Adama Science and Technology University

School of Mechanical, Chemical and Material Engineering

Department of Mechanical and Vehicle Engineering

Project title: - Design and Manufacturing of Manual Sheet Metal Rolling Machine

Submitted in Partial Fulfillment of the Requirement of the Degree of Master of Science in Manufacturing Technology

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May 2015

DECLARATION

We hereby declare that this project work entitled **"Design and Manufacturing of Manual Sheet Metal Rolling Machine**" towards MSc in Manufacturing Technology is our own work and that, to the best of our knowledge, it contains no material previously published by another person, nor material, which has been accepted for the award of any other degree of masters in any university, except where due acknowledgement has been made in the text.

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APPROVAL SHEET

The Project entitled "Design and Manufacturing of **Manual Sheet Metal Rolling Machine**" is approved for the award of degree of Master of Science in Manufacturing Technology.

BOARD OF EXAMINERS

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ACKNOWLEDGEMENTS

First and foremost, we thank God for giving us this opportunity and carrying us through this project work successfully.

This project work could have been completed with the support and encouragement from several people. First of all, we would like to express our gratitude to our advisor **Habtamu Beri (PhD)** and **Ato Melese Workneh** who have supported our throughout the whole process and for their excellent direction, invaluable feedback, their constructive suggestions, detailed corrections, support and encouragement played enormous role resulted in this successful project. We would like to extend our gratitude to all SME's, TVET workers and trainers, e.tc.in Adama city for giving us efficient data without which the project could not be completed. We also own thanks and appreciation to those instructors for providing us valuable information for the study and for giving as the basic knowledge to do this project. For providing us valuable information for the study. Furthermore, we would like to extend our thanks to ASTU tool men, for their cooperation in using machineries, hand tools and work shop to finalize our project. We thanks go to all our colleagues in section of manufacturing engineering for making the Section a nice place to work in. We would also like to thank our dorm mates. We have spent a pleasant time together, which will be remembered all our life. We also wish to thank several friends, whom we cannot list here, for sharing with ours an interesting time in Nazareth.

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LIST OFACRONYMS AND ABBREVIATIONS

CAD	Computer Aided Design
mm	Millimeter
SME	Small and Micro Enterprise
TVET	Technical Vocational Education and Training
AMRI	Agro- Mechanization Research Institute
Pcs	pieces
Kg	Kilo Gram
Pkt	Packet
&	and
CD	Compact Discs
i.e.	that is
Dia	Diameter
SAE	Society of Automotive Engineering
F	Force
T	Torque
R	radius
ASTU	Adama Science and Technology University
HERF	High-Energy-Rate Forming
ITDG	Intermediate Technology Development Group
a	a distance from exit zone to the no-slip point
F	Force applied to rollers
L	roll gap
μ	frictional force
ho	thickness of the sheet before time t
hf	thickness of the sheet after time t.
Lb	bend allowance
Θ	bend angle
k	constant
rpm	revolution per minute

OD	Outside Diameter of the gear
PD	Pitch Diameter of the gear
P	Power
W_T	tangential load
W_N	normal load
C_v	velocity factor
Φ	Pressure angle
v	pitch line velocity
b	face width of gear
c	deformation factor
$\boldsymbol{\sigma_w}$	permissible working stress
W_D	dynamic load
W_I	incremental load
σ_e	elastic limit,
M	Module
Y	tooth factor
W_S	static load
e	shaft strength factor
h	height of key way on the shaft
d	diameter of the shaft
EP	Extreme Pressure
W	Watt
MPa	Mega Pascal
Gpa	Giga Pascal
N	Newton
m/s	meter per second
Ymw	partial factor
Fwd	Fillet weld
Fu	Smaller ultimate strength weld
MSI	Muscular Skeleton Injury
ASTM	American Society Testing Material

ABSTRACT

This thesis work basically focuses on the development of intermediate technology of sheet metal rolling machines for sustainable motivated small and micro enterprise manufacturers. It presents the design, construction and testing functionality of a sheet metal rolling machine for small and micro enterprises. The rollers were made of steel l200mm long and 65 mm diameter. The rolling machines have the following parts supporting plat, bush, crank, adjusting screw, rollers, spur gear, and stand.

The sources of data for the study are questionnaires, unstructured interviews, survey of previous relevant works, consultation and personal observation at the case small and micro enterprise and TVET College. By analyzing these data, the paper can easily identify what the major problems and their causes to the existing sheet metal rolling machines.

For parametric specification of three roller sheet metal rolling machine, it is necessary to use the best roller aperture for different material, analyze the stress induced in rollers, sheet metal and gear teeth tangential and radial force

During manufacturing different processes like sawing, shearing, turning, facing, grinding, welding and finishing are implemented for different parts according to the working principles. It is also necessary to design the machine using Computer aided design (Auto CAD) and part drawing is provided for the purpose of manufacturing process. During designing it is considered that Posture and external loads such as hand force have a dominant effect on ergonomic analysis outcomes.

The result indicates the maximum bend radius obtainable as an approximate radius of roller for a typical material length. The largest measured diameter of complete cylinder the machine can handle using the given diameter of rollers.

The various cost components are involved in manufacturing a product, manufacturing manager has to identify those factors that can help to minimize them, while maintaining quality for sustainable market share. Thus it is possible to conclude that to be efficient and competitive the SME's and small industries should minimize their defective products of sheet metal using this redesign and manufactured sheet metal rolling machine than traditional sheet metal rolling.

Keywords: *sheet metal rolling, crank, bearing, rollers and spur gear.*

CHAPTER ONE: INTRODUCTION

1.1. Background

Sheet metal rolling machine is used to form cylindrical sheet metal for different purposes. The machine would be very useful for any work shop producing items of sheet metal. It allows quick and easy production of curves and cylinders for articles such as stove pipes, buckets, water troughs, fuel tanks and agricultural equipment. It is also useful in vehicle building and repair work. This machine will roll sheet steel up to 2mm thick times 1meter wide it will roll complete cylinders up to 100mm diameter (using the given size of rollers). Designed specifically for construction from locally available steel, the machine could be built by most small metal workshops and blacksmiths. The machine can be bolted on to a strong bench or mounted on the stand described[1].

The ability to make local equipment for small farms and villages in rural areas is increasingly being seen as very useful both in developing countries and in the more industrialized nations. Being built locally also means can be repaired locally, a very valid point when considering remote rural areas, transportation costs and local self – reliance.

The local artisans and craftsmen are the known major producers of simple farm tools and equipment. While the small scale welders had been found to have the highest farm tools and equipment production potentials however inadequate production facilities and lack of appropriate reconditioning tools and equipment are some of the major problems faced by these local manufacturers.

The identification, selection, design desirability and promotion of locally modified tools are made possible through the strengthening and redesigning of machine vital components, the improvement of welder's craftsmanship and adequate enhancement of local manufacturing processes through the use of locally improved work tools and machines. Considering high cost of tools and products in sheet rolling processes, detection and controlling factors for producing precise product are important. In most processes, geometry and configuration of rolling components could be obtained from the geometry of product at the end of loading. Therefore elastic recovery (known as spring back) formed part of the unloading process, and it is the most important factor in deviation of final products from desired geometry. Spring back is influenced by a combination of various process parameters such as tool shape, dimension, contact friction condition, material properties, thickness, etc. This work therefore reported the design and evaluation of a simplified shape rolling machine with simple crank mechanism, higher diameter of roll (up to 100 mm), and spring loaded bearing blocks for stress relief. When load is overbearing (machine handling a load beyond the designed safety factor and load carrying capacity), low cost and for varying roller aperture for easy sheet metal rolling.

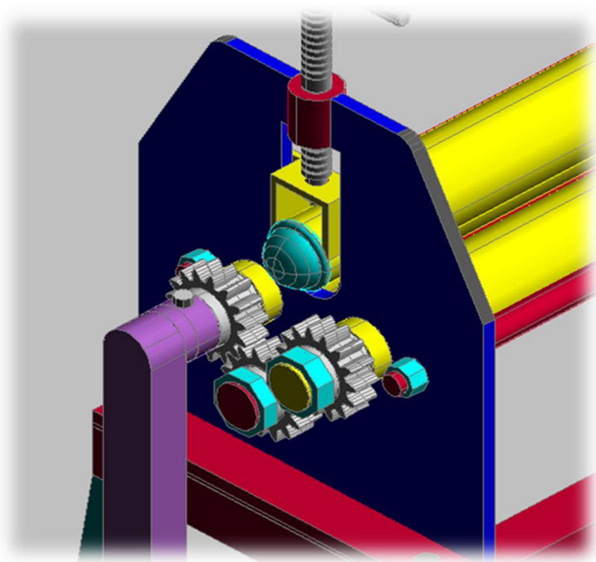

Figure 1.1 front view of the machine.

The most common sheet metal rolling machine roller sizes are [2].

- Machine 4126: Length 510mm, roller dia.25-45mm and thickness 1.2mm.
- Machine 4132: Length 1260mm, roller dia. 60mm, thickness 2mm and
- Machine 8263: Length 2020mm, roller dia. 90 - 110mm and thickness 6mm

Considering common size of products produced in small and micro enterprise which is 1000-1200mm. The roller of the project to be designed will machine 4132 standard. The imported rolling machine minimum cost of 40,000 birr and the designed project will be from 16,000 - 18,000 birr. The quality of designed project will be easily maintainable, manufactured, light in weight, affordable for local material than the imported machine.

Sheet metal fabrication plays an important role in the metal manufacturing. Sheet metal is used in the production of materials ranging from tools, to hinges, automobiles etc. Sheet metal fabrication ranges from deep drawing, stamping, forming, and hydro forming, to high-energy-rate forming (HERF) to create desired shapes. Fascinating and elegant shapes may be folded from a single plane sheet of material without stretching, tearing or cutting, if one incorporates curved folds into the design.

Shape rolling of sheet metal is the bending continually of the piece along a linear axis. This causes alteration of the original form of the sheet as it passes through a pathway of series of rollers. Such work tool as shape rolling machine is found to be very useful in manufacturing processes for used parts in various industries like inner and outer panels and stiffeners in automotive and agricultural industries, small metal workshops to roll round and conical profiles for stoves, cylinders (flue pipe, water pipes), basic machine elements with curved surfaces, buckets, bins, gear box cover, mud guards, drinkers and feeders for poultry, feed mixers etc. and also in food cans and civil engineering applications. A wide range of these products should satisfy tight tolerances compared to desired geometry. The local artisans and craftsmen are the known major producers of simple farm tools and equipment in Ethiopia while the small scale welders had been found to have the highest farm tools and equipment production potentials in Ethiopia; however, inadequate production facilities and lack of appropriate reconditioning tools and equipment's, are some of the major problems faced by these local manufacturers. The identification, selection, design desirability, and promotion of locally modified tools is made possible through the strengthening and redesigning of machine vital components, the improvement of welder's craftsmanship and adequate enhancement of local manufacturing processes through the use of locally improved work tools and machines. A critical appraisal of locally available metal rolling machines indicated a necessity of improving on ergonomic design, system complexity and cost published a work based on the report of the Intermediate Technology Development Group (ITDG) on the development of rolling machine for sheet metal work. The complexity of the crank mechanism, the numerous and intricate component parts of the machine defeated the aim of simple technology tool development and manufacture. The machine rolls sheet metal up to 2 mm thick and 1m wide and rolls complete cylinders down to 100 mm diameter with 65mm diameter rollers.

Considering high cost of tools and products in sheet metal rolling processes, detection and controlling factors for producing precise product are important. In most processes, geometry and configuration of rolling components could be obtained from the geometry of product at the end of loading. Therefore elastic recovery (known as spring back) formed part of the unloading process, and it is the most important factor in deviation of final products from desired geometry. Spring back is influenced by a combination of various process parameters such as tool shape and dimension, contact friction condition, material properties, thickness, etc.

This work therefore reported the design and evaluation of a simplified shape rolling machine with simple crank mechanism, higher diameter of roll (up to 100 mm), spring loaded bearing blocks for stress relief when load is overbearing (machine handling a load beyond the designed safety factor and load carrying capacity), low cost and for varying roller aperture for easy sheet metal rolling. The motion is transferred to the roller through gear drive rotation. These elements are mounted on metal shafts.

Hand Crank Mechanism: - The mechanical device used to drive the roller is composed of a hand crank, drive spur gear, and a hand crank mounted on drive shafts. Enhancing the competitiveness of small and micro enterprise and private sector in order to generate income and employment opportunities is the prime objective of the SME Promotion.

1.2. Statement of the problem

Locally in Ethiopia, the small and micro enterprise and industries that was not use sheet metal rolling machine for different products such as, stove pipes, bucket, water troughs, fuel tanks, and agricultural equipment's. A wide range of these products should satisfy tight tolerances compared to desired geometry. It was observed that most rolled was done by hand tools.In order to make the above mentioned equipment take a lot of time and in accurate form/shape. It was also observed in the study area, small enterprise which causes great damage to the hand tools .and products.

To import the sheet metal rolling machine from the developed countries an expensive foreign currency is required. Using traditional hand rolling methods does not support large-scale and accuracy of work on rolling sheet metals is not sufficient, especially for commercial purposes.

The availability of rolling machine in the market, which is expensive to purchase for small enterprise, therefore necessitated to design and manufacture of low cost system that will be affordable and also increase the quality of the product. In addition to design & manufacturing rolling machine from locally available steel sections.

1.3. Objective of the project

1.3.1. General objective

The objective of the project is to manufacture manual sheet metal rolling machine that was previously designed and manufactured by developed country. The reason to manufacture this sheet metal rolling machine is to introduce and transfer the technology for other fabricators specially small and micro enterprises and how too easy manufacture by minimum cost.

1.3.2. Specific objective

- To identify, select and design of vital components of the machine.
- To design and manufacture the crank mechanism to rotate the roller by gear drive mechanism.
- To design and fabricate the spur gear to mesh properly
- To fabricates the roller according to the dimension of design.
- To design and manufacture the stand ergonomically.
- To test the performance of sheet metal rolling machine**.**
- To modify and simplify the design of the existing sheet metal rolling machine in accordance with the available or local material.

1.4. Significance of the study

Since sheet metal rolling machine is basic in industrial workshops, and which involves increasing the capacity and quality of the workshops products.

The Beneficiaries form this project are the following parties:-

- Small and micro enterprise
- TVET colleges
- Universities
- Middle level industry and
- Agro-mechanization research institutes

1.5. Scope of the study

Our project will focus on the Governmental, Privet TVET colleges, micro and small enterprise found in east, west shoa zone and Addis Ababa. Most of them had not use the sheet metal rolling machine instead of they use other improper tools, equipment and working mechanism (method) so, that the quality and capacity of production is not maximum as required.

1.6. Literature survey

The survey include: market assessment and project information, review of market incompetence, productivity, design analysis, materials accessibility, machine and equipment required to manufacture etc.

CHAPTER TWO: LITERATURE REVIEW

Himanshu: Himanshu has done bend ability analysis for bending of steel plates on heavy duty 3-roller bending machine. In this experiment they found out the equivalent thickness, equivalent width and maximum width analytically &based on power law material model.

Ahmed Ktari: have done Modeling and computation of the three-roller bending process of steel sheets. This experiment consists of two-dimensional finite element model of this process was built under the Abaqus /Explicit environment based on the solution of several key techniques, such as contact boundary condition treatment ,material property definition, meshing technique, and so on.

Jong GyeShin: has done the experiment on Mechanics-Based Determination of the Center Roller Displacement in Three- Roll Bending for Smoothly Curved Rectangular Plates. The objective of this thesis is to develop a logical procedure to determine the center roller displacement, in the three-roll bending process, which is required in the fabrication of curved rectangular plates with a desired curvature.

M K Chudasama: have done the experiment on Analytical Model for Prediction of Force during 3-RollerMulti-pass Conical Bending. In this paper, the total deflection of the top roller required is divided in steps to get the multi pass bending.

M. B. Bassett, and W. Johnson: The bending of plate using a three roll pyramid type plate bending machine, J. strain Analysis Process manual, maintenance manual, machine capacity chart and technical specification of rolling machine, **M/s Larsen& Toubro ltd**, Hazira, Surat India.

2.1. Definition of Metal Forming

Metal forming is a kind of manufacturing process that the part attains a specified shape by permanent deformations through applied forces and impellent boundaries such as tool and dies. The external forces can be in the form of compression, tension, torsion, shearing, bending, drawing or a combination of the various forces. Usually ingots from simple shapes are formed using tools and dies. Shaping of the metal stock means plastic deformation throughout or some parts of the material stock. Plastic deformation is strain values due to stresses above elastic limit. Reason for this aforementioned plastic deformation is slips occurring between crystallographic planes of the metallic structure. Metal forming processes are being widely used since early ages. Starting with hammering iron to make tools, war equipment's such as swords or blades, metal forming has an immense history [3].

Many advantages of metal forming processes are listed:

1. Utilization of metal is very high in some cases 100% material is used directly as final product.

2. Fatigue life of the formed products compares very much to the conventional production methods such as casting or cutting.

3. It is not affected with cutting tools' shorter life and risk of changing dimensions because of abrasion or breakage used in machining processes.

4. It is a robust process that can give same final shape and dimensions for high amount of production.

5. Production cycle time is very low compared with chip consisting and many casting processes, since casting requires higher temperatures compared to hot forming in case heating is much significant in casting. Metal forming technology is used in following areas; Aerospace, Appliance / White goods, Construction, Medical equipment manufacturing, Military, Rail car and rail car component manufacturing and Automotive...

2.2. Classification of Metal Forming Processes

In general terms, metal forming processes can be classified in terms of type and shape of formed parts and deformation zone. Classification is bulk-forming and sheet forming at first sight. Afterwards these also have minor branches as seen on Figure 2.1.

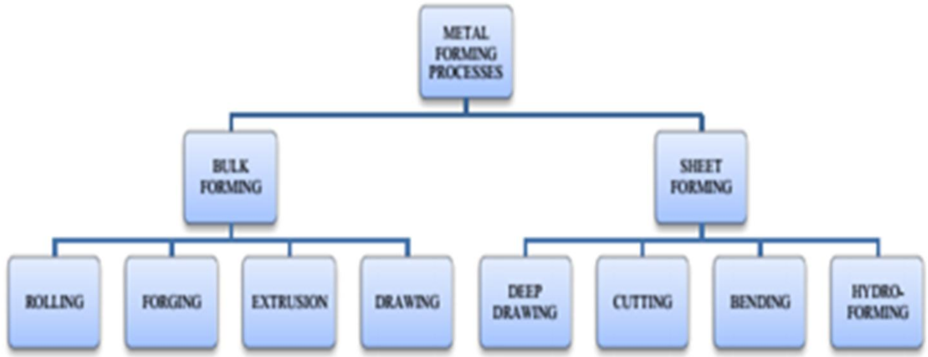

Figure2.1 Classification of Metal forming processes [4].

Bulk Forming Processes involve large amount of plastic deformation. The cross-sectional area of work piece changes without volume change.

Shape of the deformation zone that covers the cross-section changes during forming of the material. The ratio cross-section area/volume is small.

For most operations, hot or warm working conditions are preferred although some operations are carried out at room temperature. Subheadings are briefly defined as following:

Rolling: Compressive deformation process in which the thickness of a plate is reduced by squeezing it through two rotates cylindrical rolls.

Forging: The work piece is compressed between two opposing dies so that the die shapes are imparted to the work.

Extrusion: The work material is forced to flow through a die opening taking its shape.

Drawing: The diameter of a wire or bar is reduced by pulling it through a die opening (bar drawing) or a series of die openings (wire drawing).

In Sheet-Forming Processes, the cross-section of work piece does not change; the material is only subjected to geometry changes. The ratio cross-section area/volume is very high. Sheet metalworking operations are performed on thin (less than 6 mm) sheets, strips or coils of metal by means of a set of tools called punch and die on machine tools called stamping presses. They are always performed as cold working operations. However, there are new trends to warm the sheet before forming.

2.3. Temperature of metal forming process

According to working temperature forming operations are also classified as seen on Figure 2.2 where Tm is the melting temperature of the solid metal;

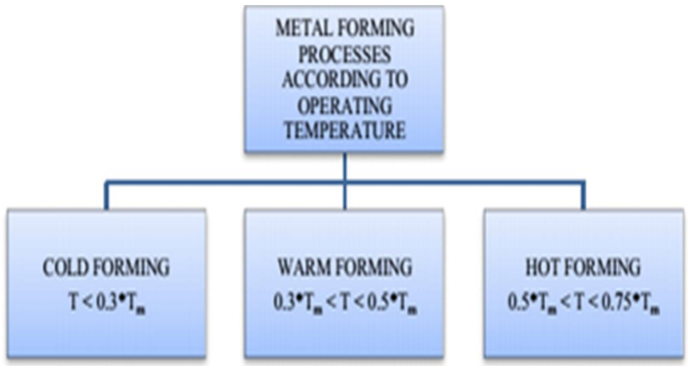

Figure 2.2 Operating Temperature Ranges of Metal Forming Processes[4].

