A PROJECT REPORT

ON

"DESIGN & FABRICATION OF THREE ROLL BENDING MACHINE"

SUBMITTED TO

UNIVERSITY OF MUMBAI

In Partial Fulfilment of the Requirement for the Award of

BACHELOR'S DEGREE IN

MECHANICAL ENGINEERING

BY

SIDDIQUI ANAS SUHAIL	**13ME58**
ANSARI EZAZ MOHAMMED HAIDER	**16DME123**
KHAN SALMAN KHAN MOHD AKRAM	**16DME151**
KHAN ARMAN AMIRUL HASAN	**16DME146**

UNDER THE GUIDANCE OF
PROF. ATUL N.MESHRAM

DEPARTMENT OF MECHANICAL ENGINEERING
ANJUMAN-I-ISLAM'S KALSEKAR TECHNICAL CAMPUS
SCHOOL OF ENGINEERING & TECHNOLOGY
Plot No. 2 3, Sector - 16, Near Thana Naka,
Khandagaon, New Panvel - 410206

2018-2019

AFFILIATED TO

UNIVERSITY OF MUMBAI

A PROJECT II REPORT

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Department of Mechanical Engineering

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Plot No. 2 3, Sector - 16, Near Thana Naka,

Khandagaon, New Panvel - 410206

CERTIFICATE

This is certify that the project entitled

"DESIGN & FABRICATION OF 3 ROLL BENDING MACHINE "

submitted by

SIDDIQUI ANAS SUHAIL	**13ME58**
ANSARI EZAZ MOHAMMED HAIDER	**16DME123**
KHAN SALMAN KHAN MOHD AKRAM	**16DME151**
KHAN ARMAN AMIRUL HASAN	**16DME146**

is a record of bonafide work carried out by them, in the partial fulfilment of the requirement for the award of Degree Of Bachelor Of Engineering (Mechanical Engineering) **At Anjuman-I-Islam's Kalsekar Technical Campus**, navi mumbai under the university of MUMBAI. This work is done during year 2018-2019, under our guidance.

Date:30 /04 /2019

(Prof. ATUL N. MESHRAM)
Project Supervisor

(Prof. RIZWAN SHAIKH)
Project Coordinator

(Prof. ZAKIR ANSARI)
HOD, Mechanical Department

DR. ABDUL RAZAK HONNUTAGI
Director

External Examiner

ACKNOWLEDGEMENT

I would like to take the opportunity to express my sincere thanks to my guide **PROF. ATUL N. MESHRAM**, Assistant Professor, Department of Computer Engineering, AIKTC, School of Engineering, Panvel for his invaluable support and guidance throughout my project research work. Without his kind guidance & support this was not possible.

I am grateful to him for his timely feedback which helped me track and schedule the process effectively. His time, ideas and encouragement that he gave is help me to complete my project efficiently.

We would like to express deepest appreciation towards **DR. ABDUL RAZAK HONNUTAGI**, Director, AIKTC, Navi Mumbai, **Prof. ZAKIR ANSARI**, Head of Department of Mechanical Engineering and **Prof. RIZWAN SHAIKH**, Project Coordinator whose invaluable guidance supported us in completing this project.

At last we must express our sincere heartfelt gratitude to all the staff members of Mechanical Engineering Department who helped me directly or indirectly during this course of work.

At last we would like to thank **BENDSOR MACHINE AND TOOLS** for giving us this great opportunity to conduct our project successfully.

SIDDIQUI ANAS SUHAIL

ANSARI EZAZ MOHAMMED HAIDER

KHAN SALMAN KLHAN MOHD AKRAM

KHAN ARMAN AMIRUL HASAN

Project Approval for Bachelor of Engineering

This project entitled "DESIGN & FABRICATION OF 3 ROLL BENDING MACHINE" by Siddiqui Anas, Ansari Ezaz, Khan Salman, Khan Arman is approved for the degree of Bachelor of Engineering in Department of Mechanical Engineering.

Examiners

1.................................

2.................................

Supervisors

1.................................

2.................................

Chairman

…......…………………..

DECLARATION

I declare that this written submission represents my ideas in my own words and where others ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed.

Student Name:-
Siddiqui Anas
Ansari Ezaz
Khan Salman
Khan Arman

Roll Number:-
15ME58
16DME123
16DME151
16DME146

ABSTRACT

In present time, the motorized 3 roll bending machine is universal forming equipment for sheet plate into cylinder and curved sheet. It is widely used boiler, shipbuilding, petroleum, chemical, metal structure and machinery manufacturing industries.

The aim of this project is to design a new motorized 3 roll sheet bending machine for industry, having latest feature like lowering top roll by single lever mechanism and providing input motion to both the lower roller to avoid the problem of slippage.

The existing 3 roll sheet metal bending machine of industry is totally hand operated. The existing machine has many problem like slippage, accuracy and time required to make one cylinder is more than motorized machine. The demand of hand operated 3 roll sheet metal bending machine is low, so in order to survive the competition of market industry has given a task to make a motorized 3 roll bending machine.

In this project the problem of slippage of sheet in between roller is solved by providing input motion to both the lower roller. In most common design adjuster is provided at both the ends of top roll to move up and down. In this project a single lever (adjuster) is provided to move up and down the top shaft.

The cost of our machine is less than the cost of the same machine available in the market. We have reduced the cost by eliminating bulky mounting for motor. We have mounted our motor on L shaped plate and this L plate is directly attached to stand on angle. We also compared the productivity of machine with two different company's 3 roll sheet bending machine. One company's machine speed is 10 rpm and our machine speed is 20 rpm , so speed is more in our machine and therefore time taken will be less which improve productivity.

CONTENT

1. INTRODUCTION

Since the project is in industrial project the task given to us by the company was to improve the existing design of their three roll bending machine so that they can maintain the company's competitiveness in existing market. The company currently is making hand operated three roll bending machine and desires to enter the market of motorized machine as it is lagging behind many other manufacturers. Thus they gave us the task of making design improvement in existing design in order to make it more ergonomic, easy to use and motorized.

Bending is a process by which metal can be deformed by plastically deforming the material and changing its shape. The material is stressed beyond the yield strength but below the ultimate tensile strength. The surface area of the material does not change much. Bending usually refers to deformation about one axis.

Our project, the 3 Roll Bending Machine was first brought into use around 1830, it is very simple in operation with 3 rollers one of which are coupled with motor. This machine produces cylindrical objects of different diameters. This machine can be used in various fields. This machine is simple in construction and working.

There are many examples of Sheet Metal work, which can be seen in our everyday lives. The metals generally used for Sheet Metal work include black iron sheet, copper sheet, tin plate, aluminum plate, stainless sheet and brass sheet. The range of this paper has been restricted to pyramid type machines which are the most common.

With the rapid development of manufacturing, coal-fired power, hydropower, nuclear power and wind power encouraged by the national clean energy policy, also closely followed, pipeline and column tower parts processing needs of large complete sets of plate rolling machine. Offshore oil and gas, petrochemical, coal chemical industry, heavy duty high-pressure vessel product has become increasingly popular, thousand tons of hydrogen reactor, two thousand tons of coal liquefaction reactor, $10000m^3$ natural gas spherical tank are widely applied, which make heavy duty plate rolls specialized for rolling thick plate and high strength plate become key equipment. 3 roll bending machine finds huge application in Sheet Metal industry.

