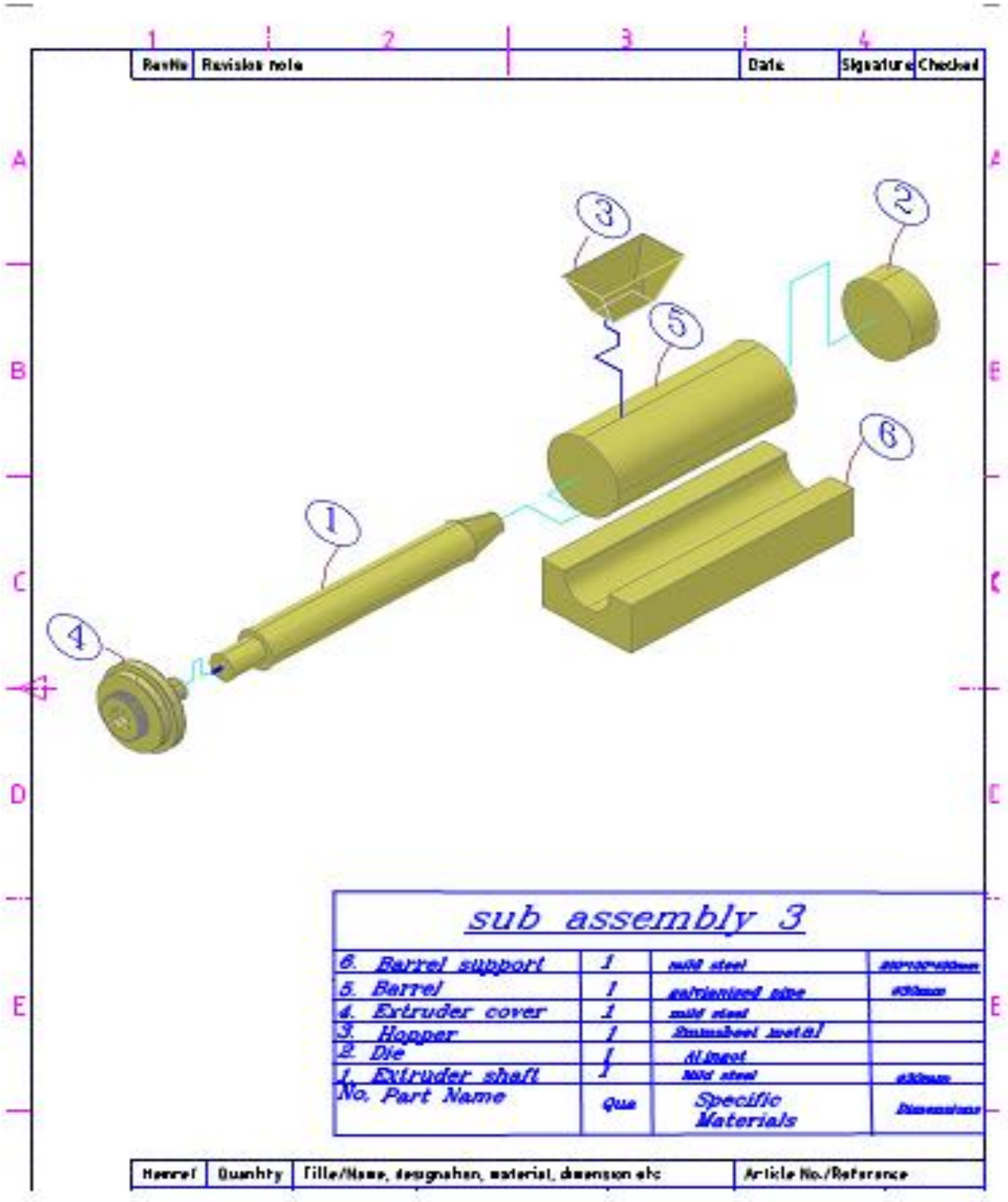

1
2
3
4
sub assembly 1
4 Stem 1
3 Blade 4 mild steel
2 Rotor 1 mild steel
1 Crushing shaft 1 mild steel
No. Part Name quantity Specific Materials
Crushing system


sub assembly 2


1
2
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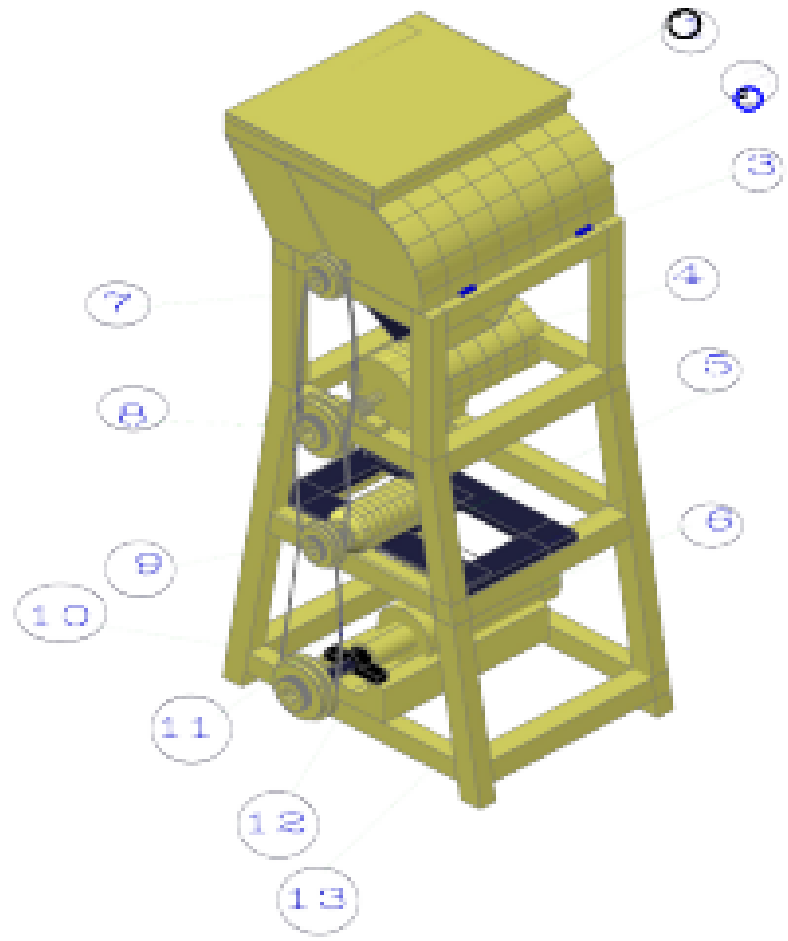
4
5
6
sub assembly 3
6. Barrel support
5. Barrel
4. Extruder cover
3. Hopper
2. Die
1. Extruder shaft
No. Part Name
Qua
Specific Materials
Revisio note
Date
Signature
Checked
Item
Quantity
Article No./Reference



13	body frame	1	angle iron	50X50X4mm
12	bearing house	6		standard
11	belt	3	rubber belt	A36,A40,A51
10	extruder pulley	1	Al,ingot	Ø300mm
9	motor pulley	1	Al,ingot	Ø75mm
8	mixing pulley	1	Al,ingot	Ø140mm
7	crushing pulley	1	Al,ingot	Ø140mm
6	extruder system	1		
5	motor	1	standard	single phase 3HP
4	mixing system	1		
3	Hinge	1		standard
2	Crushing system	1		
1	Hopper	1	sheet metal	2mm thick
part no	Part Name	quantity	specific material	dimension

ASTU

Total assembly of the system