Cold Forming: Cold Forming is a metal deformation process performed at room temperature namely below the melting and recrystallization temperature. Advantages are dimensional accuracy, better surface finish, high strength and hardness of the finished part. Whereas; there is need for higher forces and power in addition sometimes annealing before process.

Warm Forming: Warm Forming is metal deformation performed at temperatures above the room temperature but below the re crystallization one. Advantages are lower forces and power, more complex geometries and no annealing process. However; another heating process is required before forming.

Hot Forming: Hot Forming process involves deformation of preheated material at temperatures above the re crystallization temperature. Advantages of the process are forming of the large geometries being possible, requirement of lower forces and power due to low flow stresses and occurrence of no work hardening. However, process gives lower dimensional accuracy and surface finish, higher production cost and shorter tool life.

2.4. Introduction to Sheet Metal Forming

Sheet metal is simply metal formed into thin and flat pieces, which are usually less than 6mm. There are different metals that can be made into sheet metal. Aluminum, brass, copper, cold rolled steel, mild steel, tin, nickel and titanium are just a few examples of metal that can be made into sheet metal. Sheet metal has wide applications in car bodies, airplane wings, medical tables, roofs for building and many other things. Sheet metal forming refers to various processes used to convert sheet metal into different shapes for a large variety of finished parts. The typical forming processes include stretching, drawing, cutting, bending and flanging, punching and shearing, spinning, press forming and roll forming. Sheet metalwork is the manipulation of sheet metal of 3.5 mm in thickness, or less, using mainly hand tools or portable power tools in order to manufacture a range of diverse products. Plate metalwork is the manipulation of metal plate over 3.5 mm in thickness using mainly power tools. The forming operations used range from simple bending and rolling operations to more complex flow-forming operations such as spinning and presswork as shown in Fig. 2.3

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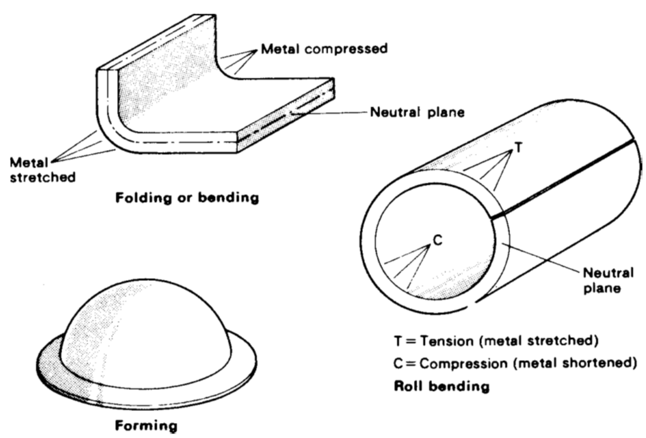


Figure 2.3 Different forming operations[5].

2.4.1. Sheet Metal Forming Machines

For an indefinite period previous to the introduction of the forming machine or rolls, as the machine is sometimes called, pipe and cylinders of sheet metal generally were worked into shape around cast iron stakes very similar to the conductor stake so commonly seen in use in the sheet metal shop today. The conductor stake, however, has not out lived its usefulness for working down diameters of sheet metal pipe after leaving the forming machine. The conductor stake is also making itself useful in shops where tubes of small diameters must be turned out occasionally. But the forming of pipe and the bodied of vessels is now more dependent on the rolls of the forming machine.

Since that time the forming machine has found a valuable place in every sheet metal shop. During these days of industrial activity in which many new uses have been found for sheet metal, the forming machine is more commonly employed than in the past. In all these years, however, little improvement was possible with the plain forming machine with solid bearings as shown in Fig.2.4. In a forming machine, (Fig. 2.4), it will be seen that the gear is fixed to the upper and lower front roll. As the upper roll is raised by thumbscrews for receiving the work the gear is attached to the upper roll, is thrown out of contact with the gear on the lower roll. Consequently the gears would often ride on the edges of their teeth causing the gears to jump and frequent gear break

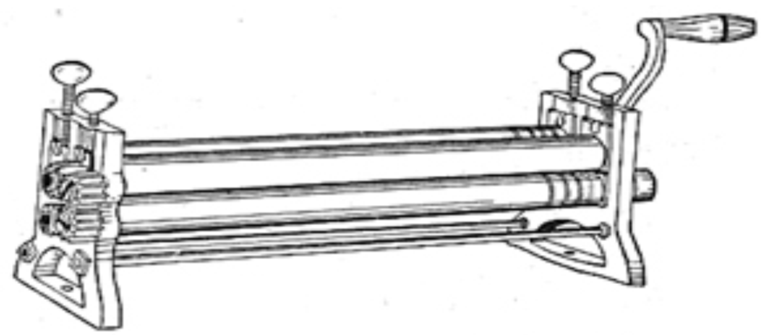


Figure 2.4 Common forming machines with solid bearings

While it has been stated that little improvement has been made in the plain pattern forming machine since the days of its origin an improvement in arrangement of gearing in this type of former as shown in (Fig.2.5) has been well received. It is surprising, regardless of this improvement, that the old style common forming machine with two cast iron gears that work with their rolls no different than a wash ringer, should even today prove so greatly the favorite over the former shown in (Fig. 2.5) Perhaps this condition is due chiefly to a lack of education on the part of the purchaser and without observing what might appear as a quite insignificant detail of construction, nevertheless very valuable from the viewpoint of durability and convenience.

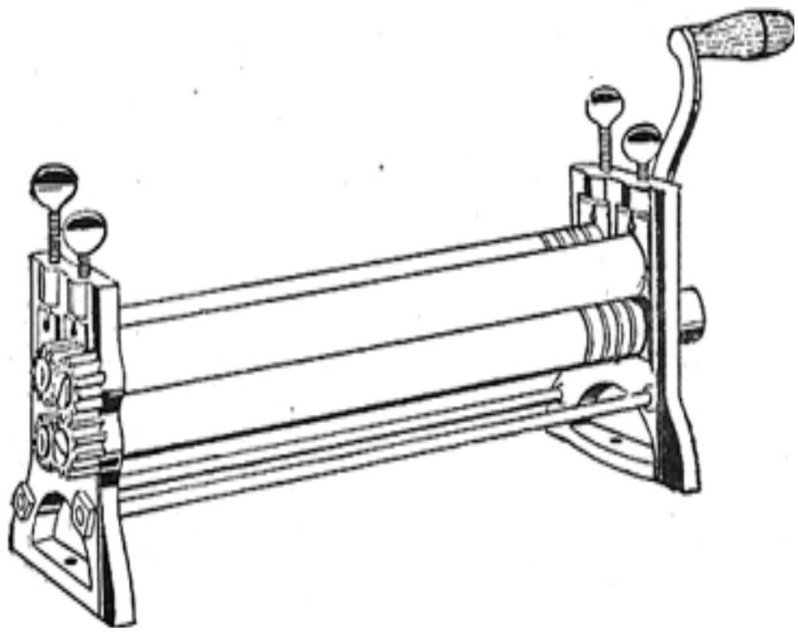


Figure 2.5 forming machine with cut steel compensating gears

The former in (Fig.2.5) is known as a former with compensating gears. This term means that in addition to the gears being fixed to the front upper and lower rolls, two gears are also hung to the frame and so arranged that no matter how high the upper roll may be raised out of contact with the lower roll, the gears will always remain in mesh. The gears in these formers are cut from steel and while they will wear after long usage they will not break like cast iron.

2.5. Definition of Roll Forming Process

In Rolling Process, thickness of the work is reduced by compressive forces exerted by two or more opposing rolls. Process produces continuous strip of metal through a series of contoured rolls. Accordingly, cross-section of the metal part is formed into a pre-determined shape. Cross-section area of the rolled material is decreased in single direction or both directions while passing through the rollers. Aforementioned change leads to elongation in the rolling direction. The nature of roll forming when cold rolling is applied; allows the finished part to be within very tight tolerances. Roll formed sections have an advantage over extrusions of similar shapes due to being generally much lighter and stronger, when having been work hardened in a cold state. Exclusions are observed when hot rolling is applied.

2.5.1. Classification of Roll Forming Processes

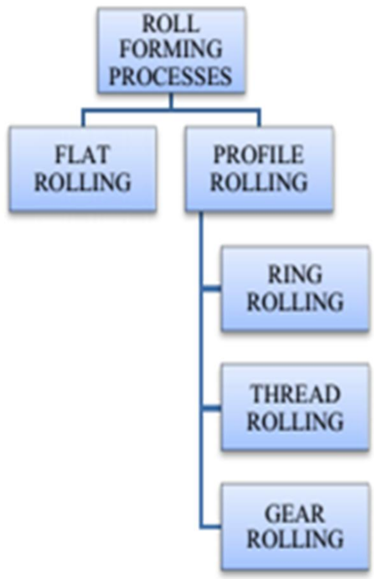


Figure 2.6 Classification of Roll Forming Processes [4].

2.5.1.1. Flat Rolling

Flat Rolling is used while rolling sheet metals, thickness of the work is reduced by compressive forces exerted by two or more rollers or any cross-section without boundaries at perpendicular direction to both rolling and rollers axis. At the same time; the rollers have no contours along their movement axis.

2.5.1.2. Sheet metal rolling

Sheet metal fabrication plays an important role in the metal manufacturing world [7]. Sheet metal is used in the production of materials ranging from tools, to hinges, automobiles etc. Sheet metal fabrication ranges from deep drawing, stamping, forming, and hydro forming, to high-energy-rate forming (HERF) to create desired shapes [7]. Fascinating and elegant shapes may be folded from a single plane sheet of material without stretching, tearing or cutting, if one incorporates curved folds into the design [8].

Shape rolling of sheet metal is the bending continually of the piece along a linear axis. This causes alteration of the original form of the sheet as it passes through a pathway of series of rollers. Such work tool as shape rolling machine is found to be very useful in manufacturing processes for used parts in various industries like inner and outer panels and stiffeners in automotive and agricultural industries, small metal workshops to roll round and conical profiles for stoves, cylinders (flue pipe, water pipes), basic machine elements with curved surfaces, buckets, bins, gear box cover, mud guards, drinkers and feeders for poultry, feed mixers etc. and also in food cans and civil engineering applications. A wide range of these products should satisfy tight tolerances compared to desired geometry [9].

The local artisans and craftsmen are the known major producers of simple farm tools and equipment in Nigeria while the small scale welders had been found to have the highest farm tools and equipment production potentials in Nigeria [10]. However, inadequate production facilities and lack of appropriate reconditioning tools and equipment's, are some of the major problems faced by these local manufacturers [11].

As discussed above the two rollers are connected to the shaft and are driven by the gears, each rollers are interconnected by individual gear having same number of teeth on it to facilitate same rotary motion to it. For construction of various structures as well as integral part of machines various cylindrical sections are widely used. Such cylindrical sections are manufactured by various methods and 3-roller conical bending process is one such process. It consists of two bottom rollers and a top roller. Metal plates with specified contours are rolled without decrease in thickness to get the desired cone angle. The plate undergoes plastic deformation and it is cold forming process and hence it has higher dimensional accuracy.

The identification, selection, design desirability, and promotion of locally modified tools is made possible through the strengthening and redesigning of machine vital components, the improvement of welder's craftsmanship and adequate enhancement of local manufacturing processes through the use of locally improved work tools and machines. A critical appraisal of locally available metal rolling machines indicated a necessity of improving on ergonomic design, system complexity and cost [12]. Published a work based on the report of the Intermediate Technology Development Group (ITDG) on the development of rolling machine for sheet metal work [1]. The complexity of the crank mechanism, the numerous and intricate component parts of the machine defeated the aim of simple technology tool development and manufacture. The machine rolls sheet metal up to 1.5 mm thick and 1m wide and rolls complete cylinders down to 75 mm diameter with 55 mm diameter rollers.

Considering high cost of tools and products in sheet rolling processes, detection and controlling factors for producing precise product are important. In most processes, geometry and configuration of rolling components could be obtained from the geometry of product at the end of loading. Therefore elastic recovery (known as spring back) formed part of the unloading process, and it is the most important factor in deviation of final products from desired geometry. Spring back is influenced by a combination of various process parameters such as tool shape and dimension, contact friction condition, material properties, thickness, etc. [14]. This work therefore reported the design and evaluation of a simplified shape rolling machine with simple crank mechanism, higher diameter of roll (up to 200 mm), spring loaded bearing blocks for stress relief when load is overbearing (machine handling a load beyond the designed safety factor and load carrying capacity), low cost and for varying roller aperture for easy sheet metal rolling.

2.5.2. Process of rolling

The sheet metal is always having line contact with the roller which is parallel to roller axis during the process. The forces acting during the bending are larger than the self-weight of the sheet metal. The shift of the neutral plane is zero, i.e., it is considered to be at the center line of the sheet metal thickness. Frictional force at the bottom roller and the sheet metal interface is always tangent to the roller surface. Rollers are assumed to be rigid. Roller material and sheet metal material is assumed to have stable microstructure throughout the deformation process. Deformation occurs under isothermal conditions and E, i.e., Modulus of Elasticity Remains constant during the process. Plane section remains plane, before and after the bending. Blank thickness (t) remains constant during and after the bending. Blank is having uniform/constant radius of curvature for the supported length of the blank between two bottom rollers.

CHAPTER THREE: METHODOLOGY OF THE STUDY

The research method will be descriptive study type particularly the survey method. The main purpose of such research is the description of the state of nature or affairs as it exists at present. It involves collecting numerical data to test hypothesis or answer questions about the current status of the subject of the study. The research will carry out actual on small and micro enterprise (SME),TVET college and private TVET work shop observation and see how rolls sheet metal work for different applications. In addition, we also interview them on the drawbacks of using in traditional methods. Locally in Ethiopia, the small and micro enterprise and small industries that was not use sheet metal rolling machine for different products such as, stove pipes, bucket, water troughs, fuel tanks, and agricultural equipment's. It was observed that most rolled was done by hand tools and to make the above mentioned equipment take a lot of time and in accurate form/ shape. It was also observed in the study area, small enterprise which causes great damage to the hand tools and products. Through questionnaire, asked them the benefits of redesign and manufacture of low cost system sheet metal rolling machine that will be affordable and also increase the quality of the product.

In the data collection process, the following procedures were used:-

1. Introducing the objective of the research to the concerned officials in different sections
2. Visiting production flow in the SME, TVET College etc.
3. Distributing questionnaires to concerned personnel's, trainers and workers.
4. Interviewing them to strengthen the information obtained using the questionnaires.

Since the main objective of the thesis is analyzing and solving the sheet metal rolling machine problem of SME, and TVET College proposing methods of improving the design, various useful data are collected from different divisions of the small and microenterprise.

- The production system of the enterprise is physically observed.
- Different department heads, trainers, some supervisors and workers in the SME, and TVET College and concerned employees were interviewed and asked to respond to the questionnaire designed for the study.
- The raw data that is also collected and analyzed.

3.1 Instrument development

For the purpose of the project to be successful, exploratory research method is used to identify key issues and key variables. Exploratory research might involve a literature search or conducting focus group interviews.

The exploration of new phenomena can help our need for better understanding and test the feasibility of a more extensive study, or determine the best methods to be used in a subsequent study. For these reasons, exploratory research is broad in focus and provides definite answers to specific research issues.

3.2 Sample selection

Sampling involves selecting relatively small number of elements from the large defined group of elements and expecting that the information gathered from small group allow generalization to be made about the larger group of population [15].

The sampling units are the defined target population elements available for selection during the Sampling process. In this research, east shoa is selected specially Adama, town artesian workers are selected purposely as the total population since the result can be considered for artesian workers in the country

A total of 15 numbers of artesian workers are randomly selected from the population of 30 number of artesian workers including SMEs at Adama town that are currently working in the field of sheet metal works. The reason why Adama town is selected for this study is because the town is near to the university and due to shortage of budget and limited time the research couldn’t include other places. The sampling is selected by using systematic random sampling method. Sample ratio can give sufficient information because it is taken 50% out of total population.

3.3 Data Collection

Three data gathering techniques have been used to understand current problems of sheet metal rolling machine for the need of this machine. Data are collected by questionnaires (closed and open questionnaires), interviewing and direct observation. The documents which are analyzed for the project are internet, and many types of reports and researches about sheet metal rolling machine. after the quantitative and qualitative data are gathered from those sources, sheet metal rolling machine is designed and manufactured as a solution to facilitate sheet metal products and to avoid exhausting and time consuming of rolling and shaping activities.

3. 3.1. Survey questionnaire

It is designed the survey questionnaire for assessing about sheet metal rolling machine in selected areas. This questionnaire was distributed to different persons living in Adama city and other personal users for their comments and suggestions before finalizing it. The questionnaire was finalized taking into account the above suggestions under the guidance of our advisor. Fifteen questionnaires were distributed to the randomly selected users. The composition of the persons who were participated in the response of the questionnaire includes artesian workers, sheet metal users, technical workers, and others who work in related area.

The objectives of the questionnaire are:

- To identify the problems related with sheet metal work.
- To assess attitudes and tendency towards sheet metal rolling machine.
- To know how many artesian workers use sheet metal rolling machine.
- To compare the efficiency of traditional working with hand tools and manual sheet metal rolling machine.

The survey questionnaire contains about fifteen questions requiring two types of answers.

a. The first type uses options from the alternatives (objective)
b. Subjective type questions, which need brief answer

3.3.2 Interview's

The interview included from different private sectors and customers especially small and microenterprise. Structured interviews (face to face) conducted with different sheet metal product workers, 17 sheet metal forming with traditional method and artesian workers and sheet metal product users. Most of the interview questions conducted is similar to the questions in the questionnaire. This helped us to cross check the response given by the respondents on both methods of assessment.

Objectives of conducting the interviews:

- To investigate feeling of the people who use manual sheet metal in Adama.
- To observe overall activities and processes in the respective areas of artesian workers.
- To assess the existing system of sheet metal rolling and shaping method and identify the drawback of traditional working process.
- To assess the needs of users and getting idea that how to be changed current traditional sheet metal rolling and shaping in to modern system.

3.3.3 Direct observation

Also used this method for collecting the required data and information from different documents. by using this observed the traditional working methods of sheet metal using hand tool from artesian workers and identify the problems that faced during rolling and shaping sheet metal work.

3.4 Data Analysis and Interpretation

The collected data through the means of questionnaires, interviews, direct observation of documents are analyzed & interpreted. It is believed that the current situation of the traditional sheet metal work and forming methods has exactly reflected the problems in these questionnaires and interviews. This analysis is important to get wide and in depth information from the respondents. The questionnaires also prepared for the respondents openly that he/she can describe freely much information on the space provided. It helps to get genuine information from respondents because the research is not to interfere the participant's idea. The findings indicate that, there is lack of sheet metal rolling machine and currently this machine is highly wanted by the artesian worker at Adama town.

Table 3.1 Major findings of the result

No	Question	No respondents	Yes	No
1	Have you ever used sheet metal rolling machine?			100%
2	At this time is there a need for sheet metal rolling machine on the market?		90%	10%
3	Are you interested to buy if this sheet metal rolling machine is produced at SME’s with responsible cost?		95%	5%
4	Is it easy to purchase any sheet metal rolling machine in the market at a reasonable price?	N=20	95%	5%
5	Do you have sheet metal rolling machine		95%	5%
6	Do you use sheet metal rolling machine in your shop		95%	5%
7	Are you interested to buy sheet metal rolling machine if it is produced at SME’s with reasonable cost?		95%	5%
8	Do you accept technology that can increase the utilization of sheet metal rolling machine?		95%	5%
9	Do you think that sheet metal rolling machine keep safety, increase productivity and quality of work		95%	0%

CHAPTER FOUR: MATERIAL SELECTIONAND DESIGN ANALYSIS

This chapter presents the design analysis and material selection of the parts based on the problems identified with a view to evaluate the necessary design parameters, strength and size of materials for consideration in the selection of the various machine parts in order to avoid failure by excessive fatigue during the required working life of the machine. Based on the analyzed data the available machines (imported) is very large in weight and costly for the users.