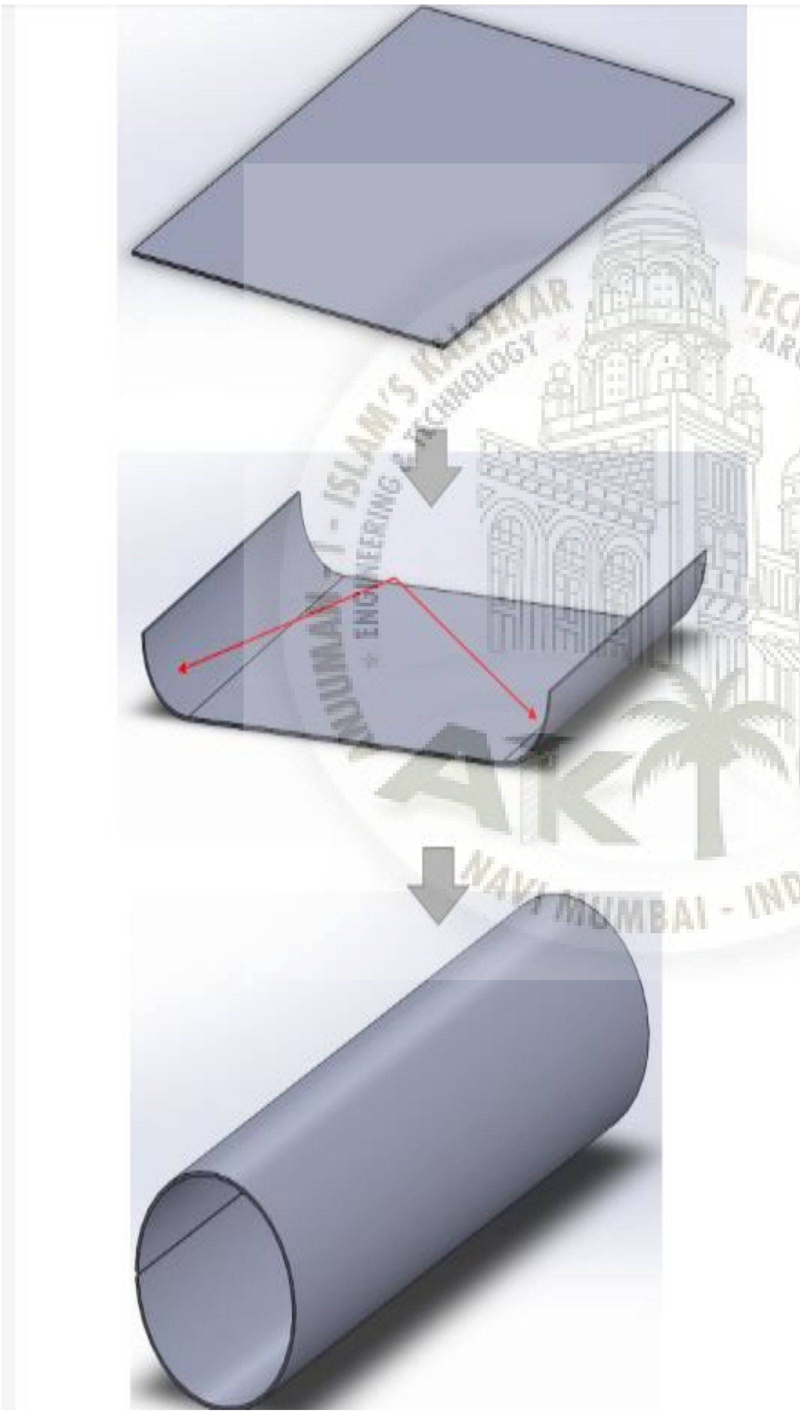

Fig. 1.1. shows the prerequisite operation to be done on the sheet which is giving the sides an initial curve due to the inherent property of pyramid type roll bending machine which is its inability to roll start and end side of the sheet to some extent

Roll bending machine has also been called rounder and roller machine, which is universal forming equipment for rolling metal plate into the cylinder, cone, curved and other shapes.

According to a principle of three point forming circle, the relative position change and rotational motion of the working roll make the metal sheet produce continuous plastic deformation to obtain the predetermined shape of the work piece.

It is widely used in boiler, shipbuilding, petroleum, chemical, metal structure and machinery manufacturing industries.

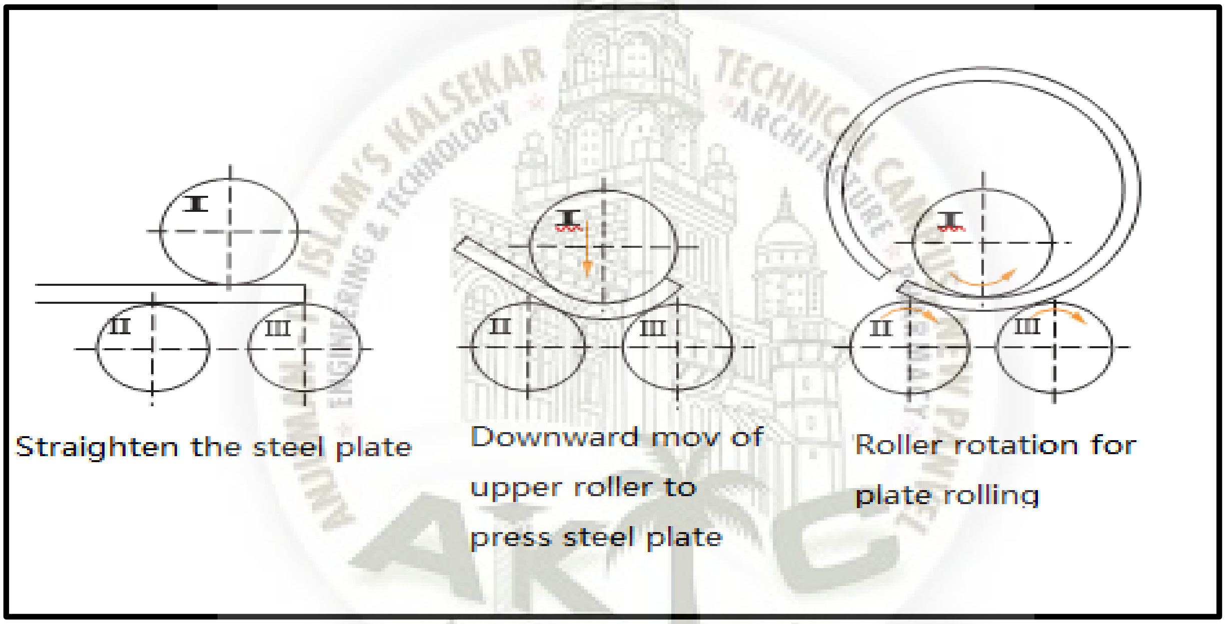

Fig.1.2. various stages during the sheet rolling operation

2. PROBLEM DEFINITION

In an era of fully automatic products if you need to be competitive in the market you have to constantly improve/upgrade your products to meet customer demands and avail great profit margins.

The 3 roll bending process is considered to be suitable for small batch production with great variety. However, this process has not been well understood and the prediction of the displacement of the center roll to give a particular curvature is very difficult. This may be attributed to the following features:

- The curvature of the product is dependent on the spring back characteristics of the work piece material.
- The positions of the contact points between the rolls and the work piece shift in accordance with the displacement of the center roll and hence the distribution of the curvature changes;
- The value of the displacement of the center roll which gives a particular curvature is different if the work piece has different initial curvature.

Manufacturing is a field of transferring raw material into finished goods. There are many manufacturing firms that can be found such as automobile factories, bakery factories,

Electrical factories, etc. Many of the factories produce their products in mass production. So, these factories or companies are competing each other to get their products in the market. Therefore, they must have good manufacturing facilities to improve their productivity.

The manual process causes fatigue to labors, lowers the efficiency of labors and there by lowers the working efficiency of sheet bending operation. Trial and error experience of operator is still a common practice in the industry. Sequential bending on a roller bending machine is widely used in practice but involves very high amount of labor in marking, locating, shifting and inspecting the sheet after each sequential bend. An operator must have knowledge of different machine parameters to obtain cylinders with desired diameter.

In earlier design there was a brief phenomenon of slippage, as the power was given to only one of the bottom rolls, resulting difference in angular velocity of both rollers.

The vertical adjustment (movement) of the top roller was previously provided at both the ends of the top roller, hence precise alignment was necessary. It was time consuming and good operator skill and experience was needed.

3. OBJECTIVE

The aim of this project is to develop 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.

- To increase the productivity by updating the current design and making it motor equipped
- Giving input power to both the bottom roller to minimize slippage.
- To make arrangement for lowering top roll by single lever mechanism.
- Estimating of power for selection of motor.

4. LITERATURE SURVEY

In order to be aware of the market condition and to know what is already there in the market we get through many papers already published related to our project topic. While going through papers we get to know gaps, technology used and areas of development and advancement.
Following are the list of papers we have studied during survey.

Sr. No.	Paper Title	Name of Journal	Year of Publication
01	Review paper on design and development of metal bending machine	IOSR journal of mechanical & civil engineering	March 2017
02	Design and development of three roller sheet bending machine	International journal on recent and innovation trend in computing & communication	August 2105
03	Analytical and empirical modelling of top roller position for three roller cylindrical bending	Journal of material processing technology	June 2107
04	Design aspects and parametric study of 3 roll heavy duty plate bending machine	Journal of material processing technology	August 1991
05	Modeling and computation of 3 roller bending process of steel sheets	Journal of mechanical science & technology	September 2018
06	Design and fabrication of roll bending machine	International research journal of engineering and technology	April 2018

07	Design and analysis of portable rolling and bending machine using CAD and FEA tool	International journal of engineering research & technology	April 2013
08	Study of portable 3 roller pipe bending machine	International journal of advanced technology in engineering and science	March 2016
09	Design and fabrication of hydraulic Bending machine	International conference on recent innovations in science and engineering	April 2018
10	Design of bending machine	International Journal of Current Trends in Engineering & Research	May 2016

Table. 4.1. literature survey

5. CLASSIFICATION OF ROLL BENDING MACHINE

Roller bending machine can be divided into different types due to the use in different industries.

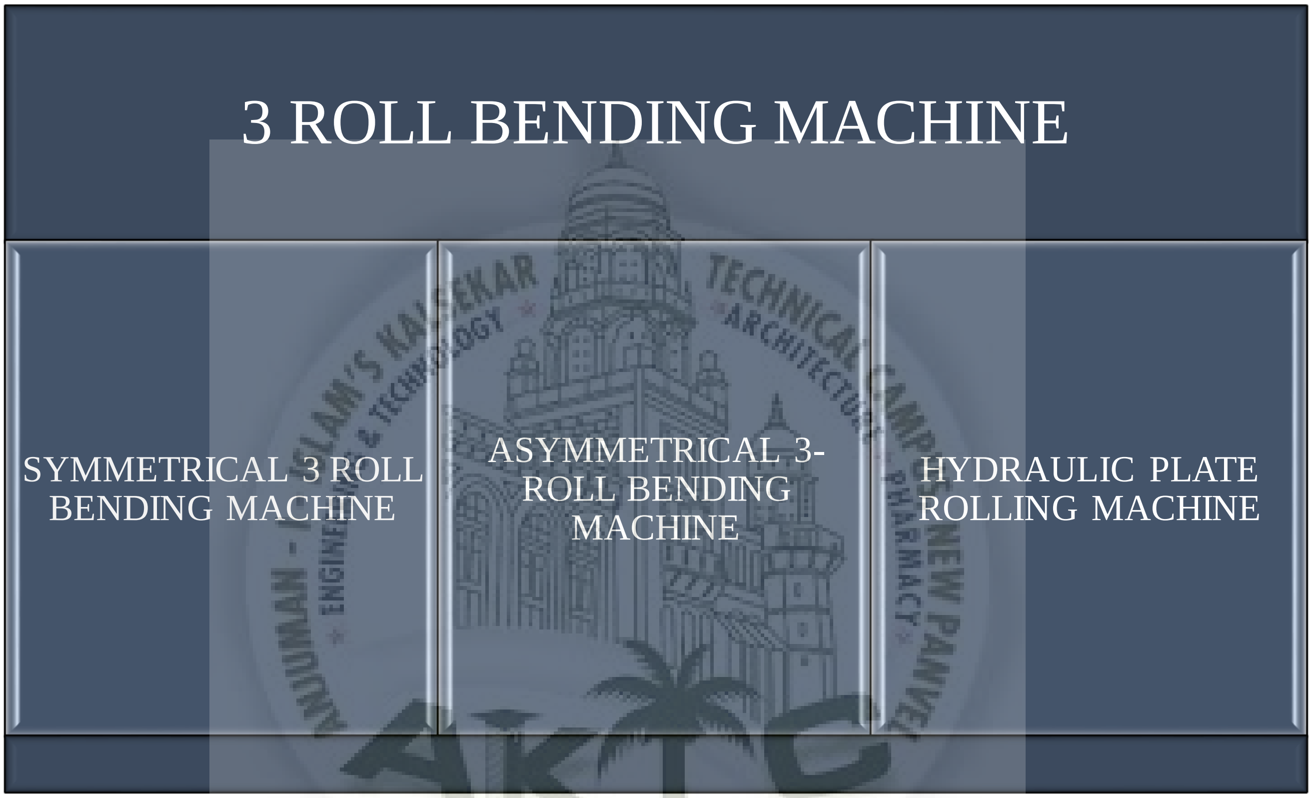

Fig.5.1. classification of 3 roll bending machine

5.1 SYMMETRICAL THREE ROLL BENDING MACHINE

- The structure of the machine is three-roller symmetrical.
- The upper roller in the center of the two rollers under the symmetrical position for vertical movements, through the screw to lead the worm gear drive.
- The two roller for the rotary motion, through the reduced output gear and the lower roller gear meshing to provide torque for the rolled plate.
- The short coming of the machine are the end of the plate need other equipment to realize pre-bending.

5.2 ASYMMETRICAL THREE ROLL BENDING MACHINE

- The machine structure is three roll asymmetrical.
- The upper roller is the main drive, the lower roller makes the vertical movement. Through the lower roller gear and the upper roller gear meshing to clamp the plate. The side roller does the vertical movement, with pre-bending and round rolling friction.
- It is featured compact structure, easy operation, and maintenance.

5.3 HYDRAULIC PLATE ROLLING MACHINE

- Feature of hydraulic three rollers symmetrical bending machine: the machine can do the vertical movement.
- It is realized by the hydraulic oil in cylinder drive piston rod. The lower roller for the rotation drive, through the reducer output gear meshing, to provide torque for the rolling plate.
- The bottom part of the roller has the carrier roller can be adjusted. The upper roller is in the drum shape, improve the straightness of the finished product, suitable for the tank with long size and various cross-shape.
- Up adjust symmetrical three-roll bending machine is able to roll metal plate into circular, curved and tapered shape within a certain range.
- The lower roller of the machine is the driving roller and the upper roller is the driven roller.
- It is widely used in shipbuilding, boiler, aviation, hyper power, chemical, metal structure and machinery manufacturing industry.

6. CONSTRUCTION OF TTHREE ROLL BENDING MACHINE

After the calculations, application of constraints and delivery of the material we started manufacturing parts on regular basis. It was challenging because none of us had enough exposer to manufacture our own idea, in this scenario we got help from industry in such cases where accuracy mattered the most. Following are the parts we manufactured with the brief explanation of processes involved and the problems tackled.

Parts:

- UPPER ROLLER
- LOWER ROLLERS
- SIDE FRAME
- ROLLER BUSH
- TIE ROD
- CAM
- CAM SHAFT
- SLIDING BLOCK
- PULL TYPE BUSH
- BASE
- WORM AND WORM WHEEL
- SPROCKET
- CHAIN
- MOTOR

6.1. ROLLERS

Top Shaft:

Top Shaft is the one which directly applies the force on the metal sheet and hence it has to be of a tougher material, for this reason EN9 carbon steel is chosen. This shaft can move up and down and with the change in its relative position different radius of curvatures of the sheet can be achieved. Its journals are supported in the pull type bush at one end and in the spherical bush at the other. This shaft can tilt in the horizontal plane with spherical bush as the pivot to facilitate easy removal of the job after a 360° bend.