4.1. Equipment Description

This study shows redesigning and manufacturing of sheet metal rolling machine with low cost and light weight than the existing imported machine. Definition of the project in clear and concise manner is sheet metal rolling machine that means bending long rectangular sheet metal thickness up to 2mm into cylinders. Machine should be manually operated which means load is applied manually by the help of hand crank and spur gears driven or rotate the rollers. Bending of the sheet should be based on the three roller bending concept. It has been seen that the 3- rollers sheet metal bending machine are widely used in heavy engineering industries for the manufacturing of skeleton of oil and gas rigs, the construction of tunnels, cylindrical tanks, boiler equipment, fuel tanks for launch vehicle in space application, industrial buildings, pressure vessel, heat exchangers, tall towers, reactors, etc.

As discussed above the two rollers are connected to the shaft and are driven by the gears, each rollers are interconnected by individual gear having same number of teeth on it to facilitate same rotary motion to it. The primary aim is that a part must be designed to be satisfactory in all ways for its intended purposes. Another aim which is almost as important is to design a part for the most economical method of manufacturing. This may be accomplished by considering all feasible manufacturing methods and selecting the manufacturing method which appears to be most advantageous during the early stages of the design of a part. Ordinarily the most important consideration in this selection is the total cost per day. Each different manufacturing process uses its own basic principle or principles to make desired shape, accuracy of dimensions, surface smoothness, or a desired property within the material.

The major design components consisted of three rollers supported on spring loaded bearing blocks mounted on a frame (Figure 4.1).

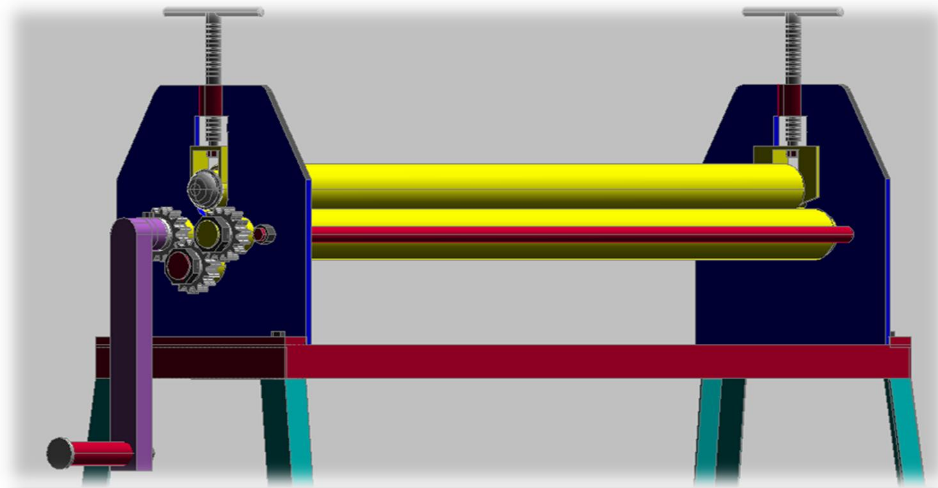


Figure 4.1 Schematic drawing of the machine

The rollers were arranged in triangular form; two sets of rollers below and one above. The upper roller provide the bending force while the back base roller provides the required driving force and the front end roller bends the metal according to set radius of bend. Two base bearing blocks (made of bronze) mounted on the supports for the rollers while the floating roller is run in two bronze bearing and mounted on supporter (Figure4.2).

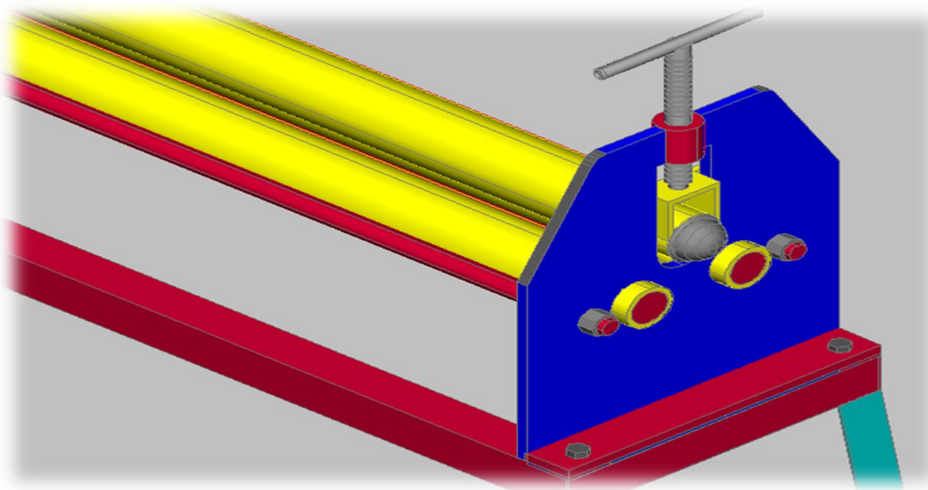


Figure 4.2 Bushing block assembly

The clamping beam is to simplify positioning and radius adjustment on the sheet. It is also fully adjustable by means of two threaded knobs, which results in very accurate bends. The free end of the top bearing block is spring loaded to increase or to reduce top-base roller clearance. The top roller provides the bearing load (bending force) and also compliments the driving roller when working on thick materials. The lower back roller provides the necessary driving forces while the floating roller does the bending and material delivery. There is crank lever on the end of driving roller used to drive the gear and roller shaft. The lever (handle) coupling head has a square configuration which fits in to the square end of the roller shaft. The frame structure is made of (40×40×3mm) angle iron for the purposes of strength. The height of the entire machine when mounted on the frame is 1300 mm. This height is convenient for operators of an average height of 1680mm. A tool table is provided below the rollers for safekeeping of tools and cranks. The roller head assembly is detachable from the frame and can be mounted on a table to be used as a table top machine for tinkering works.

4.2. Equipment Design

Following basic shearing operation on a sheet metal, components can be rolled to give it a definite shape. Bending of parts depends upon material properties at the location of the bend. To achieve bending, the work material must be subjected to two major forces; frictional force which causes a no-slip action when metal and roller came in contact and a bending force acting against the forward speed and the torque applied to move the material (Figure4.3)

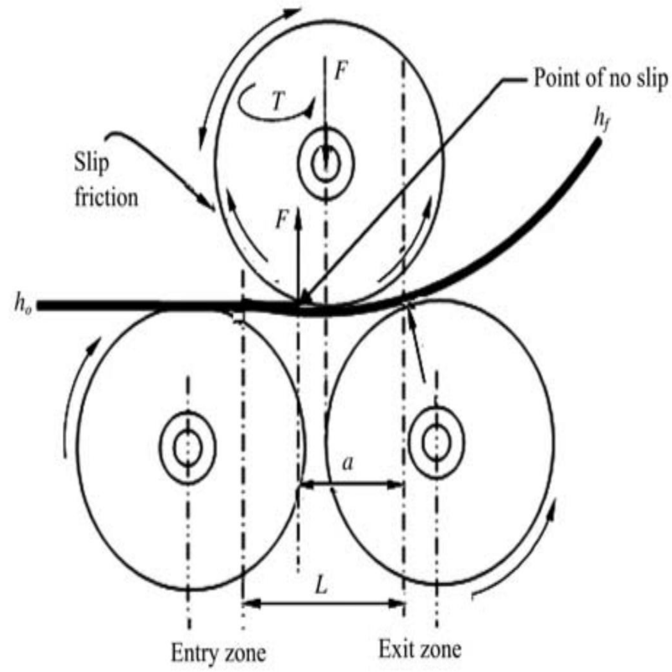


Figure 4.3 Shape rolling mechanism [3]

Where: - a = distance from exit zone to the no-slip point (assume a = L/2)

F = force applied to rollers

T = torque applied to rollers

L = roll gap

r = radius of rollers

μ = frictional force 0.4 Nm-1

ho= thickness of the sheet before time t

hf= thickness of the sheet after time t.

At least two rollers were involved in flat rolling depending on the thickness and properties of material while three or multiple roller system is required in shape rolling. A work material under bending load is subjected to some form of residual stress and deformation as it bends. Materials at the outer bend radius undergo tensile plastic deformation while the material at the inner bend radius undergoes compressive plastic deformation. The width along the bend radius will reduce in length based on Poisson's ratio and if the bend radius is too small, the plastic deformation at the outside of the bend results in fracture.

The limit to which such material can be bent is evaluated by the following Equation (1) [13].

$$\boldsymbol{Lb} = \theta(r + \kappa T) \quad \text{--} \quad (4.1)$$

Where: -Lb= bend allowance

θ= bend angle

r= bend radius to neutral axis

k= constant for material, for $r<2T$;$k=0.33$; for $r>2T$, $k=0.5$

T=thickness of material.

4.3. Selection of Material

Proper selection of material though the list of materials will always be governed by material properties and manufacturing issues.

The selected material should meet:

- Availability of the materials
- Service requirements
- Fabrication or manufacturing requirements, and
- Economic requirements.

Availability of the materials:-The selection of a proper material should basically consider locally existing material that can satisfy the characteristics and requirements to fulfill the purpose as soon as possible and the designer will use to manufacture the required products.

Service requirements:- For the component to give successful service, it must have suitable mechanical properties like strength, hardness, impact strength, rigidity, specific gravity etc. It must have suitable corrosion, fatigue and creep resistance. All these factors narrow the choice of a suitable material. Pure metals normally cannot fulfill all these requirements. Alloys offer a much greater choice and their properties could be altered by changing their composition or by suitable heat treatment.

Manufacturing requirements: - A component has definite shape and size. The material selected should be capable of being cast or worked to the required shape and size. If the tolerances or surface finish demand that the material may be finish machined, it should be possible to do so., weld ability of material is a major requirement. The material selected should meet all the requirements of manufacturing.

Economic requirements: Finally, the component has to pass the criterion of cost. The raw material and the manufacturing cost should not be prohibitive; otherwise there will be no demand for the component or that item. The above are some considerations which govern the selection of material for a specific job. Material selection process will always be governed by material properties and manufacturing issues. However, the material selection process for a new product development differs slightly from the process for materials substitution in an existing design. The procedure for selection is establishing the link between materials and functions. A design demands a certain profile of attributes which include density, strength, cost, resistance to corrosion, etc. Selecting the right material for the machine which fulfills the functional requirement for the specific part is very important. To identify these materials, there are some steps to be followed.

The steps are:-

A) Setting the functional requirements for the part under consideration. These are used to set rating factor.

B) Ranking the rating factors (properties) then determine the weight factors.

Total number of decision/N/=n (n-1)/2 Where n number of rating factors/properties/.

C) Writing the most suitable candidate materials and enlist properties from standard data table /the data quantitative or qualitative/.

D) Normalizing the outcomes of the parts.

E) Value the outcomes and overall satisfaction of parts. The overall satisfaction is ranked, and the rank shows the result on the basis of the allocated weight factors which gives the best overall satisfaction for the functional requirements of the part.

4.4. Material selection for the roller

Material for roller shaft should have good fatigue strength, high stiffness, low cost and in some applications, good wear resistance. Steel materials meet the strength, stiffness, and cost criteria. If case hardening or through hardening alloys are utilized, such steel materials can meet the wear resistance criterion as well.

Roller materials: -Total number of decision, N=n(n-1)/2, Where rating factor, n = 5

N = **10**

Table 4.1. Weighting factors for the shaft

Properties	Number of Decision										Weight factor
	1	2	3	4	5	6	7	8	9	10	
Tensile strength(MN/m^2)	1	1	0	0							0.2
Yield strength(MN/m^2)			1	1	0	0					0.2
Brinell hardness					1	1	0	0			0.2
Density (g/cm^3)	0						1		0	0	0.1
Cost (birr/m)		0						1	1	1	0.3

Table 4.2.Candidate materials for roller

Material	Tensile strength (MN/m^2)	Yield strength (MN/m^2)	Brinell hardness	Density (g/cm^3)	Cost (birr/m)
Carbon steel SAE 1025 annealed	462	234	120	7.81	133
Carbon steel SAE 1045 water quenched	742	518	248	7.81	156
Nickel alloy steel oil quenched	712	511	262	7.75	192

Table 4.3 Decision matrix for the roller

Material	Tensile strength (MN/m^2)	Yield strength (MN/m^2)	Brinell hardness	Density (g/cm^3)	Cost (birr/m)
Carbon steel SAE 1025 annealed	462	234	120	7.81	133
Carbon steel SAE 1045water quenched	742	518	248	7.81	156
Nickel alloy steel oil quenched	712	511	262	7.75	192

Table 4.4.Normalized outcome for the roller

Material	Tensile strength (MN/m^2)	Yield strength (MN/m^2)	Brinell hardness	Density (g/cm^3)	Cost (birr/m)
Carbon steel SAE 1025 annealed	62.3	45.2	46	100	100
Carbon steel SAE 1045 water quenched	100	100	95	100	85.3
Nickel alloy steel oil quenched	96	99	100	99	69.3

Table 4.5.Values of outcome and overall satisfaction

Material	Tensile strength (MN/m^2) (x0.2)	Yield strength (MN/m^2) (x0.2)	Brinell hardness (x0.2)	Density (g/cm^3) (x0.1)	Cost (birr/m) (x0.3)	Overall satisfaction
Carbon steel SAE 1025 annealed	12.46	9.04	9.2	10	30	70.7
Carbon steel SAE 1045waterquenched	20	20	19	10	25.6	94.6
Nickelalloy steel oilquenched	19.2	19.8	20	9.9	20.8	89.7

The result shows that on the basis of allocating weight factor, carbon steel (SAE 1045water quenched) gives the highest overall satisfaction among those materials. Therefore, this material is preferable for the production of the shaft.

4.5. Design analysis of the roller shaft

The selected materials for the shaft is SAE 1045 that is water quenched for calculation, we have taken factor of safety 5.

- Yield strength of SAE 1045 = 518 Mpa

  Allowable yield stress (without key) =518/5Mpa = 103.6 N/mm^2

  Allowable Tensile yield stress (with key) = 0.7x 103.6 N/mm^2= 78 N/mm^2

- Tensile strength of SAE 1045 = 742 Mpa

  Allowable yield stress (without key) =742/5Mpa = 148 N/mm^2

  Allowable Tensile yield stress (with key) = 0.7x 148N/mm^2= 111.3 N/mm^2

The maximum force exerted by human being to rotate the crank is from 150N-400N force take average 250 N [17].

The standard arm length for single person =200mm,n= 15rpm

T = FxS (l) = 250x200mm=50,000Nmm

$T = \frac{px60}{2\prod N}$ $= P = \frac{2\pi NxT}{60}$

$= \frac{2x3.14x50,000Nmm}{60}$

P= 5233.3 Nm

5233x10^{3}N.mm= $\frac{\pi}{16}x\tau$d^3

= 5233x10^{3}N.mm

=$\frac{3.14x78}{16}$ N/mm^{2}xd^3

5233x10^{3}N.mm=15.3N/mm^2 d^3

d^3=$\frac{5233x103N.mm}{15.3N/mm2}$

d^3= 342026.14mm

d=$\sqrt[3]{342026.14mm}$

d= $\underline{\boldsymbol{69.9mm \approx 70mm}}$

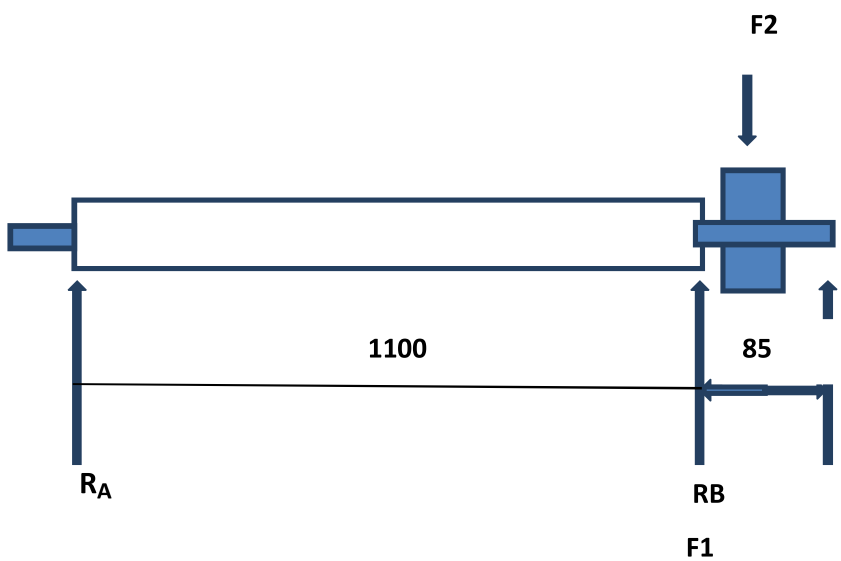


Figure 4.4. Free body diagram of shaft

Then we know, the normal force that act on the roller:

$$\frac{2T}{\mu d} = \frac{2x50{,}000Nmm}{0.5x70mm} F_N$$

$$= \frac{100{,}000}{35}$$

= **2857N**

Tangential force on the gear :

$$F_t = \frac{2xT}{D} \frac{2x50{,}000\ Nmm}{0.35}$$

$$= \mathbf{285714\ N}$$

The normal load acting on the tooth of the gear:

$$W = F_t/_{\cos}\alpha = \frac{285714\text{N}}{\cos(14.5°)} = \frac{285714\text{N}}{0.968}$$

$$= \mathbf{295159N, sin\alpha}$$

The gear is mounted at the end of the shaft, therefore the maximum bending moment at the center of the shaft

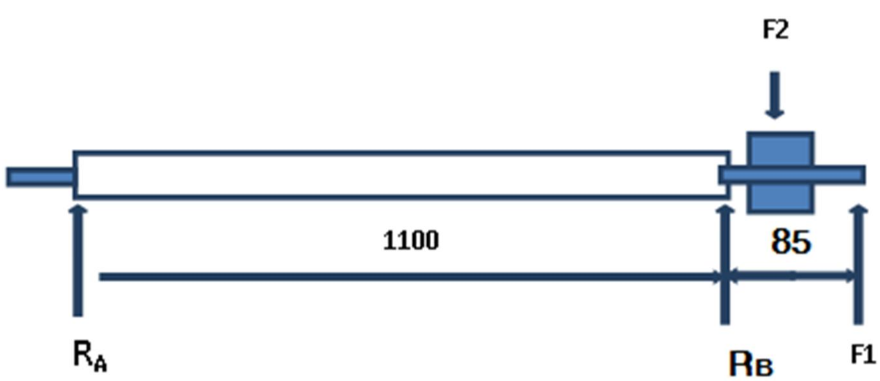


Figure 4.5 free body diagram of shaft

RA and **R_B** are the reaction force at each support respectively. From this to calculate te reaction force at **B**