Bottom Shafts:

The material for these shafts is same as that for the top shaft viz. EN9 carbon steel. These shafts support the sheet and provide an upward force to bend the sheet with a smooth curvature. The journals of these shafts are supported in the bushes which are inserted into the sides. At one end, the journals are longer with key slots at their ends and carry the sprockets both these shafts are given power input with the help of chain drive.

- The material for the roller is EN9.
- EN9 is a medium carbon steel grade commonly supplied in the rolled condition. The main objective behind the selection of the material is it has high surface hardness with excellent wear resistance characteristic which is the paramount requirement of the roller in this machine.

Fig. 6.1.1. top and bottom rollers after receiving prior to machining

Fig. 6.1.2. rollers during and after machining

PROCESS INVOLVED

- Purchased all the three rolls of material EN9 having finished size of 75mm collectively (i.e. one for top and two for bottom rolls).
- Faced the both ends to bring its length to required dimension.
- We clamped first roller on the lathe machine and did turning and step turning to make it as per the design and then finally given the roller its finishing touch by sand paper all over its length.

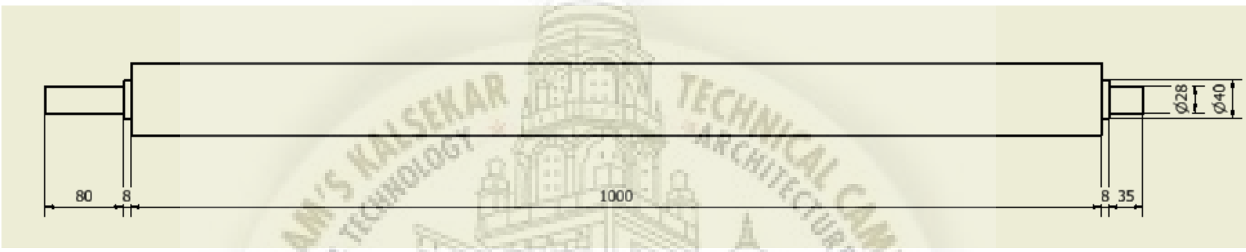

Fig 6.1.3. 2D sketch of bottom roll

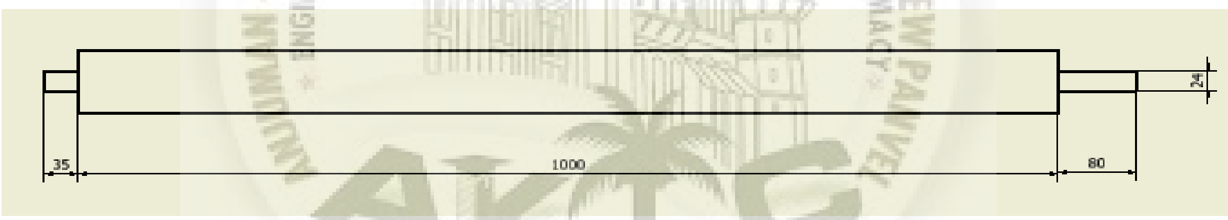

Fig. 6.1.4 2D sketch of top roll

6.2. SIDE FRAME

- The sides of the machine sports the bushes and the rollers as well as the casting circles and the sliding blocks. It is made of mild steel and it provides structural rigidness to the machine with the help of tie rods.
- Made a 2D cad drawing of side frame in proportionate with rollers, bushes, sliding block dimensions and ordered the material.
- Keeping in minds the allowances for machining, made a sketch on the cardboard. Then sent the both material and design for gas cutting operation.

Fig.6.2.1 side frame after gus cutting operation (left) and after all the machining required (right)

PROCESS INVOLVED

Clamped the side frame on the shaper machine and machine the all side of it one by one.
In lathe machine, since the job is not circular not symmetric we used four jaw chuck and then perfectly centered the job to finish the circle.
We repeated the procedure and did drilling and boring on the side frame to accommodate lower rollers.
At last, we fixed the job on drilling machine and drilled the hole on both the sides for grub screw which then later finished by tapping.

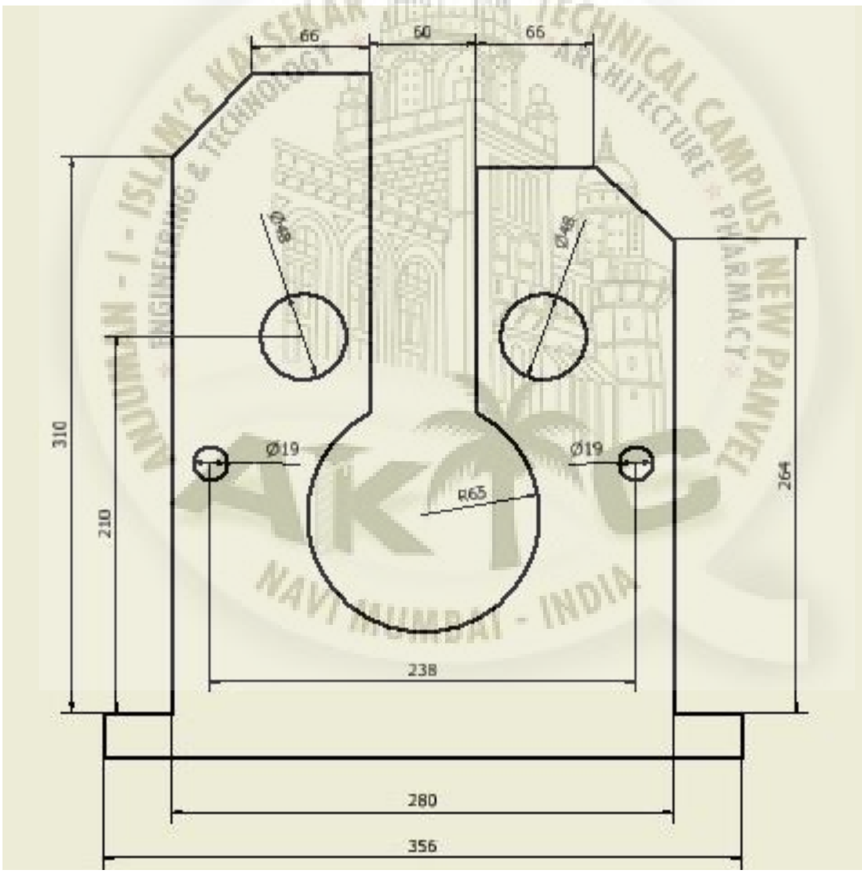

Fig.6.2.2 2D CAD drawing of side frame

6.3. ROLLER BUSH

- Purchased the casting slightly larger and greater than the length and diameter required respectively.
- The outer diameter would fit in the side frame and the rolls would fit in the inner diameter of the bush.

Fig.6.3.1. spherical bush (left) and circular bush (right)

Fig.6.3.2. all cylindrical bush together for demonstration

Process involved

- After receiving the casting billet we cut it down four equal pieces (since we needed four bushes of same design for lower rollers) on the hacksaw cutting machine.

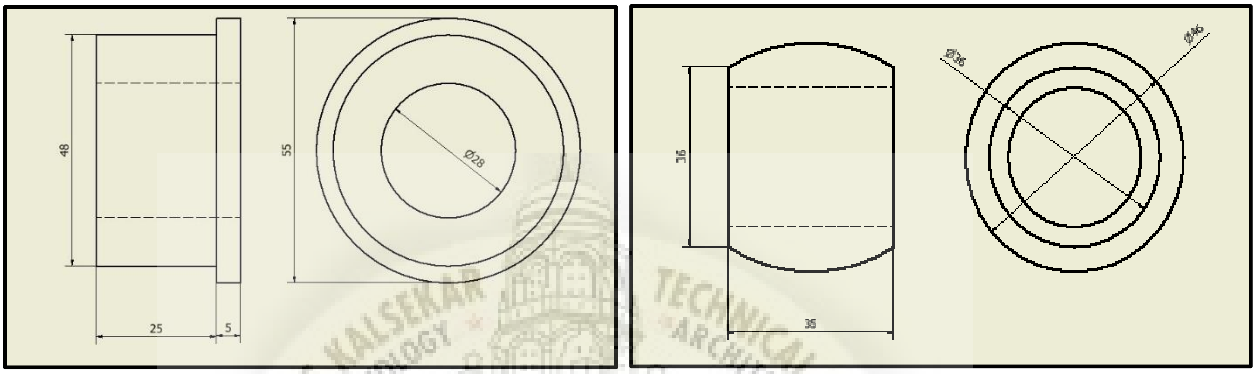

Fig.6.3.3. spherical bush (left) and circular bush (right)

- Faced the both sides to and made it to 30mm length and then turned it to required diameter of 55 mm.
- Then we again turned it to make 48mm outer diameter for 25mm length to get 5mm collar thickness.
- After finishing outer portion we switched to drilling operation to make a hole followed by boring operation to get inner diameter 28mm. both drilling and boring operations are carried out on lathe machine.

6.4. SLIDING BLOCK

- Sliding block is serving the purpose of accommodating plates of different thickness into the system and helps getting the variations in the radius of the sheet as per required.
- The analogy of movement is taken from IC engine. Sliding block is set to reciprocate in the cavity of side frame when cam is given rotary motion with the help of wheel

Fig.6.4.1 sliding block with a slot for tilting mechanism (left) and sliding block housing circular bush to (right)

Process involved

- Again we made a sketch and ordered the material. Upon getting we faced all the six faces on the shaper machine. The dimension was 30*70*108mm.
- We had to make a slot which would reciprocate in the respective slot of side plate. Therefore we machined 30mm side to remove the material, we leaved 5mm wall thickness on both the side for the depth of 5mm.

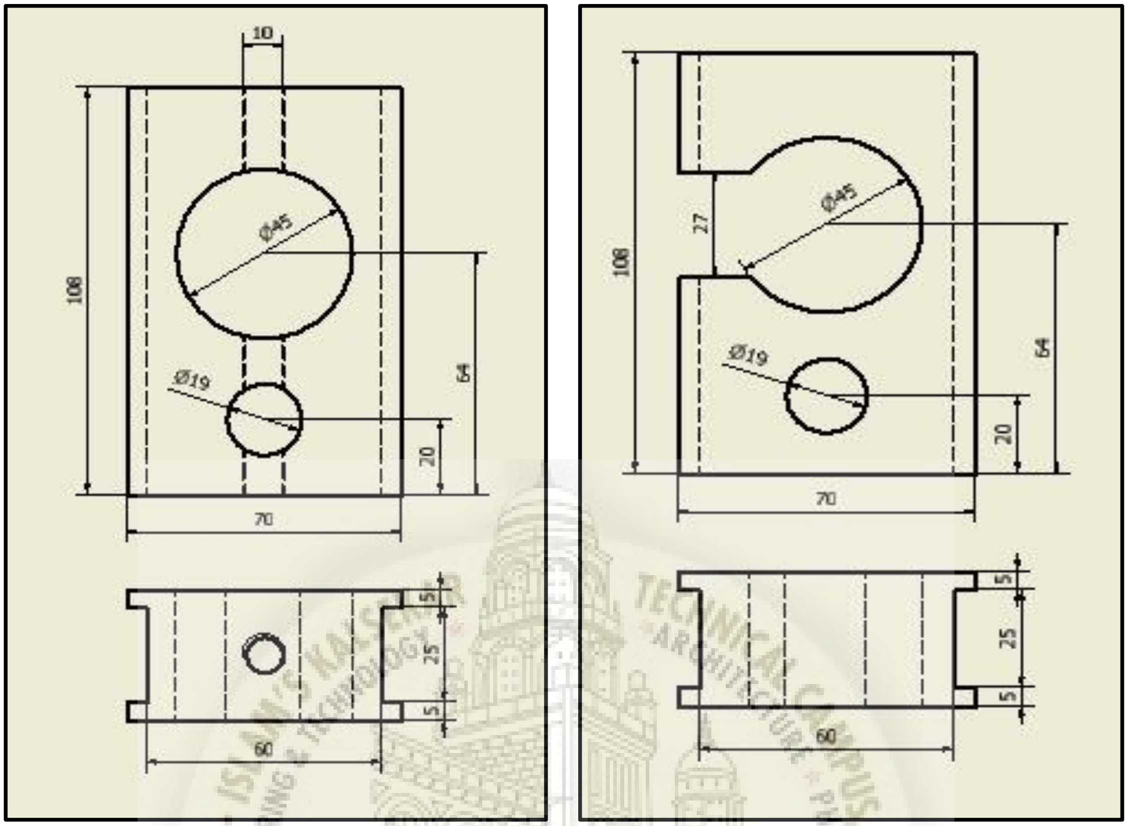

Fig.6.4.2. 2D CAD design of sliding blocks

- We made a slot and sent it to lathe for further operations which was drilling and boring. In drilling we used subsequent drills in the increasing diameter order to get maximum diameter of hole get machined (12mm-24mm-32mm change it later) and remaining machining was done by boring to 48mm internal diameter.
- We again drilled but this time at the offset position for the link directly by exact drill and tapped it later to make thread.

6.5. TIE ROD

- Tie rod is the backbone of our machine. It strictly keeps the alignment unchanged during the operation.
- Without it, during shocks or ejection of rolled sheet from the system may undergo into vibrations which can slightly change the alignment, and resetting the whole system wouldn't be feasible if proper expertise is not available.

Fig.6.5.1. tie rod

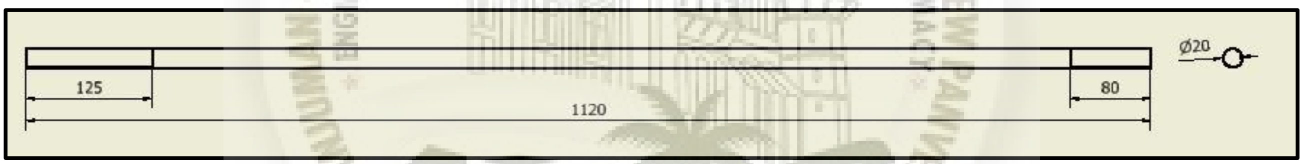

Fig.6.5.2. 2D CAD design of tie rod

Process involved

- Easy if not the easiest part to manufacture in the whole project.
- We ordered the shaft as per the design dimensions.
- Cut through the middle to make it equal in length, faced and finally did threading.

6.6. CAM

- Rotary motion of cam will be transmitted to linkage will then produce a reciprocating motion to sliding block.
- Cam is made slightly lesser in dimension in comparison with cam housing so it will freely rotate in its place.