By summation of moment at point **A**

$$\sum MA = 2857x550 - RBx85 + 250Nx1123$$

R_B=1571350-R_B+280750

R_B= 1852100N

From $\sum_{FX} = 0$ or $\sum_{Fy} = 0$

R_A +R_B - 2857+250N-1852100

$R_{A=}$ 1848993N

Then by finding the maximum moment at each force:-

$$MF_2 = 2857x550 = 1571380$$

$$MF_1 = 250x85=21250$$

Then we select maximum moment:

$$\sigma_b = \frac{MF2}{\tau/c} = \tau/_c = \frac{\pi}{32}d^3$$

$$\sigma_b = \frac{MF2x32}{\pi d3}$$

$$d^3 = \frac{MF2x32}{\sigma b\pi}$$

$$d^3 = \frac{1571380x32}{185.5x3.14}$$

$$d = \sqrt[3]{86337.9}$$

d = 44mm

$$M = \frac{W.L}{4} = \frac{295159x1.223}{4}$$

$$= \mathbf{90245\ N.m}$$

Let d is diameter of the shaft

We know that equivalent of twisting moment:-

$$T_e = \sqrt{M^2+T^2} = \sqrt{90245^2+ 50,0002}$$

$$= \sqrt{8144160025} + 250000000$$

$= \sqrt{103171 \times 10^3}$

$= \mathbf{103171000\ N.mm}$

Equivalent twisting moment

(T_e): $103171000 = \frac{\pi\tau}{16} d^3$

$103171000 = \frac{\pi x 742 x}{16} d^3$

$\frac{103171000}{146} = \frac{146}{146} d^3$

$d^3 = \sqrt[3]{7066.\mathbf{5}}$

$\mathbf{d=41mm} \approx \mathbf{45\ mm}$

Then take the larger value

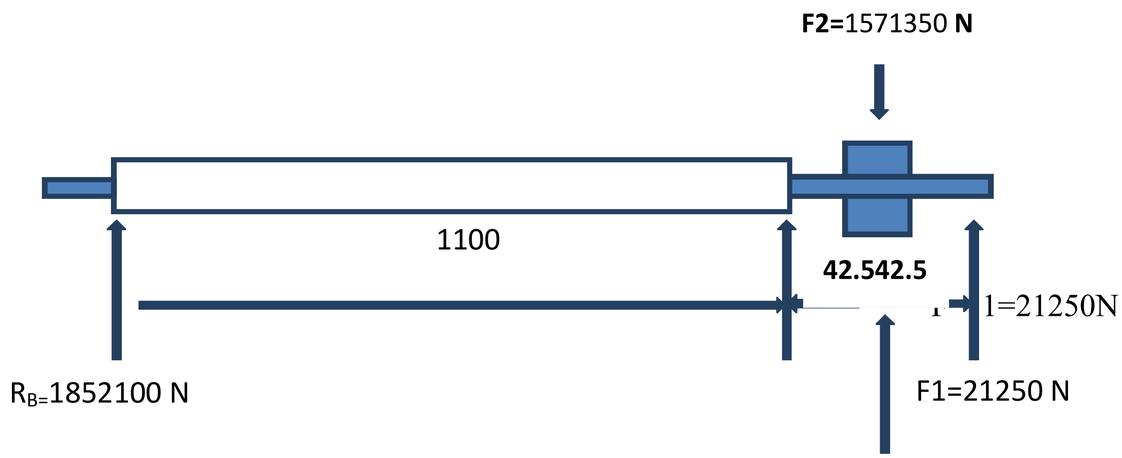


Figure 4.6 free body diagram of shaft

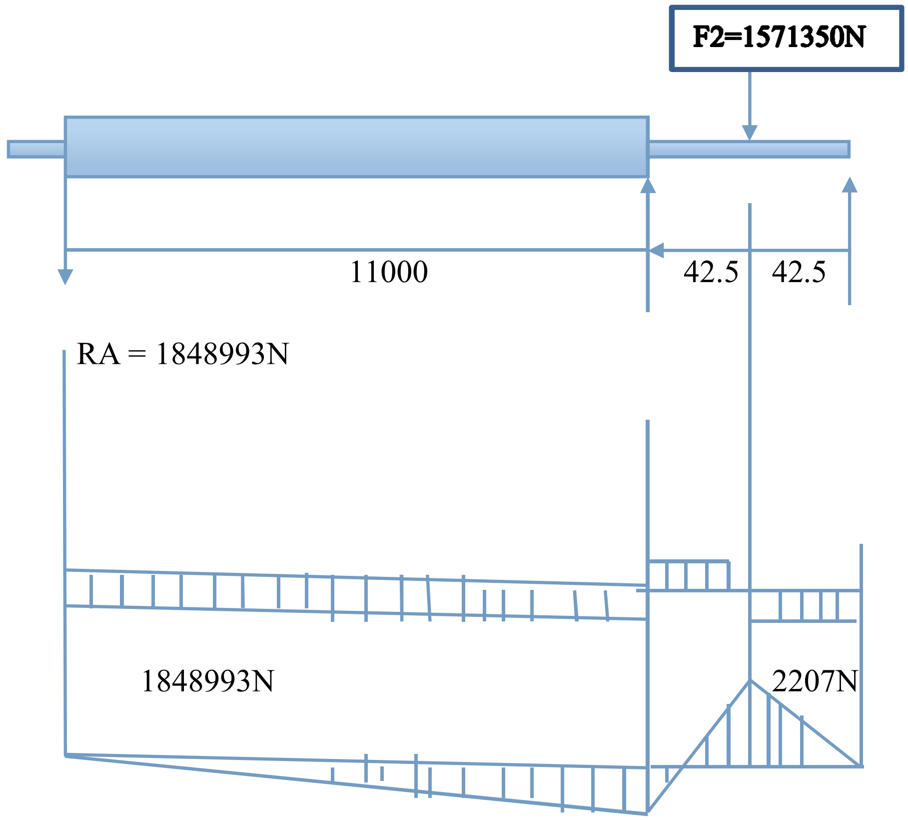


Figure 4.7 Bending moment and shear force diagram

4.6. Material selection of Spur Gear

Material for gear production should possess high strength, fatigue resistance, high stiffness and wear resistance.

This thesis work basically focuses on the development of intermediate technology of sheet metal rolling machines for sustainable motivated small and micro enterprise manufacturers. It presents the design, construction and testing functionality of a sheet metal rolling machine for small and micro enterprises. The machine consists of three rollers; a rigid forming roller, a free floating roller and a drive roller arranged triangularly with its handle for shape-rolling. The rollers were made of steel 1200 mm long, 65 mm diameter. The rolling machines have the following parts crank, bearing, rollers, spur gear, and stand. The efficiency are improved by varying some dimensions and parameters for the purpose of rolling sheet metal.

The sources of data for the study are questionnaires, unstructured interviews, survey of previous relevant works, consultation and personal observation at the case small and micro enterprise and TVET College. By analyzing these data, the paper can easily identify what the major problems and their causes to the existing sheet metal rolling machines.

For parametric specification of 3-point sheet metal rolling machine, it is necessary to use the best roller aperture for different material, analyze the stress induced in rollers, sheet metal and gear teeth tangential and radial force. It also requires the gear train mechanism with the human power to drive roller, to transfer torque to overcome the vertical load acting during operation, and speed reduction for ease bending & rolling process.

During manufacturing different processes like sawing, shearing, turning, facing, grinding, welding and finishing are implemented for different parts according to the working principles. It is also necessary to design the machine using Computer aided design (Auto CAD) and part drawing is provided for the purpose of manufacturing process. During designing we consider Posture and external loads such as hand force have a dominant effect on ergonomic analysis outcomes.

The various cost components are involved in manufacturing a product manufacturing manager has to identify those factors that can help to minimize them, while maintaining quality This project uses many materials such as plate, angle bar, round bar, sheet metal and others. Overall, this work involves many processes, starting from the design concept to assembling and finishing procedures.

Gears of the same pitch and numbers of teeth can be paired. Spur gears in a 3-gear drive system (Gear #1, Gear #2 and Gear #3) will rotate in. Gears in mesh are capable of transmitting force and motion alternately from one gear to another [22].

Spur Gears are the most common means of transmitting power in the modern mechanical engineering world. They vary from tiny size used in the watches to the large gears used in marine speed reducers; bridge lifting mechanism and railroad turn table drivers. They form vital elements of main and ancillary mechanism in many machines such as automobiles, tractors, metal cutting machine tools, rolling mills, hoisting and transmitting machinery and marine engines etc.

4.6.1. Advantages

- Gear is one kind of mechanical parts. It can be widely used in industries. A gear is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part in order to transmit torque.

- Spur gear is the simplest type of gear which consists of a cylinder or disk. Its form is not straight-sided, thus, the edge of each tooth is straight and aligned parallel to the axis of rotation. .

- As the most common type, spur gears are often used because they are the simplest to design and manufacture. Besides, they are the most efficient. When compared to helical gears, they are more efficient. The efficiency of a gear is the power output of its shaft divided by the input power of its shaft multiplied by 100. Because helical gears have sliding contact between their teeth, they produce axial thrust, which in turn produces more heat. This causes a loss of power, which means efficiency is lost.

- In addition to these, they also have many other advantages. Spur gears have a much simpler construction than helical gears because their teeth are straight rather than angular. Therefore, it is much easier to design and produce them. And they will not fail or break easily. And this makes them cheaper to purchase and to maintain which then leads to less cost. `

- Simplicity because their teeth are straight rather than angular, spur gears has a much simpler construction than helical gears. As such, they are easier to produce, and they tend not to break or fail as easily. This also makes them easier to find.

Efficiency

Spur gears are more efficient than helical gears. The efficiency of a gear is the power output of its shaft divided by the input power of its shaft multiplied by 100. Because helical gears have sliding contact between their teeth, they produce axial thrust, which in turn produces more heat. This causes a loss of power, which means efficiency is lost.

Cost

Because spur gears are simpler, they are easier to design and manufacture, and they are less likely to break. This makes them cheaper to purchase and to maintain.

4.6.2. Disadvantages

` Although they are common and efficient, spur gears have disadvantages as well.

- Firstly, they are very noisy when used at some speeds because the entire face engages at once. Therefore, they're also known as slow-speed gears.
- Secondly, they can only be used to transfer power between parallel shafts. They cannot transfer power between non-parallel shafts.
- Thirdly, when compared with other types of gears, they are not as strong as them. They cannot handle as much of a load because the teeth are small and situated parallel to the gear axis, rather than being large and situated diagonally as the teeth on a helical gear are.

According to the above, we can conclude that spur gears have many advantages as well as some disadvantages. Although sometimes, its Disadvantages may affect them a lot, their advantages still outweigh their Disadvantages. That is to say, spur gears are still popular among many Industries. And they can have good performances to meet people requirements.

4.6.3. Surface Deterioration

Wear is a general term to cover the sliding of metal against metal, or abrasion by lapping or scratching.

Normal Wear

Normal Wear: is the loss of metal from the surface of a gear tooth which results from unavoidable abrasion at such a rate, and to such a degree, which will not prevent the gear from performing satisfactorily during its expected life.

Overload Wear

Overload Wear: is a form of wear experienced under conditions of heavy load and low speed in both hardened and unhardened gears. Metal seems to be removed progressively in thin layers or flakes, leaving surfaces that appear somewhat as if etched.

Ridging: is a particular form of scratching that may occur on case-hardened surfaces of hypoid pinions under heavy load. It would appear as closely spaced grooves and ridges in the direction of surface sliding.

Surface Fatigue: is the formation of cavities in the surface of the teeth, usually quite small at first, and at separated areas of high compressive stress. It often results from surface irregularities.

Surface Fatigue: is a more advanced degree of welding which shows deep scratches and adhesion, and leads to rapid deterioration.

Peening: is a form of plastic yielding caused by localized impacts or by uneven heavy or shock loads.

Plastic Yielding: is a deformation of tooth surfaces resulting from heavy loads and characterized by fins on the tip edges (or ends) of the teeth (not to be confused with shaving fins), and by an occasional ridge and matching groove on the mate at the pitch lines. It is usually associated with ductile materials but occurs with hardened steel as well

4.6.4. Lubrication in gear

To avoid premature failure from one of the surface failure. Such as adhesive or abrasive wear. Controlling temperature at the mesh interface is important in reducing scuffing and scoring of the teeth. Lubricants remove heat as well as separate the metal surfaces to reduce friction and wear. Sufficient lubricant must be provided to transfer the heat of friction to the environment without allowing excessive local temperatures in the mesh. The usual and preferred approach is to provide an oil bath by housing the gears in an oil-tight box, called a gearbox. Gear rotation will carry the lubricant to the meshes and keep the un submerged gears oiled. The oil must be kept clean and free of contaminants and should be changed periodically. A much less desirable arrangement, sometimes used for situations in which a gearbox is not practical, is to periodically apply grease lubricant to the gears when they are stopped for servicing. Grease is merely petroleum oil suspended in a soap emulsion. This topical, grease lubrication does little for heat removal and is recommended only for low-velocity, lightly loaded gears.

Light oils (10-30W) are sometimes used for gears with velocities high enough and/or loads low enough to promote elastic hydrodynamic lubrication (see components, extreme pressure (EP) lubricants are often used. These are typically 80-90W gear oils with fatty-acid type additives that provide some protection against scuffing under boundary-lubricated conditions.

Total number of decision, N=n (n-1)/2, Where rating factor, n = 5   N = 10

Table 4.6 Weighting factors for the gear

Properties	Number of Decision										Weight factor
	1	2	3	4	5	6	7	8	9	10	
Ultimate strength (Mpa	1	1	0	0							0.2
Yield strength(MN/m^2)			1	1	0	0					0.2
Modulus of elasticity (Gpa)					1	1	0	0			0.2
Density (g/cm^3)	0						1		0	0	0.1
Cost (birr/m)		0						1	1	1	0.3

Table 4.7 Candidate materials for spur gear

No	Material	Ultimate strength (Mpa)	Yield strength (Mpa)	Modulus of elasticity (Gpa)	Density (g/cm^3)	Cost (birr/m)
1	Structural steel ASTM A572	590	330	207	7.81	124
2	Nickel alloy steel oil quenched	712	511	207	7.75	192
3	Carbon steel SAE 1080	965	524	207	7.81	168

Table 4.8 Decision matrix

No	Material	Ultimate strength (Mpa)	Yield strength (Mpa)	Modulus of elasticity (Gpa)	Density (g/cm^3)	Cost (birr/m
1	Structural steel ASTM A572	590	330	207	7.81	124
2	Nickel alloy steel oil quenched	712	511	207	7.75	192
3	Carbon steel SAE 1080	965	524	207	7.81	168

Table 4.9 Normalized outcomes for the spur gear

No	Material	Ultimate strength (Mpa)	Yield strength (Mpa)	Modulus of elasticity (Gpa)	Density (g/cm^3)	Cost (birr/m
1	Structural steel ASTM A572	61.13	62.97	100	99.23	100
2	Nickel alloy steel oil quenched	73.78	97.50	100	100	64.58
3	Carbon steel SAE 1080	100	100	100	99.23	73.81

Table 4.10 Values of outcome and overall satisfaction

No	Material	Ultimate strength (Mpa) X 0.2	Yield strength (Mpa) X 0.2	Modulus of elasticity (Gpa) X0.2	Density (g/cm^3) X0.1	Cost (birr/m) X0.3	Overall satisfaction
1	Structural steel ASTM A572	12.23	12.59	20	9.92	30	84.74
2	Nickel alloy steel oil quenched	14.76	19.50	20	10	19.37	83.63
3	Carbon steel SAE 1080	20	20	20	9.92	22.14	92.06

The result shows that on the basis of allocating weight factor, carbon steel (SAE1080) gives the highest overall satisfaction among those materials. Therefore, this material is preferable for the production of the gear.

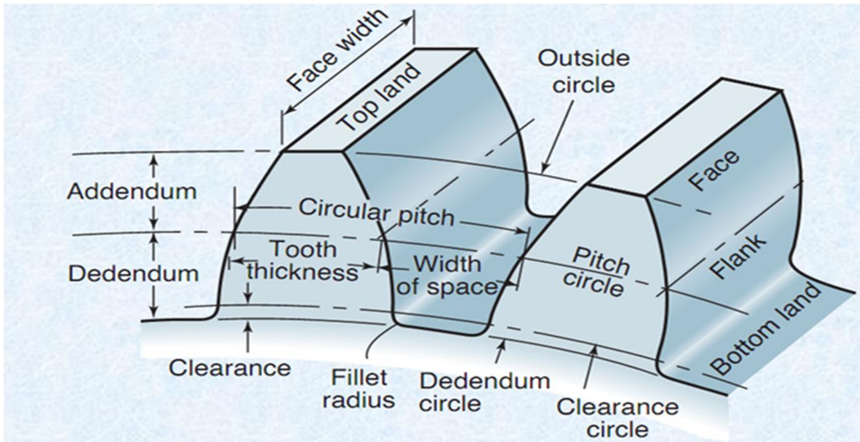


Figure 4.8 Term of spur gear

4.6.5. Design Analysis of Spur Gear

Design consideration of spur gear:-

1. The power to be transmitted.
2. The speed of the driving gear,
3. The speed of the driven gear or the velocity ratio, and
4. The center distance.

From the design analysis of shaft, the following parameters used to design the spur gear.

Gear ratio = 1:1 (because the pinion and gear are equal in diameter)

Radius of roller = 32.5mm with gap of 25mm to roll sheet metal.

The power transmitted by the pinion = FXL

= 250Nx200mm

= **50000Nmm**

Where: F = Force applied

= 250N,

L = the arm length

= 200mm

Revolution per minute, **N** **= 15rpm**

Since gear ratio in this design is $D_{pinion} = D_{Gear}$

From the table the selected standard module and number of teeth are 15.

Table 4.11 Metric module gear cutters

Milling cutter numbers	
Cutter no.(module)	No. teeth to be cut
1	12-13 teeth
2	14-16 teeth
3	17-20 teeth
4	21-25 teeth
5	26-34 teeth
6	35-54 teeth
7	55-134 teeth
8	135 to rack

M=2

Number of teeth ranges from 14-16 the selected number of teeth is15.

Pressure angle (Φ) = 141/2^{o} composite system

OD = PD(N+2)/N

70 = PD(15+2)/15

70 = PD(17)15

70 = PD(17)15=70x15=PD(17)=PD= 1050/17=61.7647

PD = 61mm

Standard proportions of the spur gear systems:

The module, m of the spur gear is calculated to be module 2. So, for 14.5^{o} composite gear:

Circular pitch = $\pi x M$ = CP=3.14X2=**6.28mm**

Addendum = Module =**2mm**

Dedendum = 1.25M =1.25X2=**2.5mm**

Tooth face = 14XM =14x2=**28mm**

Whole depth = 2.157M or 2.25M=2.15X=**4.3mm**

Tooth thickness = 1.5708M= 1.5708x2=**3.14mm**

Minimum clearance = 0.25M = 0.25 x 2mm **= 0.5mm**

Fillet radius at the root = 0.4M = 0.4 x 2mm =**0.8mm**

Center to center distance = $PD1 + PD2/2$=61+61/2=**61mm**

We know that

T = FxL = 250Nx200mm = **50000Nmm = 50Nm**

Torque, T = $\frac{PX60}{2\pi NP}$=50Nm, N=15rpm

Power=P=TX2x3.14xN/60=50Nmx2x3.14x15/60 = **78.5Nm**

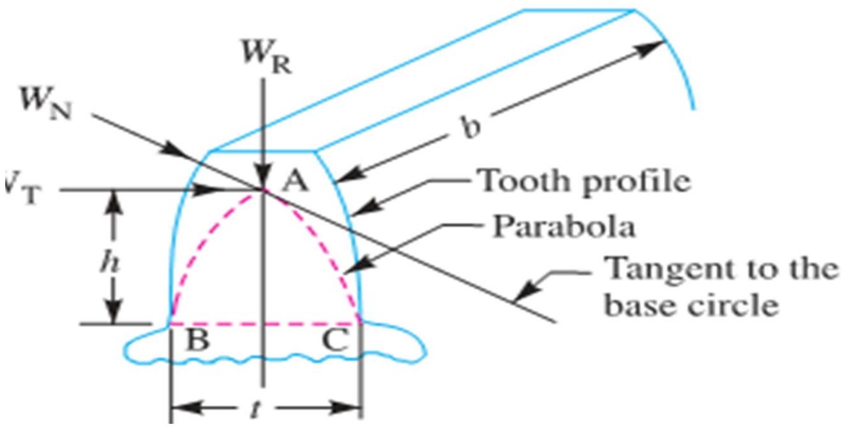


Figure 4.9 Tooth of gear

Therefore, tangential load, $W_{T} = T/DP/2$

=50Nm61/2

= 50000Nmm/30.5mm

=**1639.3N**

And the normal load, W_N on the tooth, $W_N = \frac{WT}{COS\phi}$

= 1639.3N/COS14.5^0

= 1639.3/0.9681

=**1693.3N**

To find **b**, width of tooth face;

Pitch line velocity, v = 3.14xDPx15/60

= 3.14x0.061/60

=**0.0478m/s**

Since the pitch velocity (v) is less than 12.5m/s, therefore velocity factor, C_v is

C_V =3/3+v

= 3/3+0.0478m/s

= 0.98m/s

Since allowable static stress of carbon steel (SEA 1080)

= 524N/mm^2

= 524N/mm^2/Safety factor

= 524N/mm^2 /3

=**175N/mm^2**

The permissible working stress, **σ_w = σ_oxC_v**

= 175N/mm^2 x 0.98

= **171N/mm^2**

Tooth form factor (Lewis factor,) y = 0.124 –0.684/T

= 0.124 – 0.684/15.

=**0.0784**

We know that tangential load, W_T = $\sigma_w$xb x p_cx y = $\sigma_{w.}$xbxπM

From this width of pinion**,** = 1639.3N/171x1.515x2x3.14x2

B = **0.5038**

Therefore, width of tooth face, b = 1.515 x 2

= 3.03

We know that the dynamic load (W_D) on the tooth is tangential load (W_T) plus incremental load

(W_I)W_D = W_T + W_I

W_D = W_{T+} W_I

Where: - v- pitch line velocity

b- Face width of gear

c- Deformation factor.

WD = 1639.3 +21x0.0478x3.03+1639.3/21x0.0478+√3.03+1639.3

= 45.6N

The static tooth load, W_S on the spur gear is

$$W_S = \sigma_e .b.p_c .y = \sigma_e .b.\pi.m.y,$$

Where: σ_e – elastic limit,

b- Face width,

m- Module and

Y-tooth factor

For steel, σ_e= 1.75 x BHN(Mpa)

= 1.75 x 524Mpa

= **917Mpa**

Therefore, W_S = 917N/mm^2 x0.5038mm x π x 2 x 0.0784

= **227.46Mpa**

Maximum limit wear must be greater than static load [17].

4.7. Design of Key

A key is used to prevent relative motion between shafts and member to whom it is connected. To accommodate the key, a groove called key way is cut both on shaft and hub. A square sunk key is selected. After assembly half of the key is in the shaft and the other half is in the hub, Key has been standardized and is generally proportioned to the shaft diameter. The key has taper 1 in 100 on top sides only [1].

Yield strength of SAE 1045 =518Mpa

Allowable yield stress (without keyway) = 518Mpa/5 = **103.6N/mm^2**

Allowable yield stress (with keyway) = 0.75x103.6N/mm^2 = **78N/mm^2**

Tensile strength of SAE1045 = **742Mpa**

Allowable tensile stress (without keyway) = 742Mpa/5 = **148.4N/mm^2**

Allowable tensile stress (with keyway)= 148.4Mpax0.75= **111.3N/mm^2**

L=length of key = 1.5d to 3d

= 1.5x35

= **52mm**

W = t = d/4

= 30/4 =**8mm**

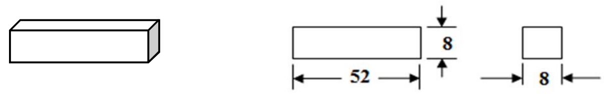


Figure 4.10 key

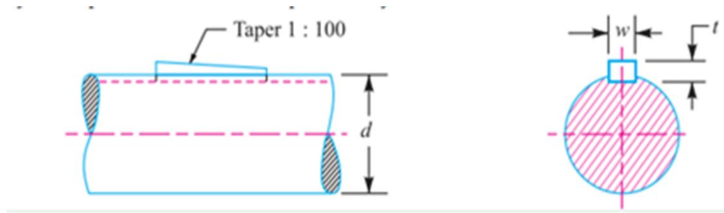


Figure 4.11 key way on shaft

- The torque transmitted by the key from the shaft is

$T = \frac{PX60}{2\pi N}$

T = 250N X 200mm

= 50000Nmm

= 50Nm

N = Rpm = 15

= 50000w x 60/ 2 x 3.14

= **477707watt**

Let w = width of keyway Considering the key in shearing, the torque transmitted (T)

T = l x w xƮ x d/2

=50000Nmm

= 45mm xwx8 x 30/2

W = 10

Ʈ = 42Mp_a,

δb = 84MP_a

Since δ_b = 2Ʈ, therefore a square key of w = 10mm and a depth (t) = 8mm is adopted

The shaft strength factor, e =1- 0.2[w/d] - 1.1[h/d]

h = t/2, 15/2=8

= 1- 0.2[10/30] – 1.1[8/30]

= 0.64

Where: - e = shaft strength factor

h = height of key way on the shaft

d = diameter of the shaft

- Strength of the shaft with key way = $\pi/16 \times \tau \times d^3 \times e$

  $= \pi/16 \times 42 \times 30^3 \times 0.64$

  = **142430.4N**

- Shear strength of the key = $l \times w \times \tau \times d/2$

  = 45 x10 x 42 x 30/2

  = 283500N

Shear strength of the key is greater than shear strength of the shaft therefore the key is safe against shear [18].

4.8. Bearing Materials and Selection Criteria

4.8.1. Bearing Materials

The ideal journal bearing material would have the following characteristics:

1. High compressive strength to withstand the applied radial loading
2. High fatigue strength to endure any cyclic changes in load direction and/or load intensity
3. Compatibility with the journal material to minimize surface scoring and bearing seizure whenever the journal and bearing surfaces come into contact (e.g., during startup)
4. Embed ability to permit foreign particles in the lubricant to penetrate the bearing surface to avoid scoring and wear
5. Conformability of surface to tolerate journal misalignment, deflection, or manufacturing inaccuracies
6. High corrosion resistance to withstand chemical attack by the lubricant
7. High thermal conductivity to permit generated heat to be transported from the lubricant film
8. Appropriate coefficient of thermal expansion to avoid differences in thermal expansion of the journal and bearing
9. Low wear to prevent surface destruction, especially under boundary lubrication conditions (i.e. thin-film high-friction lubrication), and thereby lengthen the life of the bearing.

Besides all these, the material should be inexpensive, highly available, and easily machined.
To be sure, no single material has been developed that satisfactorily combines all characteristics of the ideal bearing material. In fact, some of the characteristics are contradictory. For example, soft bearing materials generally do not have sufficient strength. To strengthen soft bearing materials, they are frequently bonded to stronger backing materials. Bearing linings or overlays may be cast, electrodeposited, sprayed, or chemically applied, and they have thicknesses which range from0.01 to 0.5 inch (in).

Journal bearing materials may be broadly divided into two groups: metallic and nonmetallic. The metallic group includes aluminum alloys, Babbitt's (tin-, lead-, and aluminum-based), copper alloys (brass and bronze), zinc, and iron. The nonmetallic group includes plastics, carbon graphite's, cemented carbides, and other proprietary materials. The nonmetallic has been widely used in self-lubrication applications because they can provide low friction and wear without the aid of a lubricant.

4.8.2. Analysis of bearing material requirements

The compressive strength of the bearing material at the operation in the present case must be sufficient to support the load acting on the bearing; f the machining is not strong enough it could suffer considerable plastic deformation by extension fatigue strength also becomes important under condition or fluctuating load. Both compressive and fatigue strength are known to increase as the thickness or the bearing material decrease. Conformability of the bearing material allows it to change its shape to compensate for slight deflections, misnaming and in accuracies in the bearing. Bearing materials with lower young's modulus will undergo more desirable.

- Wear resistance of the bearing material is an important parameter in cases where the position of the bearing is to keep within narrow to clearness.
- Thermal conductivity becomes an important factor in selecting bearing materials under condition of high speed or high loads where heat is generated at high load and friction and the ability of the bearing material to conduct heat away, wearing from friction surfaces reduce to operating.

Corrosion resistance of the bearing material becomes an important parameter when the lubricate oil is likely to contain acidic products or to be contaminated by corrosive material contain expensive element the cost may become a deciding factor is selection hardness. Determination of weight factor is given in the table.

Six properties are to be evaluated, hence the total number of decision is found as follows:-

Total decision = N (N - 1)/2

Where N = No of properties

= 6 (6 - 1) / 2

= **15**

Table 4.12 Application of Digital methods for bushing.

Property	Decision number															Positive decision	Weight factor
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Yield strength	1	1	1	1	0											4	0.266
Fatigue strength						1	1	1	1							4	0.266
Corrosion resistance										1	1	1				1	0.066
Wear resistance													1			1	0.066
Thermal conductivity														1		1	0.066
Young's module												0	1	1	1	4	0.266

Table 4.13 Properties of candidate materials for bushing

Material	Yield strength	Fatigue strength	Corrosion resistance	Wear resistance	Thermal conductivity	Young's module
Copper base alloy SEA grade 4(copper lead)	40	45	3	5	41.8	71
Copper base alloyASTM22(Bronze grade A)	168	120	2	5	41.8	100
White metals ASTM 23 (lead base)grade6	26.6	22	4	3	23.8	30.9

Table 4.14 Normalized out comes for the bushing.

Material	Yield strength	Fatigue strength	Corrosion resistance	Wear resistance	Thermal conductivity	Young's module
Copper base alloy SEA grade 4(copper lead)	23.8	37.5	75	100	100	29.98
Copper base alloyASTM22(Bronze grade A)	100	100	50	10	100	26.8
White metals ASTM 23 (lead base)grade6	15.9	18.3	100	60	56.9	8.22

Table 4.15 Value out comes and overall satisfaction.

Material	Normalized Yield strengthx0.266	Normalized Fatigue strengthx0.266	Normalized Corrosion resistancex0.266	Normalized Wear resistancex0.266	Normalized Thermal conductivity x0.266	Normalized Young's modulex0.266
Copper base alloy SEA grade 4(copper lead)	6.33	9.975	4.95	6.6	6.6	20.98
Copper base alloy ASTM22 (Bronze grade(A)	26.6	26.	3.3	3.3	6.6	26.8
White metals ASTM 23 (lead base)grade6	4.2	4.86	6.6	3.96	3.755	8.22

Overall satisfaction

Copper base alloy SAE grade 48(copper lead) =55.435

Copper base alloy ASTM 22 (lead base0 grade A = 92.4

White metals ASTM 23 (lead base) grade 6 = 31.595

The result shows that on the basis of the allocated weighting factors, Copper base alloy ASTM 22 (Bronze) Grade A-gives the highest overall satisfaction among those given candidate materials:-

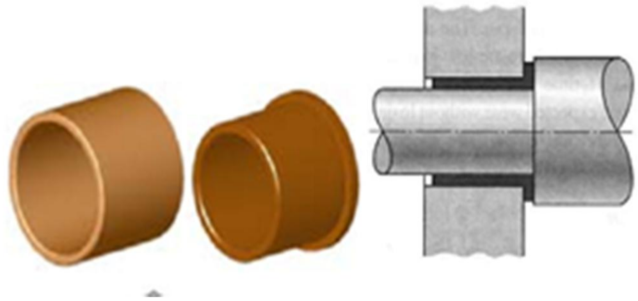


Figure 4.12 Copper lead bronze flanged bush

4.9. Design analysis of screws, bolts and nuts.

Temporary Fasteners which are bolts and nuts or a screw joints are widely used when the machine parts are required to be readily connected or disconnected without damage , when some parts of the machine requires maintenance or when some parts are required adjustments . Bolts and nuts or adjusting screws are standard machine elements and their sizes have to be designed based on the loads applied on them, i.e., tensile, shear, wear, or fatigue etc. The materials of bolts and nuts have to be tough, stiff and strong, wear resistant and corrosion resistance.
For the adjustment of the top free floating of roller up and down as needed to roll different thickness of sheet metal with different bending angle an adjusting screw are essentially necessary and has to be designed to resist loads applied to them..

4.9.1. Design of adjusting screw on the supporter of a roller

The load on the roller is 230Nand this load cause's shear effect on the adjusting screw. The standard bolt material has shear stress of 518Mpa (heat treated medium carbon steel) with factor of safety 5.

Allowable shear stress, ζ_{allow}=, where:- f_s is factor of safety

= 103.6 Mpa

We know that, shearing load carried by the screw is Shearing load, P_S=

$$d = \sqrt{\frac{4P_s}{\pi \zeta_{allow}}} = \sqrt{\frac{4 \times 27600}{\pi \times 103.6}} = 18mm$$

which is M18 coarse teeth screw thread is required

4.9.2. Design of bolt to assemble the roller supporter to base

The load on the roller support 4600N, this load causes shearing effect on the bolt. Considering the standard bolt material has permissible shear stress of 518Mpa (medium carbon steel) with factor of safety (5).

$$\tau_{allow} = \frac{\tau_{max}}{fs} = \frac{518Mpa}{5} = 103.6 \text{ Mpa}$$

We know that, shearing load carried by the bolt is

$$P_S = \frac{\pi}{4} d^2 \tau allow$$

$$d = \sqrt{\frac{4 \times 4600}{\pi \times 103.6}}$$

$$\sqrt{\frac{4P_s}{\pi \tau_{allow}}}$$

d = 7.52= 8mm.

Which are M8 coarse teeth will be out sourced.

As a bolt assembling the roller support beam is subjected to the same shearing load, it has to be fastened by M8 coarse teeth standard bolt.

4.10. Design of Pin

Pins are examples of a large number of fastening of a general type that is finding increasingly popular application in machinery, especially, in light machinery parts. Geometrically, pins may be divided in to cylindrical (straight) and conical (taper pin).

Cylindrical pins are held in the hole by frictional resistance which is due to an interference fit.

This pin is also used as key and is considered to be most suitable for low power drives. Standard taper pins may be used as fasteners for light work by placing them tangent to the shaft or a diameter.

4.10.1. Material Selection for the pin

Functional Requirement for the pin

- The pin should be highly load resistant.
- The pin should be tough enough.

- It should be resistance to wear.
- Light in weight.

4.10.2. Material Requirements for the pin

- Highly wear resistant.
- Having sufficient high strength.
- Has high fatigue strength.
- High toughness.
- Light in weight

4.11. Design of handle and crank lever

4.11.1. Crank lever for hand operated

It is commonly used hand levers for hoisting winches. This lever is rotated by a person continuously with max force of 200N to 400N. The length of the handle for one person (operator) can be 200mm. The lever is fitted to the screw with the help of crank pin. The length of lever is 200mm. The height from the ground to the end of the stand is from1m to 1.5m. In considering the average human being ergonomically we have taken 1.25m.The section of the lever is generally rectangular with the width of 30mm and the thickness 8mm.The handle of the lever is circular in cross section having diameter varying from 30-40mm [17].

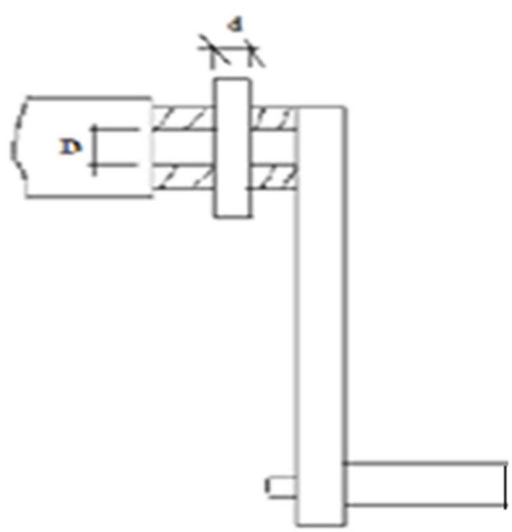


Figure.4.13 Free body diagram of crank

4.11.2. Moment at the lever arm

M = F*L, where F= average human force exerted L= length of lever arm

M = F*L = 250Nx200mm = **50000Nmm**

4.11.3. Design of crank pin

Consider the force acting on the pin (F_p)M = F_p*D

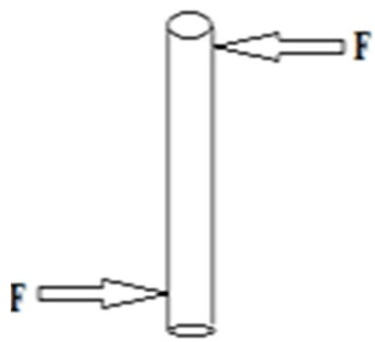


Figure 4.14 Free body diagram of pin

Where: F_p = Force on the pin

D = diameter of shaft

F_p = M/D

F_p=500000Nmm/30mm=**1666.66N**

F_p = 1666.66N this is the force that is to be exerted at the pin.

4.11.4. Calculation of shear stress on the pin

$\underline{F_p} A_p =$ 1666.6N

$$\tau = 4\pi \frac{d^2_p}{4} = 1966.6N$$

Using the maximum shear stress theory

$$\tau_{max} = \underline{\sigma_y} = \underline{0.5\sigma_y} \text{ where n = 4 is factor of safety}$$

$$\tau_{max} = \frac{0.5*530N/mm^2}{4}$$

$$\tau_{max} = 66.25N/mm^2$$

$\underline{F_p}A_p = 2360N/pd^2/4$

$$66.25N/mm^2 * \frac{\pi d^2 p}{4} = 1966.6N$$

$d_p^2 = \underline{2400N}$

$52N/mm^2$

$d_p = \sqrt{46.15}$

$d_p = 6.79mm$

$\mathbf{d_p=7mm}$

Therefore, a 7mm diameter pin is required to connect the crank lever with the shaft.

4.11.5. Force at the handle

The handle for one operator length can be kept 150mmto 200mm. We have taken150mm for our handle design [17].

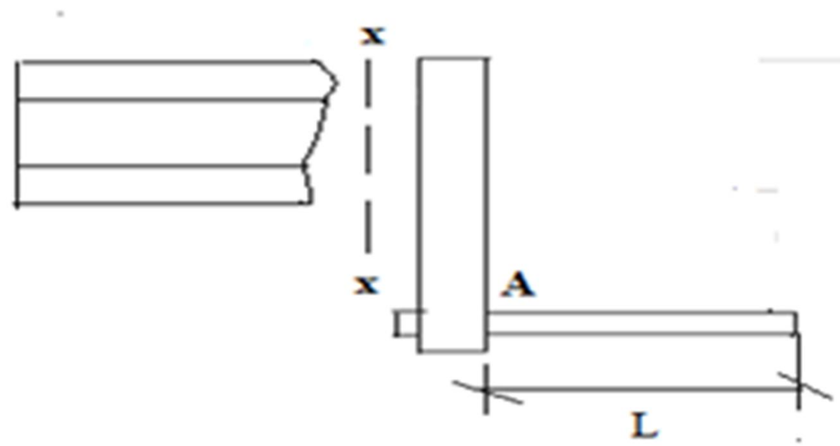


Figure 4.15 lever arm

For design, the effort (F) can be assumed to be acting at length of 2/3L from **fig**. The shaft end at xx is subjected to combined action of twisting moment and bending moment. Human force that can be applied ranges from 200N-400N. For our crank design, we have taken the average human force 250N.

The rod section at A on figure 4.13 experiences bending moment.

$M = F(2/3)L$

$= 250Nx2/3\ (200mm)$

$\mathbf{M = 33333.33Nmm}$

Force equilibrium

£F_y = 0

Bending Moment

BM at A = 0

BM at B = 250Nx200mm

= **50000Nm**

= **50Nm**

4.12. Design of critical welded joints in the machine assembly

4.12.1. Welding and welded connections

Welding is the process of joining two pieces of metal by creating a strong metallurgical bond between them by heating or pressure or both. It is distinguished from other forms of mechanical connections, such as riveting or bolting, which are formed by friction or mechanical interlocking. It is one of the oldest and reliable methods of joining. Generally welded joints are as strong as or stronger than the base metal, thereby placing no restriction on the joints. Stress concentration effect is also considerably less in a welded connection.

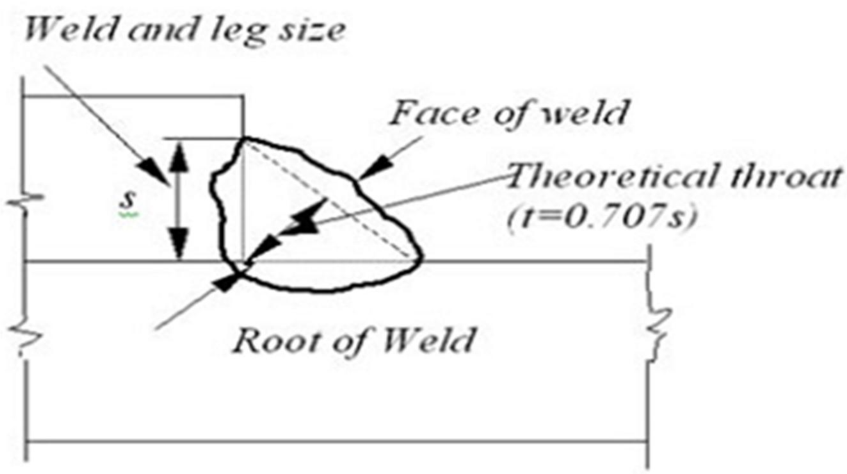


Figure 4.16 Typical fillet welds

For field welds, the permissible stresses in shear and tension calculated using a partial factor γmw of 1.5. (Cl.10.5.7.2)

4.12.2. Design of fillet welds

$$fa\ or\ q = \frac{P}{t_{tl_w}}$$

Where: f_a =calculated normal stress due to axial force in N/mm^2

Q = shear stress in N/mm^2

P = force transmitted (axial force Nor the shear force Q)

t_t = effective throat thickness of weld in mm

l_w =effective length of weld in mm

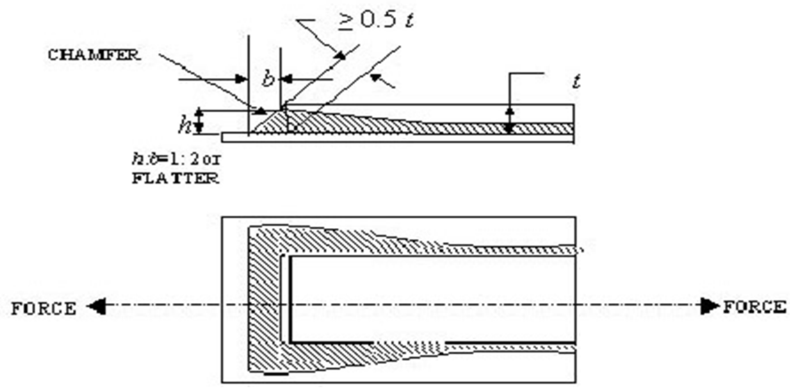


Figure 4.17 End fillet weld normal to direction of force

The design strength of a fillet weld, fwd, shall be based on its throat area (Cl.10.5.7).

$$f_{wd} = \frac{f_{wn}}{\gamma_{mw}}\ in\ which\ f_{wn} = f_u/\sqrt{3}$$

Where: f_u = smaller of the ultimate stress of the weld and the parent metal and

γ_{mw} = partial safety factor (=1.25 for shop welds and = 1.5 for field welds)

Table 4.16. Minimum size of first run or of a single run fillet weld

Thickness of thicker part (mm)	Minimum size
T≤10	3
10<t≤20	5
20<t≤32	6
32<t≤50	8 (first run) 10(minimum size of fillet)

For stress calculations, the effective throat thickness should be taken as K time's fillet size, where K is a constant. Values of K for different angles between tension fusions faces are given in Table 4.19(Cl.10.5.3.2). Fillet welds are normally used for connecting parts whose fusion faces form angles between 60°and 120°. The actual length is taken as the length having the effective length plus twice the weld size. Minimum effective length should not be less than four times the weld size.