Fig.6.6.1. cam

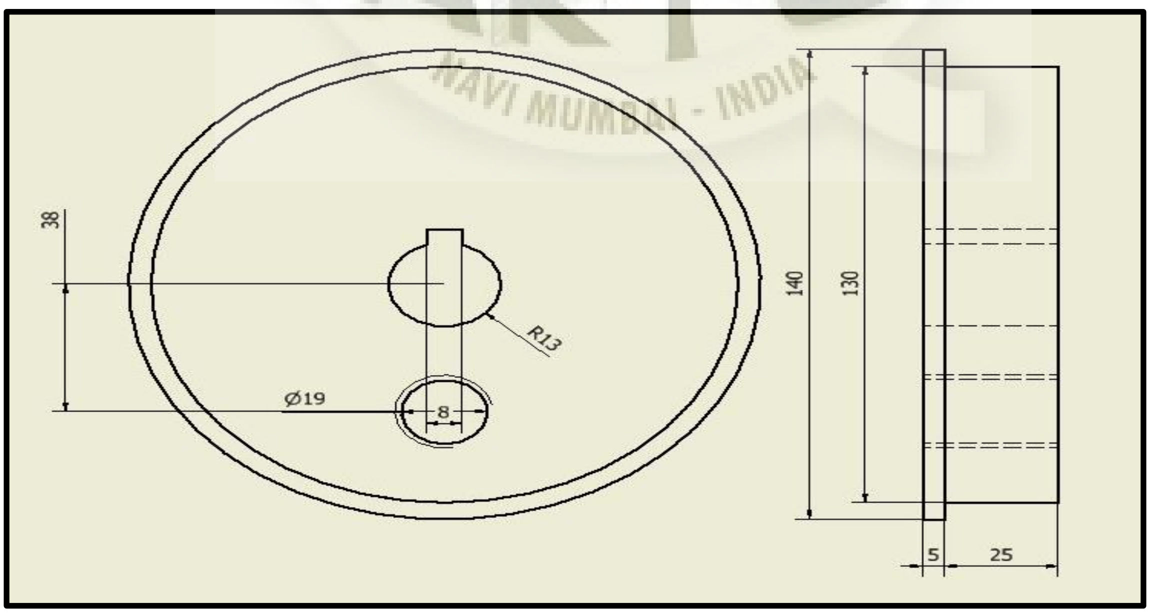

Fig.6.6.2. cam

PROCESS INVOLVED

- Made a wood pattern for casting considering the allowances.
- After receiving we faced and turned it as per the dimension.
- Drilling operation was done followed by boring to match the dimensions as the cam shaft.
- After all the operations on the lathe we switched to drilling machine and drilled the eccentric hole.
- Then we tapped the eccentric hole.

6.7. PULL TYPE BUSH

It is a spring loaded cast iron bush which is normally engaged into the sliding block to support the top shaft. After a 360° bend of the sheet, this bush can be pulled, so that only the journal of the shaft can be taken out through the slot and the job can be easily taken out. This bush has diamond knurled collar for a good grip.

Fig.6.7.1. pull type bush

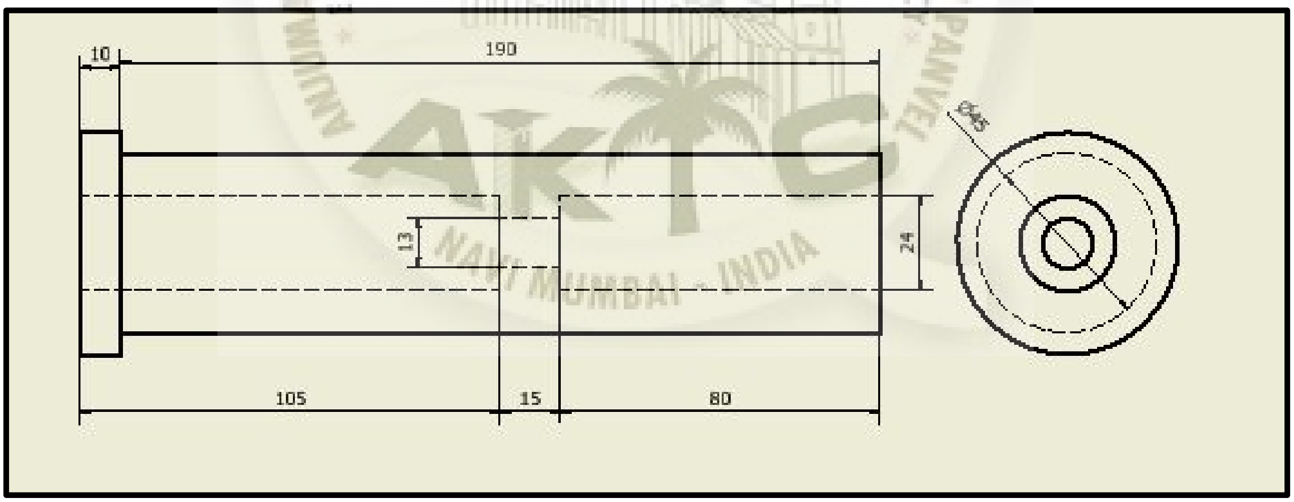

Fig.6.7.2. 2D CAD design of pull type bush

PROCESS INVOLVED

- Turn the whole bar to diameter 55mm and faced both the ends to required length.
- Did step turning to make diameter of 45mm for 190mm length.
- Then we did drilling followed by boring to make finish size of 24mm of length 80 from one side and 108 from another side.
- After this we again did drilling on the wall of 13mm hole.
- At last we did knurling on the outer face near the collar.

6.8. LINK

The links connects the sliding block and the casting circle and transfers the motion of the casting circle to the sliding block. They are made such that their length is adjustable. The link is made in two separate parts; one has a left threading done of ¾ inch with 10 tpi whereas the other part has a right threading of ¾ inch with 10 tpi. Both these parts are connected via a hexagonal drum. The drum has internal left threads at one end and internal right threads at the other both of ¾ inch and 10 tpi. Such construction of the link allows the variation of its length just by rotating the hexagonal drum with the help of a spanner. Mild steel is used as its material

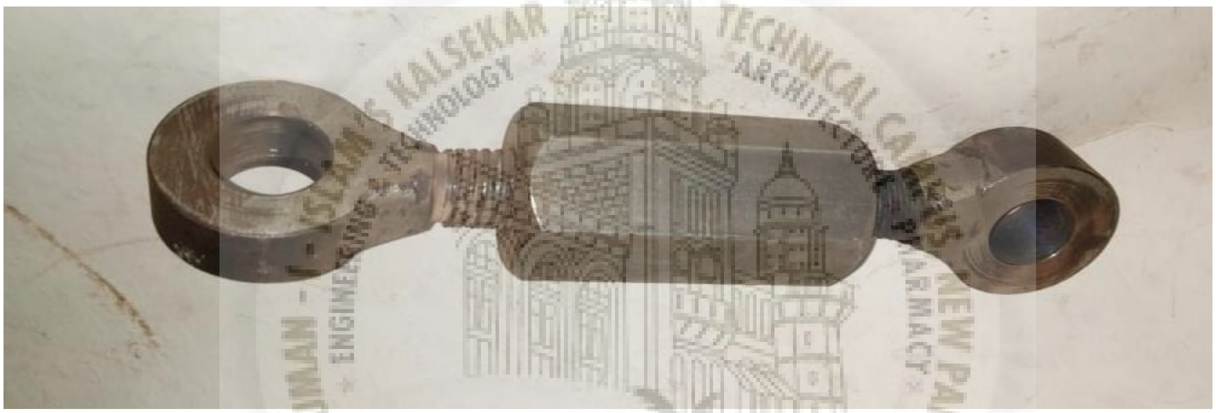

Fig.6.8.1. link

PROCESS INVOLVED

- First we needed to make an eye which would be later welded to threaded circular piece of diameter 20mm and length 75mm which could fit into the respective thread on the hexagonal nut.
- We had to make two of them, in one left hand thread would be there and in other right hand would be there.
- Hexagonal nut we purchased directly from the market and cut it to two pieces of same length which is 80mm.
- We did left hand internal thread in half portion and internal right hand thread in remaining portion in both the nuts.

6.9. PIN

Pins are inserted in the sliding block and the casting circle at both the side of the machine. These pins are threaded to a length which goes inside the sliding block and the casting circle. The remaining length of the pin has a clean smooth surface. These pins are used to connect the casting circle and the sliding block via a link and they have a collar to prevent the link coming out of them. These are made of mild steel.

Fig.6.9.1. pin

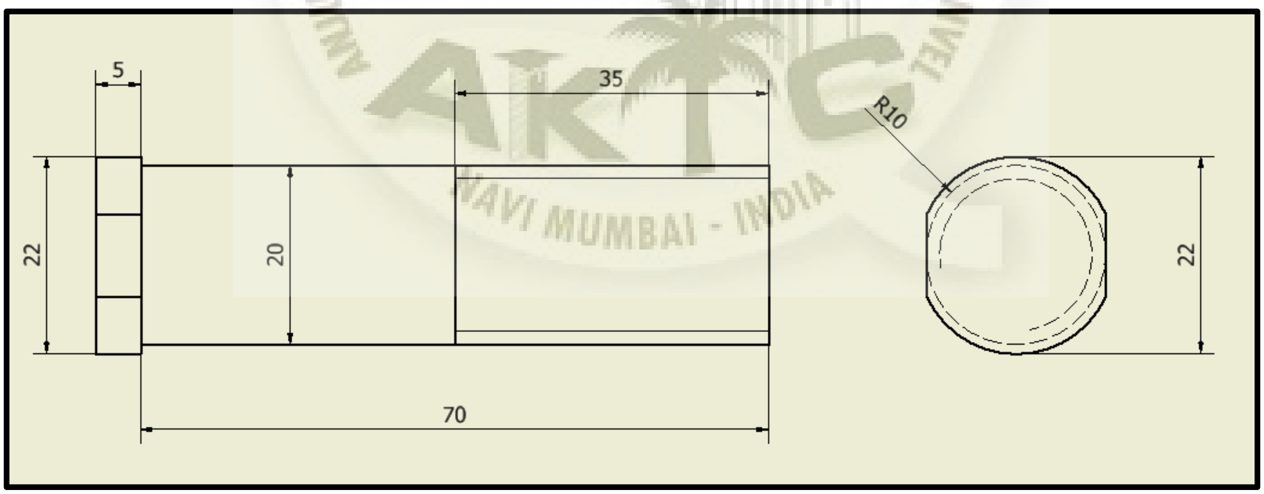

Fig.6.9.2. 2D CAD drawing of pin

PROCESS INVOLVED

- Cut four pieces of pin from 22mm diameter of shaft in hacksaw machine.
- Faced both the ends to get required length which is 75mm.
- Did step turning of diameter 20mm for a length of 70mm.
- Then did threading on pin on lathe machine for 30mm length.

6.10. WORM SHAFT

This shaft carries the worm and is supported between two bearings. It has a key slot in the middle for the worm and a key slot at one end for the handle. It is made of mild steel.

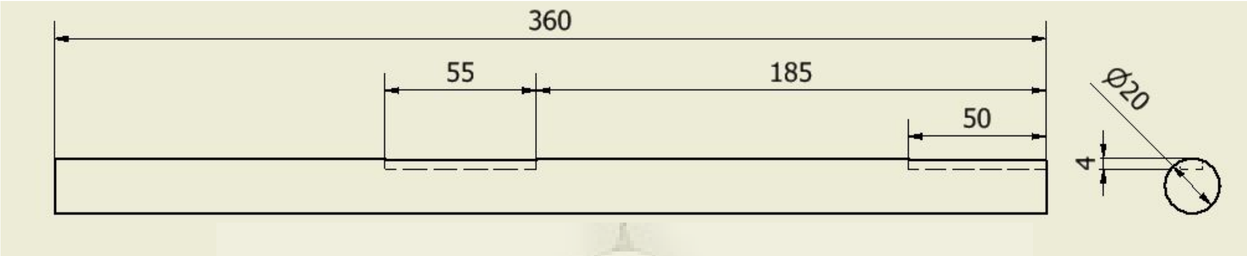

Fig.6.10.1. 2D CAD drawing of worm shaft

6.11. LEVER

The lever is used to rotate the worm thus, the rotation of the handle results in the vertical movement of the top shaft i.e. the position of the top shaft can be controlled with the handle. It has a key slot and is made of mild steel.

Fig.6.11.2. lever and bearing plate

6.12. BEARING PLATES

These plates acts as housing for the bearings and are bolted into the sides. Material used is mild steel.

6.13. CHAIN AND SPROCKET

At last, something we didn’t manufacture. We did tremendous amount of calculation, asked multiple faculties for guidance and reached the purchasing state. Thereafter we visited several store at different locations to ensure we only purchase the best one while keeping the cost at minimum.

Fig.6.13.1. sprockets

Fig.6.13.2. chain

6.14. STAND

The sides, the motor mounting and the switch are mounted over the stand. It provides suitable height to the machine and forms a rigid structure. The stands are made out of ½ inch mild steel angles.

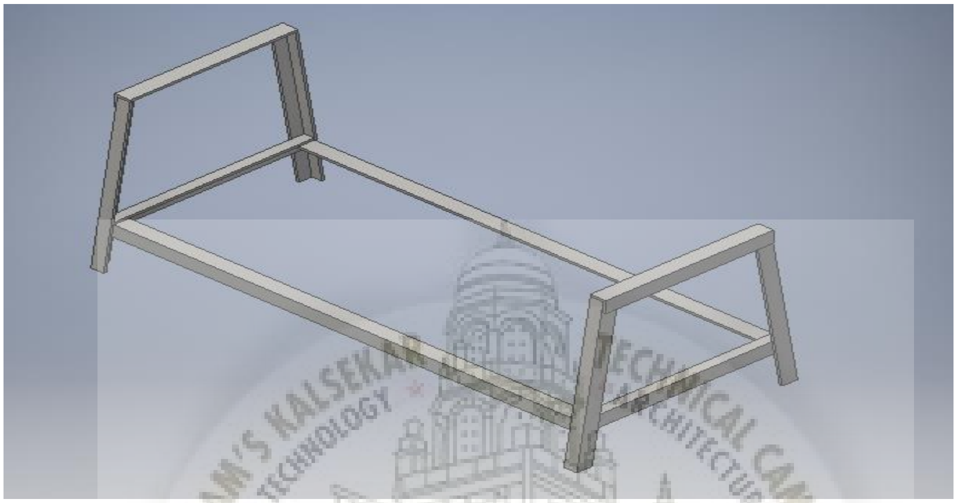

Fig.6.14.1. 3D CAD design of stand

6.15. MOTOR

The motor used is a 0.75 HP, 3 phase geared motor with an output speed of 20 rpm. It is mounted over a vertical plate which has slots to adjust the height of the motor for tightening or loosening of the chain.

Fig. motor

WORM & WORM WHEEL

A worm and worm wheel pair is used to rotate the worm wheel shaft which in turn rotates the casting circles. This motion is used to move the top shaft up and down through the links and the sliding block. The worm and worm wheel pair doesn’t allow the top shaft to come down by virtue of its own weight as the worm and worm wheel allows the motion to be transmitted only in one direction i.e. it is irreversible. Both, the worm and the worm wheel have a key slot. The gear ratio of this worm and worm wheel pair is 15:1 and is made of mild steel.