Table4.17. Value of K for different angles between fusion faces

Angle between fusion face	60^0-90^0	91^0-100^0	101^0-106^0	107^0-113^0	114^0-120^0
Constant K	0.7	0.65	0.6	0.55	0.50

Table 4.18.Stresses for welded joints

Types of weld	Bare electrode		Coated electrode	
Filet welds(all types)	Steady load(Mpa)	Fatigue load(Mpa)	Steady load(Mpa)	Fatigue load(Mpa)
Butt welds	80	21	98	35
Compression	90	35	110	55
Shear	100	35	125	55
Filet welds(all types)	55	21	70	35

F - (When the F is parallel to area shear force)

$$F = 2(0.7t)\,l$$

Permissible shear stress, $= 35N/mm^2/1.5$

$$\mathbf{=23Nmm^2}$$

$$= 250/1.4(L*3)$$

$$L \;= \mathbf{250N}$$

$$= 35 \times 3 \times 1.4$$

$$\mathbf{= 147\ mm}$$

In order to allow for starting and stopping of the bead, 12.5mm should be added to the length of each weld, therefore

L = 3mm + 12.5mm =15.5mm (for starting and stopping of weld run) [17].

4.14. Performance evaluation

Performance evaluation of the fabricated machine was carried out in the Department of Mechanical and Vehicle Engineering workshop of Adama Science and Technology University School of Mechanical, Chemical and Material Engineering. The capacity of the machine was evaluated based on the maximum width of strips of metal that can be rolled without exceeding the designed maximum bearing load and the numbers of operators required to conveniently operate the machine without overbearing efforts. Maximum length capacity of the machine is determined by the width of material that can conveniently be passed through the aperture without difficulty. The roller aperture is determined by the maximum size opening between the three rollers when aligned axially. The percentage acceptance is determined from the analysis or respondents acceptability of the adapted technology.

4.15. Ergonomics Consideration

Ergonomics is the science of studying people at work and then designing tasks, jobs information, tools, equipment, facilitates and the working environment so people can be safe and healthy, effective, productive and comfortable. It is sometimes called human factor engineering which is the practice of designing products so that user can perform required use operation service and supportive tasks with and minimum of stress and maximum of efficiency. To accomplish this the designer must understand and acknowledge the needs, characteristics, capabilities and limitation of intended user and design "from the human out" In other words the designer should make the design "fit for user" rather than trying to make the user to fit for design [19]. Posture and external loads such as hand force have a dominant effect on ergonomic analysis outcomes. Yet current digital human modeling tools used for proactive ergonomic analysis lack validated models for predicting posture for standing hand -force exertions. To address this need the effect of hand magnitude and direction or whole-body posture for standing static hand force exertion tasks were quantified in a motion capture study, which was to identify posture behaviors that might be incorporated in to a posture prediction algorithm for standing hand force tasks. Analysis of one handed exertions indicates that, when possible, people tend to align their bodies with the direction of force applied.

The process of identifying risk factors and quantifying the level of exposure will require intensive work but will provide tremendous benefits in terms of finding solutions that address the root cause of the problem. When quantifying the level of exposure for these primary risk factors such as musculoskeletal injury (MSI) is an injury or disorder of the muscles, tendons, ligaments, joints, nerves, blood vessels or related soft issue arising from exposure to risk factors such as awkward postures, repetitive motions and forceful exertions. So we will need to consider measuring peak force, sustained force, weight of object, cumulative weight handled various joints angles, duration of exposure, frequency, working height, workstation dimensions affecting body position, productivity, etc. Observation from the literature regarding posture selection and postural changes during force full exertions suggests a strong relationship between hand force and posture [20]. Furthermore, previous researches on force exertion postures have mainly focused on two handled tasks [21]. Several researches have examined postural changes in response to hand forces, and have proposed explanations regarding the observed trends.

Open versus closed torso orientation

The following figure presents example of one -hand force exertion posture characterized by open, closed and neutral torso orientations. All three torso strategies were observed during push and pull exertions.

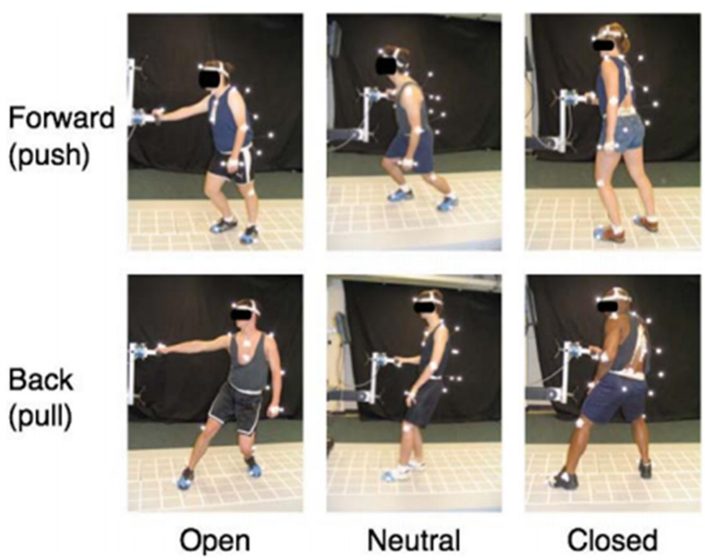


Figure4.18 open neutral and closed torso strategies used across one hand elbow- height) height forward (push) / back (pull) exertions

Prevalence of open, closed and neutral strategies across forward and back exertion was quantified and the force is different at different orientation and it varies from 125N to 150N that mostly designers used to analyze the torque, moment etc. during machine design. Other factors that can affect the magnitude of force during rotating the crank of the roller machine are the torso rotation angle and friction at the shoe floor interface that is the ground reaction forces determine the effects of foot traction on push/pull posture.

When pulling at elbow height an increase in torso rotation angle was observed with increasing pull horizontal force. This is consistent with the hypothesis that people are opening up (i.e. rotating towards the left) to reduce the low-back rotational moment. Based on this idea the design of the roller machine crank is mounted at elbow height on a standing position on average height of man/woman to operate smoothly or without risk.

CHAPTER FIVE: MANUFACTURING PROCESS AND ASSEMBLY OF THE MACHINE

5.1. Manufacturing process

Manufacturing is derived from the Latin word 'manufactures' means made by hand. In modern context it involves making products from raw material by using various processes, by making use of hand tools, machinery or even computers. Manufacturing is the backbone of any industrialized nation. Manufacturing and technical staff in industry must know the various manufacturing processes, materials being processed, tools and equipment's for manufacturing different components or products with optimal process plan using proper precautions and specified safety rules to avoid accidents. It is therefore a study of the processes required to make parts and to assemble them in machines. Manufacturing process is that part of the production process which is directly concerned with the change of form or dimensions of the part being produced. So, in the manufacturing process of the main parts of sheet metal rolling machine is described.

5.2. Types of manufacturing techniques implemented

Production of the obtained design includes understanding and preparation of the design material. Some important procedures and processes that may be used for the manufacture of the product or the project are included as recommendations beside a material specification to ease preparation. These procedures are supported by workshop drawings to ease the processes.

5.2. 1.Cutting process

Cutting operation is required in most of the production that incorporate sheet metal processing and may include use of simple hand tools while further shaping of components like pulleys, shafts and keys is done through machining. The raw material has to be cut to size. This is done with a variety of tools;

Sawing: Metals and many other materials, in addition to wood are often sawed with power-operated sawing machines. Sawing machines may be grouped in to three classifications as follows: power hack saws, circular sawing machines and band sawing machines. Sawing is governed by the same cutting conditions which apply to the other machining processes. The sawing processes is used because it has advantages, including doing the job faster, saving material, and using less power. Also, a minimum of material is lost as chips.

Shearing: It is an operation that is used to cut sheet metals in to the required dimensions. The machine used for this purpose is called shearing machine. There are different types of shearing machines based on the thickness of the blade. Proper utilization of the machine based on the thickness of the blade is important for its durability.

5.2.2. Machining process

It is an occupation or hobby or a class of material-working processes that involves using a power-driven machine tool, such as a lathe, milling machine or drill, to shape metal. Machining is a part of the manufacture of almost all metal products.

Turning: It is a lathe operation in which an external cylindrical surface is produced. The cutting tool is first adjusted for the desired depth of cut, using the cross slide. Then as the work piece rotates, the cutting tool is advanced relatively slowly in a direction parallel to the rotational axis of the spindle.

Facing: It is a lathe operation which generates an internal cylindrical surface with a single-point tool. It can be described as internal turning, if the work piece is rotated as in a lathe. As in turning, depth of cut is adjusted with the cross slide and the feed is obtained with the carriage movement.

Drilling: It is one of the cutting operations using drill bits to produce rough holes. The machine tool involved in this case is a drill press. There are two cutting edges that produce chips similar to those produced in turning on a lathe and a certain web region that extrudes the metal at the center of the hole which is not removed by the cutting edges. Both lips (cutting edges) of a drill operate with variable rake angle, inclination angle, and clearance angle along the cutting edge. The flutes of a drill play the important role of conveying the chips out of the hole and the helix angle of the drill is important in this connection.

5.2.3. Welding process

Welding may be defined as the metallurgical joining together of two metal pieces to produce essentially a single piece of the metal. It produces what is known as a" permanent fastening". Welding is a fabrication method in which portions of metal plate, various rolled sections, castings and other metal pieces are joined to produce desired shapes. Its products are known as "weldments". Welding is also useful as a method of repairing broken, worn or defective metal parts. The types of welding used in these manufacturing processes are lap-joint, T-joint, corner joint, edge joint.

5.2.4. Fabrication process

Fabrication, when used as an industrial term, applies to the building of machines and structures by cutting, shaping and assembling components made from materials. Metal fabrication is a value added process that involves the construction of machines and structures from various raw materials. A fabrication shop will bid on a job, usually based on the engineering drawings, and if awarded the contract will build the product.

5.3. Steps for manufacturing of different parts

5.3.1. Manufacturing process for supports

Material------------St37 plate

Blank size---------300x260x20 mm

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

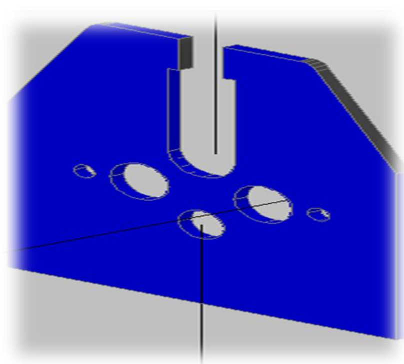


Figure 5.1 Supports

Table 5.1 operation sheet for support

No	Operations	Measurement	Tools and equipment	Machinery used	Time in min
1	Measure &lay out	L=302mmx270 mmx20mm	Steel rule, scriber, try square	Oxyacetylene (oxidizing flame)	20
2	cutting edge with the required shape for accurate surface	L=300mmx268 mmx20mm	Steel rule, scriber, try square	Portable grinding machine	160
3	Prepare plate to drill holes used to insert the bush	L=300mmx268 mmx20mm	steel rule, center punch, Drill bit End mill &V. Caliper	Drilling machine	40
4	Rough drilling operation of the hole three	With Ø 45mm	steel rule, Drill bit End mill &V. Caliper	Drilling machine	240
5	Finishing and smoothing of the holes	With Ø 45mm	steel rule, Drill bit End mill &V. Caliper	Drilling machine	160
6	Weld the plate with its side	L=30mm,x20m mx10mm	Electrode 2.5mm	Shield metal Arc welding	60
7	Drill the plate	L=30mm,x20m mx10mm	Center drill, drill bit & V. caliper	Drilling machine	90
8	Finishing the support	L=33mmx30mm x20mm	Portable grinder and sand paper	Portable grinder and sand paper	50

5.3. 2. Procedure to produce adjusting screw

Material------------round bar

Blank size--------- for handle150mmx Ø12mm and for screw 164mmx Ø19mm

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

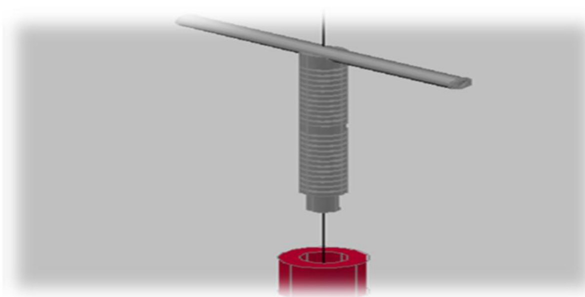


Figure5.2 Adjusting screw

Table 5.2 operation sheet for adjusting screw

No.	Operation	Measurements	Tools and equipment	Machinery used	time (minute)
1	Measure & layout	L=152xØ20mm	steel rule, tape rule, & try-square	portable grinder machine	20
2	Cut the parts to the required size	L=150xØ20mm	-steel rule, V. caliper &HSS cutter,	Lath machine	20
3	Turn the rods with specified diameter	200mmxØ20mm	-steel rule, V. Caliper& tape rule	Lath machine	80
4	Facing& Finishing operation for the screw	180mmxØ20mm	V. Caliper, & carbide cutter	Lath machine	30
5	Chamfer the ends	Ø20mmx45^0	V. Caliper, & carbide cutter	Lathe machine	30
6	Select M20x3mm cutting tool & make screw thread	180mmxØ20mm	Tap & die	Lath machine	70
7	Turn the end to make thread for the smaller diameter	30mmxØ12mm	Tap & die	Lath machine	45

5.3.3. Manufacturing process of the Driving roller shaft

Material------------round bar SAE 1045

Blank size---------1223mmx Ø65mm

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

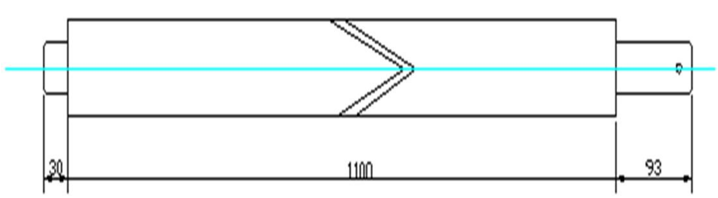


Figure 5.3 Driving Roller

Table 5.3 operation sheet for driving roller

No.	Operations	Measurement	Tools& equipment	Machinery	Time
1	Measuring , lay out& cut to size	L=1226mmxØ70	steel rule, tape rule, scriber, V. Caliper & try-square	Power Hacksaw	90
2	Facing on one side	L=1125xØ70 mm	Scriber. Caliper try-square& HSS cutter	Lathe machine	40
3	Facing on the other side	L=1124xØ70 mm	Scriber. Caliper try-square& HSS cutter	Lathe machine	40
4	Prepare for center	L=1123xØ70 mm	Caliper center drill & HSS cutter	Lathe machine	30
5	Turning	L=1123xØ67 mm	V. Caliper , & HSS cutter	Lathe machine	180
6	Perform finishing operation	L=1123xØ65 mm	V. Caliper ,& HSS cutter	Lathe machine	120
7	turn one end of the stepped shaft	L=85xØ35 mm	V. Caliper , & HSS cutter	Lathe machine	120
8	Finish other end of the stepped shaft	L=85xØ35 mm	V. Caliper ,& HSS cutter	Lathe machine	80
9	Chamfer both ends to the angle of $2x45^0$	L=85XØ35mm	HSS cutter	Lathe machine	20
10	Cut key ways on the stepped end of the shaft	L=85xØ35 mm	End mill	Milling machine	140

5.3.4. The procedures to produce the floating roller and back roller

Material------------round bar SEA 1045

Blank size---------1160mmx Ø65mm

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

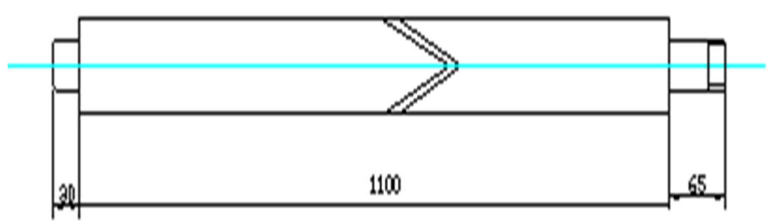


Fig 5.4 Floating & Back Roller

Table 5.4 operation sheet for flouting and back roller

	Operation	Measurement	Tools& equipment	Machinery	Time
1	Measure, lay out & cutting to Size	L=1163mmxØ70	steel rule, tape rule, , scriber, V. Caliper & try-square	Power Hacksaw	120
2	Facing on one side	L=1162xØ70 mm	Scriber V. Caliper try-square& HSS	Lathe machine	80
3	Facing on the other side	L=1161xØ70 mm	Scriber V. Caliper try-square& HSS	Lathe machine	80
4	Prepare for center	L=1160xØ70 mm	HSS cutter, V. caliper	Lathe machine	60
5	Turning	L=1160xØ67 mm	V. Caliper& HSS cutter	Lathe machine	300
6	Perform finishing operation	L=1160xØ65 mm	V. Caliper& HSS cutter	Lathe machine	120
7	turn one end of the stepped shaft	L=85xØ35 mm	V. Caliper& HSS cutter	Lathe machine	240
8	Finish other end of the stepped shaft	L=85xØ35 mm	V. Caliper& HSS cutter	Lathe machine	60
9	Chamfer the both ends to the angle of $2x45^0$		HSS cutter	Lathe machine	40
10	Cut key ways on the stepped end of back roller	L=85xØ35 mm	End mill	Milling machine	60

5.3.5. The procedures to produce the reinforcement rod

Material------------round bar

Blank size---------1200mmx Ø20mm

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

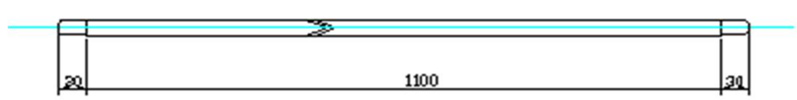


Fig 5.5 Reinforcement rod

Table 5.5 operation sheet for supporter rod

No.	Operation	Measurement	Tools& equipment	Machinery	Time
1	Measure, lay out & cutting to Size	L=1200mmx Ø20	steel rule, tape rule, scriber, V. Caliper & try-square	Power Hacksaw	20
2	Facing on one side	L=1119xØ20 mm	Scriber V. Caliper try-square& HSS	Lathe machine	20
3	Facing on the other side	L=1180xØ20 mm	Scriber V. Caliper try-square& HSS	Lathe machine	20
4	turn one end of the stepped shaft	L=1180xØ14 mm	HSS cutter, V. caliper	Lathe machine	40
5	Make a thread M14X1.5	L=20X Ø14 mm	Die, screw pitch gauge	Lathe machine	40
6	Perform finishing operation	L=1200xØ14 mm	V. Caliper& HSS cutter	Lathe machine	10

5.3.6. The procedures to produce the bushes

Material------------Copper base alloy ASTM 22 (Bronze) Grade A
Blank size---------30mmx **Ø**55mm

Quantity------------07

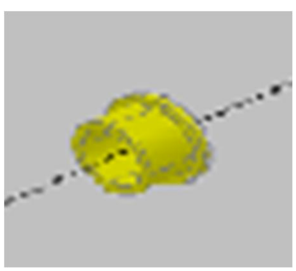


Figure 5.6 bushes

Table 5.6 operation sheet for bronze

No.	Operations	Measurement	Tools and equipment	Machinery	Time
1	Measure, lay out	L=30mmx Ø60mm	scriber, V. Caliper& cutting tool	Lathe machine	20
2	Rough drill	L=30mmx Ø10mm	Scriber V. Caliper, center drill & drill bit	Lathe machine	50
3	Enlarge the drilled hole	L=30xØ25 mm	Drill bit ,v caliper	Lathe machine	70
4	Make the required size of holes	L=30x35 mm	V. Caliper &boring tool	Lathe machine	160
5	Turning the head of bush	L= 30xØ5 5m m	V. Caliper& HSS cutter	Lathe machine	120
6	Turn the shoulder of the bush	L=30xØ55 mm	V. Caliper& HSS cutter	Lathe machine	120
7	Cut off the bush to its size	L=30xØ55 mm	Drill bit	Lathe machine	90

5.3.7. The procedures to produce the Gear

Material------------round bar SEA 1080

Blank size--------- Ø 70mmx37mm

Quantity------------03

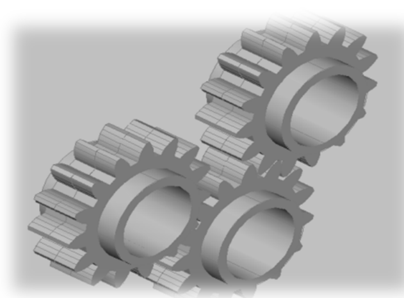


Figure 5.7 Spur gear

Table 5.7 operation sheet for spur gear

No.	Operations	Measurement	Tools and equipment	Machinery	Time
1	Measuring & cutting to Size	L=40mmxØ75	steel rule, scriber, V. Caliper	Power Hacksaw	40
2	Facing on one side	L=38mmxØ75	Scriber V. Caliper, center drill & HSS	Lathe machine	60
3	Facing on the other side	L=37xØ75 mm	Scriber, V .Caliper, try-square& HSS	Lathe machine	60
4	Rough turning	L=37xØ73 mm	V. Caliper& HSS cutter	Lathe machine	90
5	Turning	L= 37xØ71 m	V. Caliper& HSS cutter	Lathe machine	90
6	Perform fishing operation	L=37xØ70 mm	V. Caliper& HSS cutter	Lathe machine	90
7	Drilling	Ø10mm	Drill bit	Lathe machine	160
8	Enlarged drilled hole	L=37xØ25 m M	Drill bit and boring tool	Lathe machine	140
9	Finish drill	37xØ38 mm	reamer tool	Lathe machine	90
10	Making a key way	37mmx4mmx35 mm	Slotting attachment with end mill	Milling machine	90
11	Gear cutting	M = 2, Z = 15	Indexing head and Module cutter	Milling machine	240

5.3.8 Manufacturing process of the crank

The handle of the crank

Material-----------round bar

Blank size---------200mmx26mm

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

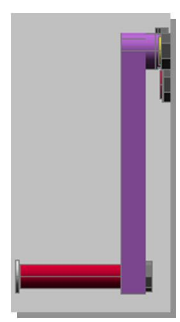


Figure 5.8 Crank

Table 5.8 operation sheet for crank

No.	Operation	Measure ment	Tools & equipment	Machine used	Time
1	Measure , layout and cut	L=152xØ 30mm	steel rule, , V. Caliper, scriber & try-square	Power Hacksaw/ Hacksaw	140
2	Make first drill for journal	L=36xØ1 0mm	Drill bit & V. Caliper,	Grinder/File &drill machine	180
3	Drill the journal	L=36xØ3 5mm	Drill bit &V. caliper	Drill machine	180
4	Cut the plate for the arm length of crank	L=200x4 0x5mm	Grinding disc	Grinding machine	90
5	Drill the plate to the required size	Ø14mm	Drill bit &punch	Drill machine	100
6	Cut the pipe according to the give dimension	L=150x Ø30mm	Hack saw		40

5.3.9. Manufacturing process of the pin

Material-----------round bar

Blank size---------42mmx Ø 6mm

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

Figure 5.9 Pin

Table 5.9 operation sheet for pin

No.	Operation	Measurement	Tools & equipment	Machine used	Time
1	Measure & layout	L=152xØ30mm	steel rule, , V. Caliper& scriber	Hacksaw	20
2	Cut the piece to size	L=42xØ6mm	V. Caliper, hack saw	Hacksaw	40
3	Chamfer the end of the pin	L=36xØ35mm	file	File	30

5.3.10. Manufacturing process of the key

Material-----------round bar SAE 1045

Blank size---------37mmx 8mmx8mm

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

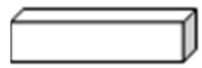


Figure 5.10 key

Table 5.10 operation sheet for key

No.	Operation	Measurement	Tools & equipment	Machine used	Time
1	Measure & layout	L=40x12mmx12mm	steel rule, , V. Caliper& scriber		30
2	Cut the piece to size	L=40x12mmx12mm	,V. Caliper, hack saw	Power hack saw	40
3	Cut all the faces to specified size	37mmx 8mmx8mm	Plain cutter	Milling machine	80
4	Chamfer the two ends	2mmx45^0	Flat file		20

5.3.11. Manufacturing process of a base or stand for the supporter

Material------------ angle iron

Blank size---------1261x260x2mm

Quantity------------12

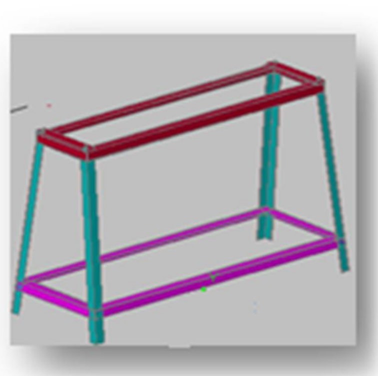


Figure 5.11Stand (base)

Table 5.11 operation sheet for stand (base)

No.	Part name	Operation	Measure ment	Tools &equipment	Machinery	Time
1	Main vertical frame	Measure, layout and cutting	800x40x 40mm	Scriber, tape rule, try square	hack saw	120
2	Main horizontal frame(front& back)	Measure, layout and cutting	1097x40 x40mm	Scriber, tape rule, try square	hack saw	140
3	Main horizontal frame(left &right side)	Measure, layout and cutting	1261x30 x40mm	Scriber, tape rule, try square& hack saw	hack saw	120
4	reinforcement	Measure, layout and cutting	1600xØ2 0mm	Scriber, tape rule, try square& hack saw	hack saw	90
5	Assemble or weld all the above parts	Cleaning &welding	1261x80 0x40mm	Face shield, chipping hammer, glove, try square&	Shield metal arc welding	60
6	Finishing by grinding spatters	Finishing & cleaning	1261x80 0x40mm	Wire brush	Grinding machine	60

5.4. Procedures of assembling components

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

1. Assembly of bush with roller support by press fit and mounting on the stand.

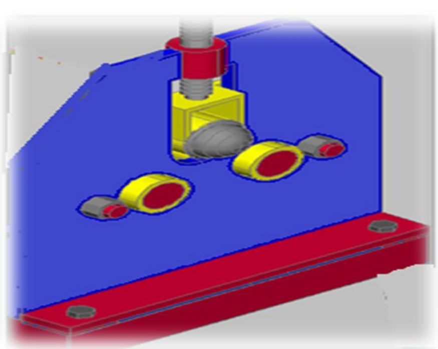


Figure 5.12 Bushing and plate

2. Insert the driving and back roller in the bush on supporter

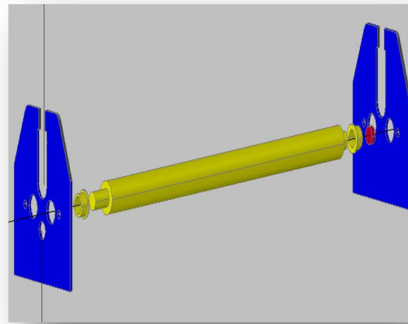


Figure 5.13 Driving and back roller

3. Insert the flouting bush in the supporter guide

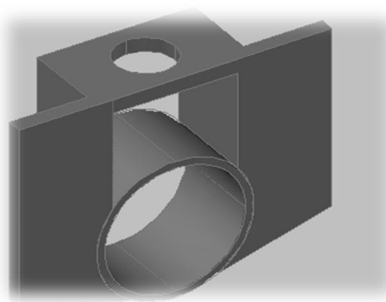


Figure 5.14 flouting bush holders

4. Insert the adjusting screw in flouting bushing

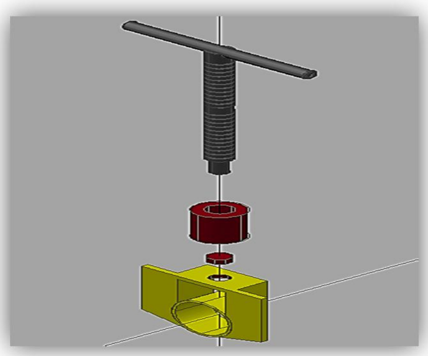


Figure 5.15 Adjusting screw in flouting bush

5.Insert the bush in the flouting supporter

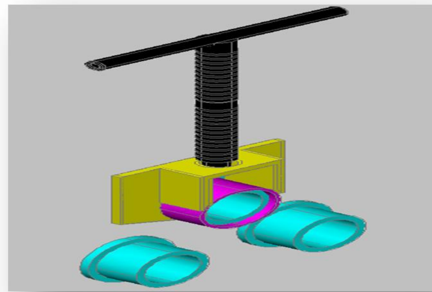


Figure 5.16 Assemblies of bush the flouting support

6. Insert the flouting roller in the bush

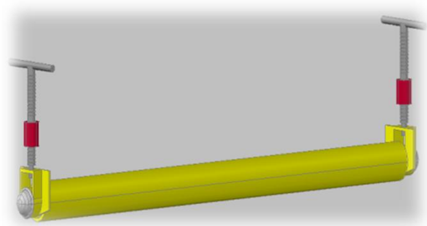


Figure 5.17 Assemble of flouting roller

7. Mount the reinforcement on the supporter tightly loose

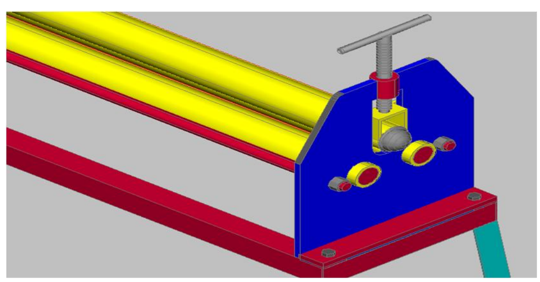


Figure5.18 Assembly reinforcement on the supporter tightly loose

8. Insert the crank handle in to the driving roller

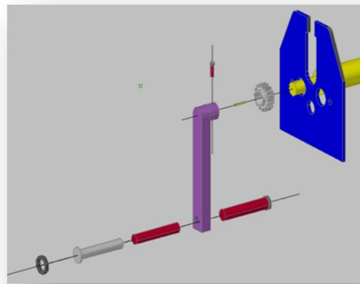
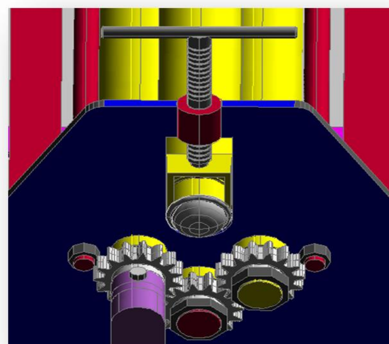


Figure5.19 Assembly of crank/handle

9. Assembly of spur gear



FigureFigure5.20 Assembly of gear on its position

10. Final assembly of the project and finishing, painting and testing of the project to be functional

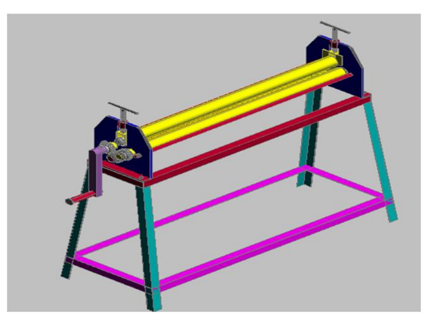


Figure5.21 final assembly of project

5.5. Fitness between parts (Allowance)

1. Allowance between shaft and bushing
2. Allowance between bushing and support
3. Allowance between shaft and gear
4. Allowance between crank and shaft
5. Allowance between pin and shaft

5.5.1. Allowance between shaft and bushing

The suitable selected fitness is between shaft and bushing is clearance fit with H_7/f_7 because the shaft will rotate in abusing easily.

From the table the basic size is mm diameter.

Clearance fit for shaft

$40\ {}^{H}{}_{7}/{}^{f}{}_{7}$

$40\ {}^{f}{}_{7} = 40^{-25}_{-50}$

Max of shaft = 40-0.25=**39.75mm**

Min of shaft = 40-0.5= **39.5mm**

Clearance fit for hole (bushing)

$40^{H}{}_{7} = 40_{0}^{+25}$

Max hole = 40+0.25= **40.25mm**

Min of hole = 40+ 0 = 40mm

Allowance between bushing and support

The selected fitness between bushing and support is transition fit with H_7/k_6 because the bronze bushing should have to insert by little force on the support.

The basic size of the bushing is

Transition fit for bushing

$50^{K}{}_{6} = 50_{+2}^{+21}$

Max bushing = 50+0.21= **50.21mm**

Min bushing = 50+0.2= **50.2mm**

$50^{H}{}_{7} = 50_{0}^{+30}$

Max hole of support = 50+0.30**= 50.3 mm**

Min hole of support = 50+0 = **50mm**

Allowance between shaft and Gear

The selected fitness needed is transition fit with H_7/K_6 because little force is required to mount the gear in to the shaft.

The basic size shaft is

Transition fit for shaft

$35^{H}{}_{7}{}^{/K}{}_{6}$

$35^{H}{}_{7} = 34\,{}_{0}^{+25}$

Max shaft = 35+0.25=**35.25mm**

Min shaft = 35+0 = **35 mm**

$35^{K}{}_{6} = 35\,{}_{+2}^{+18}$

Max hole of gear = 35+0.18= **35.18mm**

Min hole of gear = 35+0.2 = **35.2mm**

Allowance between crank and shaft

The selected fitness for crank and shaft is clearance fit with H_7/K_6because by hand accurate fixed assembly is needed. The basic size of shaft is Clearance fit for shaft

$35^{h}{}_{6} = 35\text{-}{}_{16}^{0}$

Max shaft = 35+ 0= **35mm**

Min shaft = 35 – 0.16= **34.84 mm**

Clearance for crank

$35^{H}{}_{7} = \mathbf{35\,{}_{0}^{+25}}$

Max crank hole = 35 + 0.25 = **35.25 mm**

Min crank hole = 35+ 0 = **35 mm**

5.5.2. Allowance between pin and shaft

The selected fitness between pin and shaft is interference fit with H_7/P_6 because the pin will be inserting to the shaft with great force.

The basic size of pin is Interference fit for pin

$6^{H}{}_{7}{}^{/P}{}_{6}$

Max pin $= 6_{+15}^{+24}$

Max pin = 6+0.25= 6.25mm

Min pin = 6+0.15= 6.15mm

Max hole $=6_{0}^{+15}$

Max hole = 6+0.15=6.15mm

Min hole = 6+0= 6 m

CHAPTERSIX: MAINTENANCE, COST ANALYSIS, TEST AND RESULT

Maintenance all actions appropriate for retaining an item/part/equipment in, or restoring it to, a given condition. Even though maintenance engineering and maintenance have the same end objective or goal (i.e., mission-ready equipment/item at minimum cost).

6.1. General consideration about maintenance

Machines are subject to deterioration due to their use and exposure to environmental conditions. Process of deterioration, if unchecked, culminates in rendering them unserviceable and brings them to a standstill. Therefore, it is necessary to attend to them from time to time, to repair and recondition them so as to elongate their life to the extent it is economically and physically possible to do so.

Inspection is an essential function of the maintenance program. There are both 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 gears, bushes, bearings, tolerances in the parts etc., during the period, when machine is under pre-planned shutdowns. 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 means wastage of machine time and labor productivity. Hence frequency should be decided on the basis of past experiences and scheduled program for inspection.

Mechanical components like gears, bearings, bushings and other friction surfaces etc. give good performance for long periods, when they are systematically lubricated. Systematic lubrication means the application of right type of lubricant at the right time, at right place and in right quantity. For lubrication, a lubrication schedule should be prepared and that should be followed strictly.

Routine maintenance, like cleaning or lubrication, is required to ensure the rollers, the chopper knives, and beating hammers operate properly. The first maintenance activities for every workshop are cleaning. Cleaning is a prime important activity in maintenance because cleaning removes the source of contaminations; flour dust, and dirty mixed with oil and grease. They can clog into machine parts and this accelerates wear and tear on the machine components and cause breakdowns.

For optimum performance from the machine follow the maintenance schedule.

Daily check

- Loose mounting bolts
- Any other un safe condition

Weekly maintenance

- Clean the machine
- Lubricate gear
- Lubricate bushing

6.2. Preventive maintenance activities of the sheet metal rolling machine

Table 6.1. Preventive maintenance activities

No.	Activities (detail of work)	Frequency	Estimated time	Comment
	Mechanical			
1	Transmission gear check up	2 weeks	1hrs	
2	Lubrication system checkup for bearings	1 weeks	1hrs	
3	Lubrication system checkup for bushings	3 days	30 minutes	
4	check up for loosened bolts and nuts	4days	1hrs	

Table 6.2. Trouble shooting Slip Roll Operation

Symptom	Possible cause	Possible solution
Slip roll create cones when trying to create cylinder	Roller are not parallel	Adjust rear roller adjustment knob as necessary to be sure the roller and top roller are parallel
A noticeable crease is formed in the work piece	Excessive pressure applied in one spot	Reduce the radius and perform the bend in several pass
Work piece is pitted	Work piece is dirty , roller is damage	Clean work piece, polish any nick in the rollers

6.3 The expecting problems in our machine

The main expected problems in the operations of Manual sheet metal machine and the elements that will require maintenance activities are: -

- Bolt and nuts are loosen or easily damaged or broken;
- Bushing parts can be easily worn-out;
- Most parts of the machine might be corroded easily;
- Improper alignment of shaft
- Damaging of Adjusting screw

6.4. Cost Components

Economics is one of the most important aspects of any manufacturing operation. In order for the product to be successfully marketed, its cost must be competitive, optimum cost with similar product in the market place.

Availability and cost of raw materials and manufactured components are major concerns in persistent manufacturing. If raw or processed materials or manufactured components are not available in the desired quantities ,shapes and dimensions ,substitutes and/or additional processing will be required, which can contribute significantly to product cost For example ,if we need a round bar of a certain diameter and it is not available in standard form, then we have to purchase a larger rod and reduce its diameter by some means ,such as machining, drawing through a die , or grinding.

The various cost components are involved in manufacturing a product, manufacturing manager has to identify those factors that can help to minimize them, while maintaining quality. These components are:-

- Raw materials cost.
- Operation processing cost.
- Consumable material and standard item cost.
- Overhead cost and
- Labor cost.
- Machine depreciation cost

6.5. Raw material cost

The material and cost refers to those raw materials which are used to produce each components of sheet metal rolling machine.

This analysis of cost estimation of the materials is carried on the basis of the data obtained from: - Local markets Purchase documents of the faculty and Experience of market expertise.

Table 6.3 List of raw materials

Item number	Types of materials	Specification	Required size	Remark
1	Black iron sheet	1000mmx2000mmx1.5mm	1000mmx1000mmx1.5mm	
2	Angle iron	40mmx6000mmx3mm	40mmx1200mmx3mm	
3	Round bar	Dia20mmx6000mm	Dia 20mmx1000mm	
4	Round bar	Dia50mmx6000mm	Dia 50mmx4000mm	
5	Mild steel plate	50mmx200mm	Dia100mmx200mm	
6	Mild steel tubes	Dia20mmx1.5mmx6000mm	Dia20mmx1.5mmx40mm	
7	Mild steel tubes	Dia30mmx2mmx6000mm	Dia30x2mmx150mm	
8	Copper lead Bronze	Dia50mmx1000mm	Dia50mmx200mm	

1. Mild steel black iron sheet.

Standard size Unit cost

2000mmx1000mmx1.5mm = 500Birr

Required size

1000mmx1000mmx1.5mm

$2000000mm^2$ = 500Birr

$$\frac{1000000}{2000000}\text{x}500 = \mathbf{250Birr}$$

2. Mild steel Angle iron.

Standard size Unit cost

40mmx3mmx6000mm = 400Birr

Required size

40mmx3mmx6000mmx2

2x400 = **800Birr**

3. Mild steel Round bar.

Standard size Unit cost

Dia20mmx6000mm = 1000Birr

Required size

Dia20mmx1000mm

120000mm^2 = 1000Birr

20000mm^2

$$\frac{20000}{120000}x100 = 165Birr$$

4. Mild steel Round bar.

Standard size Unit cost

Dia65mmx6000mm = 4000Birr

Required size

Dia65mmx4000mm

300000mm^2 = 4000Birr

200000mm^2

$$\frac{200000}{300000}\text{x}4000 = \mathbf{2666.6Bir}$$

5. Mild steel plate. Standard size Unit cost

20mmx200mmx6000mm = 3000Birr

Required size

20mmx200mmx600mm

1200000mm^2 = 3000Birr

120000mm^2

$$\frac{120000}{1200000}x3000 = \mathbf{3\ 00Birr}$$

6. Mild steel Tube.

Standard size Unit cost

Dia20mmx1.5mmx6000mm = 1000Birr

Required size

Dia20mmx1.5mmx20mm

6000mm = 1000Birr

20mm

$\frac{40}{6000}x1000 = \mathbf{6.60Birr}$

5. Mild steel Tube.

Standard size Unit cost

Dia20mmx20mmx6000mm = 1500Birr

Required size

Dia20mmx20mmx150mm

6000mm = 1500Birr

150mm

$\frac{150}{6000}x1500 = \mathbf{3\ 750Birr}$

7. Copper lead bronze.

Standard size Unit cost

Dia0mmx500mm = 3000Birr

Required size

Dia60mmx200mm

500mm = 3000Birr

200mm

$\frac{200}{500}x3000 = \mathbf{1200Birr}$

The Total Raw materials cost is = **5427.70 Birr**

6.6. Operation Processes cost

Many processes are used to produce parts and shapes, there is usually more than one method of manufacturing a part from a given material all methods have different process cost. However Selection of a particular manufacturing process depends not only on the shape to be produced but also on a large number of other factors. The type of material and its properties are basic considerations. The design and cost of tooling, the lead time required to begin production and the effect of work piece materials on tool and die life are major considerations.

Commonly the operational cost of handling makes the total change for loading and un loading.

Therefore

- Start and stop time 50 min.
- Loading and unloading100 min.
- Cleaning 50min.

Therefore the total operational time will be estimated As50 min + 100min + 50 min = 200 min

If Operation processing cost is 60Birr/ hour and the operational cost will be

60 x 200min/60 = 200 .00Birr

Every part of the roller machine operational cost can be Estimated or obtained Based on the above method and listed in the following table.

Table 6.4.total operational cost of each part of roller machine

Item No	Part name	Start and Stop Time in min - Cost in Birr	Loading and Unloading Time in min- Cost in Birr	Cleaning Time in min- Cost in Birr	Total Cost in Birr
1	Floating roller	100 - 100.00	400 - 400.00	30 - 30.00	530.00
2	Back roller	100 - 100.00	500 - 500.00	30 - 30.00	630.00
3	Driving roller	200 - 200.00	600 - 600.00	30 - 30.00	830.00
4	Roller supporter	300 - 300.00	700 - 700.00	50 - 50.00	1050.00
5	Roller adjusting screw	75 - 75.00	200 - 200.00	20 - 20.00	295.00
6	Spring guide	40 - 40.00	100 - 100.00	20 - 20.00	160.00
7	Bushes	100 - 100.00	500 - 500.00	30 - 30.00	630.00
8	Gears	400 - 400.00	700 - 700.00	50 - 50.00	1150.00
9	Key	50 - 50.00	100 - 100.00	20 - 20.00	170.00
10	Crank/ Handle	200 - 200.00	500 - 500.00	30 - 30.00	730.00
11	Mounting pin	30 - 30.00	50 - 50.00	10 - 10.00	90.00
12	Base	100 - 100.00	700 - 700.00	50 - 50.00	850.00
			subtotal of operational cost		**7115.00**

6.7. Consumable material and standard item cost

Materials that are consumed during manufacturing the products beside the raw materials for this sheet metal roller machine are:-

1. Hack-saw blade

    Standard type and size Unit /packet/cost

    Flex-Back 14/inch-Sweden = 30 Birr

    Required size

    Flex-Back 14/inch-Sweden x3 = **90Birr**

2. Electrode

    Standard size Unit /packet/cost

    E-1011 Dia2.5 = 200Birr

    Required size

    E-1011 Dia2.5 x 2 = **400Birr**

3. Grinder disc

    Standard size Unit cost

    Diameter 180mm = 50Birr

    Required size

    Diameter 180mm x 3pcs = **150Birr**

4. Cutter disc

    Standard size Unit cost

    Diameter 180mm = 50Birr

    Required size

    Diameter 180mm x 3pcs

    3 x 50 = **150Birr**

5. Nut

    Standard size Unit cost

    M30x2mmx20mm = 20Birr

    Required size

    M30x2mmx20mm x1= **20Birr**

6. Bolt and Nut

Standard size   Unit cost

M10x1.5mmx3mm = 20Birr

Required size

M10 x1.5mm x3mm x 4pcs

4 x 20 = **<u>80Birr</u>**

7. Thinner for paint

Standard size Unit cost

In liter =   60Birr

Required size

1liter = **<u>60Birr</u>**

8. Different color paints

Standard size   Unit cost

In liter = 85Birr

Required size

2 liter

2 x 85 = **<u>170Birr</u>**

9. Brush for paints

Standard size Unit cost

In inch 3/4" = 25Birr

Required size

2 pcs

2 x 25 = **<u>50Birr</u>**

10. Sand paper

Standard size   Unit cost

200mmx6000mm - No 120 = 100Birr

Required size

200mmx6000mm -No 120 = **<u>100Birr</u>**

The Total Consumable material and Standard item cost is = **<u>1270.00 Birr</u>**

6.8. Overhead cost

Overhead cost includes different expenses for the production processes it may be the cost for deprecation of the machine used, house rent, electric consumption, telephone, water, taxation and other costs. It is calculated easily by multiplying the percentage of the sum total raw material and consumable material cost. It depends of the standard or income of the country and varies from 15%to20% of the martial cost. So ones the raw material, consumable material and standard items cost are strictly calculated the sum total will be multiplied by the standard percentage.

The raw material cost is; = 5427.70

The consumable material and standard item cost = 1270.00

Sum total of material cost = **6697.7**

Therefore the overhead cost will be for example: 15% x 6697.7 = **1004.65**

6.9. Labor cost

Labor costs are generally divided into direct and indirect costs**.** The direct labor cost is for labor directly involved in manufacturing the part (productive labor).This cost includes all labor from the time; materials are first handled to the time the product is finished. This time is generally referred to as floor –to-floor time.

The direct labor cost is calculated by multiplying the labor rate (hourly wage, including benefits) by the time that the worker spends producing the part and wage of the market.

For example - If the sheet metal roller machine will require 120hours

If the workers wage is 150birr per day and If the working time /day is 8 hour then

$$\frac{120hrs}{8} = 15 days\ will\ be\ needed$$

Therefore the labor cost is = 15 days x150 Birr

= **2250.00 Birr**

6.10. Machine Depreciation Cost

Depreciation is defined as the reduction in value of the machine over time as it is work in g at a Specific task (Sessions, 1992). Depreciation occurs due to wear that gradually declines the capacity of the piece of equipment to perform its function. The objective of the depreciation86schedule is to recover the initial investment cost of equipment each year over its economic life (Miyata, 1980).Straight-line method assumes that the value of the equipment reduces at a constant rate for each year over its economic life. The straight-line method is the simplest way for estimating depreciation costs and may be most preferable method to calculate equipment cost per unit of time (Miyata, 1980). The mathematical formula for the yearly depreciation charge using the straight-line method is

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

Where: D = Depreciation charge

P = Initial purchase price (actual price)

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

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

Example: For our project the depreciation cost Drill machine is calculated as follows

And the same is done for other machines

Where:

D = Depreciation charge

P = 50,000 Birr

S = 30% of 50,000 = **15,000 Birr**

N = 10 years

$$D = 50000 - \frac{150000}{10} = \mathbf{3\ 500Birr/year}$$

In one year we have 12 months, and the depreciation cost for a month, 3500/12=291.6Birr/month since there are 4 weeks in a month, the depreciation cost for a Week = 291/4 **= 72.9 Birr /week.**

In a week we have 6 working days the depreciation cost/day = 72.9/6 = **12.15Birr/day.**

Further we have 8 working hours in a day so the

Depreciation cost per hour = 12.15/8= **1.51 Birr/hr.**

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

Table 6.5.life span of machine

no	Machine type	Life span (year	Machine Price		Depreciation values /h		Usage time	Total depreciation Value	
			birr	cent	birr	cent		birr	cent
	Power hack saw	10	40,000	00	1	46	10:20	14	60
	Arc welding	5	30,000	00	2	19	19:10	11	30
	Portable grinder	3	5,000	00	0	0.70	15:00	10	50
	Lathe machine	10	90,000	00	11	71	5:00	58	50
	Drill machine	10	50,000	00	1	51	10:00	15	10
	Milling machine	12	100.000	00	3	65	2:00	7	30
							Total	**117**	**30**

6.11. Total production cost of sheet metal rolling machine

It is clear that the total production cost of the machine is the sum of all the above mentioned cost that is:-

Raw materials cost ------------------------------------ 5427.70

Operation processing cost. ---------------------------- 7115.00

Consumable material and standard item cost. -------- 1270.00

Overhead cost and------------------------------------- 1004.65

Labor cost. --- 2250.00

Machine Depreciation Cost-------------------------- 117.30

For market change (contingency) is 5%

= 5% of total production cost

= 0.05 x 17,184.65 **Birr**

= 859.23Birr

Total--- **18,013.88**

If we compare the newly designed machine cost with the others. The sum total cost of the machine is estimated at 18013.88 Birr including the cost of production. Market survey indicates that the cost of imported shape rolling machine ranges from 35500 up to 40000 Birr for light work sheet metal rolling machine while locally fabricated low capacity shape rollers are valued at between 25000 to30000 Birr.

6.12. Result and discussion

The major design components consisted of three rollers supported on heavy plate, rotate in plain bearing or bronze. These rollers apertures; roll gap (the space between each set of rollers), the bend radius of material and type of shape formed are decisive factors for the rollers result .It is known from the experience that for most common works the gap between rollers can be from 20mm to 30mm for light sheet metal rolling (up to 2mm thickness mild steel).The project has the average fixed roller gap that is the gap between driving and back roller is 2.5mm, but the floating roller can be adjusted at both ends for different thickness and bending radios of rolling sheet metal. The adjustment is controlled by scales fixed at the internal part of the supporter plate. The result indicates the maximum bend radius obtainable as an approximate radius of roller for a typical material length of 60 mm is 2.5 mm. The largest measured diameter of complete cylinder the machine can handle (roll) is 191 mm using the given diameter of rollers. At reduced roller aperture of 2.5 mm, the material folded over and the radius of cylinder reduced.

The fabricated machine is as shown in Figure 6.1 below under test. The rolling process requires a number of passes (increasing bending radius step by step) especially for large diameter bending radios. The maximum bend radius when the aperture is closed is approximately the circumferential distance round the roller. The spring back effect on the rolled plate is noticeable as the rolling aperture decreases and the bend radius considerably decrease. This effect can be increased by stretching out the material as it rolls or increasing the aperture width. Alternatively, variable roller diameters could be used when handling materials of varying length. Other dimensions can be obtained by varying the width of aperture until the bend radius approaches a straight line depending on the length of work material. The maximum width of material that can be handled with significant bend radius is, 1000 mm and the length is 600 mm.

Figure 6.1 during rolling

The maximum width (machine capacity) of strip of material the machine could handle is 1,000 mm for tin plates and mild steel with thickness not exceeding 2 mm. When the machine was used to roll mild steel plate of 2.5 mm thickness, the bearing blocks showed evidence of possible failure. The bronze bearing bushes could not support the bending stress exerted by the materials with higher thickness than 2 mm and as a result the machine usage can only be restricted to light gauge metal work and thus find use in tinsmith and welding workshops. Slip friction in rolling was eliminated between the rollers and the load by keeping the contact surfaces smooth and free of lubricants and dirt. The average number of operators required to operate the rollers at a giver operation is shown in Table 6.6 with their average weights.

Table 6.6.Table of performance tests

Material	Material thickness/mm	No. of operators	Ave. wt. of operator/kg	Maximum width of work/mm	Length of material/mm
Aluminum plate	3.00	1	65.00	1000.00	100000
	1.50	1	65.00	1000.00	1000.00
Galvanized plate	1.00	1	71.00	500.00	800.00
	2.00	1	68.9	500.00	800. 00
Mild steel plate	1.00	1	65	1000.00	1000.00
	2.00	1	72.00	500.00	600.00
	3. 00	1		300.00	400.00

Material thicker beyond 2 mm requires two operators while 3 mm thickness material could not be conveniently roll due to the required bending force and the strength of the material used in construction. The force exerted cannot support such material thickness. These results indicate that such or heavier rolling machines are not available or necessary within the Local Government Area.

All most all the sheet metal rolling machine component parts are fabricated by available machines and welding processes (no casting or other complex manufacturing processes are used). Which makes it better than others of course with some level of precisions and surface finish. The total cost of the machine is estimated at **18013.88Birr** including the cost of production. Market survey indicates that the cost of imported Sheet metal rolling machine ranges from **32500 up to 40000Birr** for light work sheet metal rolling machine while locally fabricated low capacity sheet metal rolling machine are valued at between **15000 to20000Birr**.

CHAPTER SEVEN: CONCLUSION AND RECOMMENDATION

7.1. Conclusion

The shape rolling machine is very efficient in rolling curved sections.The machine is cost effective based on the materials of production and simplicity of the design of component parts. Operational mode meets the level of technical knowhow of the artisans. To be truly competitive and to increase market share SME's must produce quality products on time, quickly, and economically. Thus to be efficient and to be competitive the SME's and mall industries should minimize their defective products of sheet metal using this improved redesign and manufactured sheet metal rolling machine than the traditional sheet metal rolling method. Locally in Ethiopia, the small enterprise and small industries that was not use sheet metal rolling machine for different products such as, stove pipes, bucket, water troughs, fuel tanks, and agricultural equipment's. A wide range of these products should satisfy tight tolerances compared to desired geometry. It was observed that most rolled was done by hand tools. In order to make the above mentioned equipment take a lot of time and in accurate form/shape. It was also observed in the study area, small and micro enterprise which causes great damage to the hand tools .and products.

With all these problems SME's small industry couldn't satisfy the needs of its customers in quality and quantity.

From the detailed analysis the following conclusions are derived:

- The main problems observed are the problem of excessive rejection of products due to defective outputs.
- Since most of the sheet metal rolls are done by using hand and exist repetitive hand tools break down.
- There is no effective utilization of resources (material, manpower, machineries, time).

The project concentrates on design and manufacturing of sheet metal rolling machine used to rolling sheet metal according to the required shape. Also includes all the processes followed in the project. In this work, one can observe that every design can be manufactured from cheaper and locally available materials. Since the main function of this machine is to roll sheet metal into cylindrical shape. We hope that it reduces the damage of work, hand tools and also save time.

So this machine can be:

- Easily manufactured by small and micro enterprises using readily available material and expand to different enterprises and TVET institutions throughout the country also, they can solve their problems.
- Reduce foreign currency exchange.
- Manufactured from local materials.
- Easy to be disassembled and maintain
- Operated manually by any person
- Convenient for transportation
- Low in cost than the imported
- It can be easily manufactured and distributed to various area of this country.
- Improve productivity and product quality.
- Improved competitive position in the real market.

In general by achieving good quality of sheet metal product SME's and small industry satisfies the customers' need which results better producer and customer relationship.

7.2. Recommendation

Although this is successful to this extent, there were many problems that we faced to finalize it. Among the problems we faced some of them are the following shortage of time constraint and financial problem, lack of materials. Whatever it is we tried to make joint what we want to recommended about this machine is that is operated manually in the way that it will be operated by power to get high production. The next designers can substitute the human power by motor drive to roll faster automatically. This sheet metal rolling machine is designed to optimize effective utilization of sheet metal products for different applications. In addition to what had been indicated in this project work, we would like to recommend the following points:

- Where the facilities and materials are available the bottom rollers could be connected by chain derives. In this case the shafts could be short at the other end. This end would need the same length, but the cranks would be replaced by electrical motor driven.

- Round bar up to 8mm diameter can be rolled more easily if grooves are cut in the two bottom rollers. This will weaken the tubing unless very thick wall tube has been used. This could be over cam by turning a plug of solid bar or smaller pipe to fit tightly down the roller for 100mm or so. This plug should be welded at the end and also at 4-holes drills through the roller. The hole can be filled in with weld and filed smooth.

  - The groove should ideally be having rounds of the size of wire and bar that you may wish to roll. Three, five and six mill-meters would be use full, or three V grooves which allow for some vibrations. The grooves on the front and back rollers must be in line.

It is very important to have a scientific maintenance schedule. And workers should perform a preventive maintenance to the machineries they are assigned, i.e. cleaning, oiling, greasing, checking all the controls, reporting to the required foreman or supervisor as soon as they saw serious problems on the machine.

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APPENDIX: A QUESTIONNAIRE

ADAMA SCIENCE AND TECHNOLOGY UNIVERSITY

School of Mechanical, Chemical and Material Engineering

Department of Mechanical and Vehicle Engineering

Question for data collection

Dear Participant:

The purpose of this questionnaire is to collect data about need assessment of sheet metal rolling machine for the project of master graduate to design and manufacture at Adama Science and Technology University.

For the genuine information you will give us about the demand and importance of this machine we would like to thank you in advance.

Tick in the given box

I: Personal characteristics (Demography)

1.Sex: Male ☐ Female ☐

2. Age: 18-20 ☐ 21-30 ☐ 31-40 ☐ above 40 ☐

3. Education Level: No formal education at all ☐ Primary education ☐

Secondary education ☐ Diploma Level ☐ Degree Level ☐

PART- I Read the following questions and choose the appropriate answer from the given alternatives.

-------1. Do you have sheet metal rolling machine? A/ Yes B/ No

____2.Do you usesheet metal rolling machine in your shop? A/ Yes B/ No

____3.If your answer for question No 2 is No, why don't you use it?

A/ You don't have it B/ It is not necessary for you C/ You use another rolling technique D/Any other reason

_____4. Are you interested to buy sheet metal rolling machine if it is produced at SME's with reasonable cost? A/ Yes B/ No

_____5. If your answer for question No 4 is No, why don't you want to buy it?

A/ you can manufacture it. B/ It is not relevant for you C/You want to use traditional of rolling sheet metal D/Any other reasons

______6. Do you accept technology that can increase the utilization of sheet metal rolling machine? A/ Yes B/ No

______7. Is there wastages and damage of sheet metal when rolling or shaping?

A/ Yes B/ No

______**8.**Do you think that sheet metal rolling machine keep safety, increase productivity and quality of work? A/ Yes B/ No

______9.Which type of sheet metal rolling methods is suitable for you?

A/ Traditional/using hand tools/method of rolling

B/ Locally manufactured sheet metal rolling machine

C/ Imported sheet metal rolling machine.

___10. Does the sheet metal rolling machine available in the market?

A/ Yes B/ No

____11.If your answer for question No 10 is No, which type of rolling machine?

A / The imported sheet metal rolling machine.

B / The local sheet metal rolling machine.

PART - II Write the proper answer that you feel for each of the following question.

1. What are the products mostly fabricated in your shop?

____

2. What is the use of sheet metal rolling machine in your local areas?

____

3. When do you roll sheet metal?

____

4. What are the problem using hand tools for sheet metal rolling method?

____

5 Explain how intermediate small and micro enterprises generate income from manufacturing of sheet metal rolling machine?

____

____

6. Mention any thing relating to sheet metal rolling machine that you want to use.

____

____

APPENDIX: B ASSEMBLY AND DETAIL DRAWING