Fig. worm & worm wheel

7. CALCULATION

7.1. STEP DIAMETER OF SHAFT & MOTOR POWER

Material = EN9 Carbon steel

Diameter of the shaft = 75mm

Radius of the shaft = 37.5mm

Center to center distance of the bottom rolls (Ls) = 134mm

Material of shaft

Thickness of sheet (t) = 1.6mm

∴ y = 0.8mm

$\sigma_{y\ sheet}$= 250Mpa, FOS =1

∴ $\sigma_{b\ sheet} = \frac{\sigma_{y\ sheet}}{FOS}$ x 1.5 = $\frac{250}{1}\ x\ 150$

$\sigma_{b\ sheet}$= 375 MPa

Now,

I = $\frac{Ls\ x\ t^3}{12} = \frac{134\ x\ 1.6^3}{12}$

∴ I = 45.7386 mm^4

Now,

$$\frac{M}{I} = \frac{\sigma_{b\ sheet}}{Y}$$

∴ $\frac{M}{45.7386} = \frac{375}{0.8}$

∴ M= 21440 N-mm

M= F x $\frac{134}{4}$

∴ F = 640 N

To find weight of shaft

Material density = 7850 Kgf/m^3

M = $\rho \; x \; v$

= $\rho \; x \; \pi \; x \; r_{shaft}{}^2 x L_{shaft}$

= 7850 x $\pi \; x \; 0.0375^2 x \; 1$

= 34.68 kg

Weight of shaft = m x 9.81

= 34.68 x 9.81

= 340.213 N

Ra = Rb = $\frac{F+W_{shaft}}{2} = \frac{640+340.213}{2}$

Rn = Ra = Rb = 490.106 N

Now, frictional force (Ff) = $\mu \; x \; Rn$

here, $\mu = 0.21$ for cast iron and steel lubricated contact

∴ Ff = 0.21 x 490.106

Ff = 102.92 N

T = (F +Ff) x r_{shaft}

= (640 + 102.92) x 0.0375

T = 27.8595 Nm

P = $\frac{2 \; x \; \pi \; N \; x \; T}{60} = \frac{2 \; x \; 3.14 \; x \; 20 \; x \; 27.8595}{60}$

P = 58.348 W

$\sigma_{y \; shaft}$= 300 MPa

Taking FOS = 3

$\sigma_{b\ shaft} = \frac{310}{5}\ x\ 1.5$

$\sigma_{b\ shaft}$ = 155 MPa

$\therefore \tau = \frac{\sigma_b}{2}$ = 77.5 MPa

Now, $M_{shaft} = \frac{F\ x\ L_{shaft}}{4}$

$= \frac{640\ x\ 1}{4}$

$M_{shaft} = 160\ Nm$

$T_{eq} = \sqrt{T^2 + M_{shaft^2}}$

$= \sqrt{27.8595^2 +\ 160^2}$

$T_{eq} = 162.407\ Nm$

Now,

$T_{eq} = \frac{\pi}{16}\ x\ \tau\ x\ d^3$

$162.407 \text{ x } 10^3 = \frac{\pi}{16}\ x\ 77.5\ x\ d^3$

∴ step diameter, d = 22.01 mm

7.2. DESIGN OF CHAIN

Constraints/ parameters known:

P = 0.75 HP = 0.5593 KW

N_1 = 20 RPM

N_2 = 20 RPM

1) **Design power [P] = P × service factor**

Taking service factor = 1.25 from PSG 7.76

= 0.5593 x 1.25

= 0.699

≈ 0.7 KW

2) **Number of teeth,**

Sprocket teeth = 18 = Z_1

i = 1

Z_2 = 18

3) **Pitch,**

$$P = 2.8 \text{ x } \sqrt[3]{\frac{Mt_1}{\sigma_{brg\ x}\ Z_{1\ x\ m}}}$$

m = 1 ∵ single row chain

$[\sigma_{brg}]$ = 3.5 kgf/ mm^2 PSG 7.77

= 35 N/mm^2

4) **Torque**

$$[Mt_1] = \frac{P\ x\ 60}{2\pi\ x\ N_1}$$

$$= \frac{0.7\ x\ 60}{2\pi\ x\ 20}$$

= 0.334 Nm

$= 0.334 \times 10^3$ N-mm

$[p] = 2.8\sqrt[3]{\frac{0.334 \times 10^3}{35 \times 18 \times 1}}$

[p] = 2.266 mm (pitch)

From PSG 7.71, selecting **ISO-D8B R1278 chain.**

Chain specification:

Pitch = 12.7 mm

Roller diameter maximum = 8.5 mm

Breaking Area = 0.5 cm^2

Weight/meter = 0.7 kgf

Breaking load = 1820 kgf

7.3. PIN DIAMETER OR INSIDE DIAMETER OF EYE OF LINK

Bush

$P_b = \frac{Load}{Area} = \frac{P}{L\ x\ d}$

P_b = 1.25 – 1.5 (for knuckle joint)

$1.5 = \frac{1000}{40\ x\ d}$

d = 16.66 mm

Checking shear stress,

$\tau \quad = \frac{F}{A}$

$\quad = \frac{1000}{\pi/_4\ x\ 20^2}$

$\tau \quad$ = 3.18 MPa

For **Mild Steel** tau = 50 MPa

τ = 3.18 < 50 MPa

Hence, safe.

8. ASSEMBLY

Fig.8.1. assembled machine containing all the components

9. WORKING

First sheet is placed in between top roll and bottom rolls then the required radius of sheet set by lowering the top roll by rotating lever. When we rotate the lever, cam rotates and one end of link is connected eccentrically and one end of link is connected to sliding block and ends of top shaft is hold by sliding block. The cam shaft connects both the cams situated at each side.

Worm and lever is on the same shaft. When we rotate lever worm rotates which rotate the worm wheel. Worm wheel is on the cam shaft, so it rotates cam shaft of both the side it moves up and down sliding block of both side.

The motion at both the bottom roll is transmitted by motor via chain drive. The motor can rotate in both the direction and the direction of rotation can be change by switch.

For the ejection of the sheet from the machine after its get rolled, pull type bush is used which is at one end of the top roll and that end of shaft can be taken off from sliding block as the slot is provided which helps to tilt shaft from sliding block and other end of top roll is on tilting bush. On the contrary sliding block has a tilting bush which helps shaft to tilt and sheet can be removed easily.

If the sheet thickness is less and radius required is more than it can be done in single pass, although one can reverse the motor direction and pass the sheet again in between roller without ejecting it to ensure better finishing of rolled product. More number of passes would be necessary if sheet thickness in comparatively more and radius is less, otherwise if one try to get minimum radius in the single pass chances are high that sheet would fracture.

10. MODIFICATION COMPARED TO PREVIOUS DESIGN

1) **Integration of motor**

   The existing design in the industry was hand operated. Company wanted to upgrade it by making it motor equipped. One cannot just add motor and start getting output at faster rate. There was needed to calculate the capacity, mounting position, type of drive etc. and even modification in the previous design to make it more efficient and easy to operate.

2) **Power is supplied to both the lower rolls**

   Giving input to only one bottom roller causes slippage of sheet during operation and hence it was decided to give both bottom roller a input power source so as to eliminate slippage resulting more accurate operation.

3) **Redefined arrangement for reciprocating movement of the upper roll**

   In existing machine in order to move upper roller vertically for getting different radius of curvature one needs to turn the screw provided at both the side frame. In this case if both the screws do not happened to turn by exactly same thread the shaft won't be perfectly horizontal and the effect will be noticed on finished product.

11. TESTING & ANALYSIS

Speed = 20 RPM

Diameter of roll = 75mm

$V = \frac{\pi\ x\ Dx\ N}{60}$

$T = \frac{distance}{speed}$

A) Thickness of sheet = 1mm

Sr no.	Depth (mm)	Diameter obtained (mm)	Length of sheet required (mm) = πD	Time taken for one pass of sheet (sec)
1	10	360	1131	14.4
2	15	210	660	8.4
3	20	140	440	5.6
4	25	110	346	4.4
5	30	95	298	3.79
6	36	77	242	3.08

B) Thickness of sheet = 1.2mm

Sr no.	Depth (mm)	Diameter obtained (mm)	Length of sheet required (mm) = πD	Time taken for one pass of sheet (sec)
1	10	285	895	11.46
2	15	215	675	8.6
3	20	155	487	6.2
4	25	125	393	5
5	30	95	298	3.71
6	36	80	251	3.19

C) Thickness of sheet = 1.6mm

Sr no.	Depth (mm)	Diameter obtained (mm)	Length of sheet required (mm) = πD	Time taken for one pass of sheet (sec)
1	10	385	1210	15.41
2	15	230	723	9.21
3	20	150	471	5.6
4	25	115	361	4.6
5	30	90	283	3.6
6	36	80	251	3.19

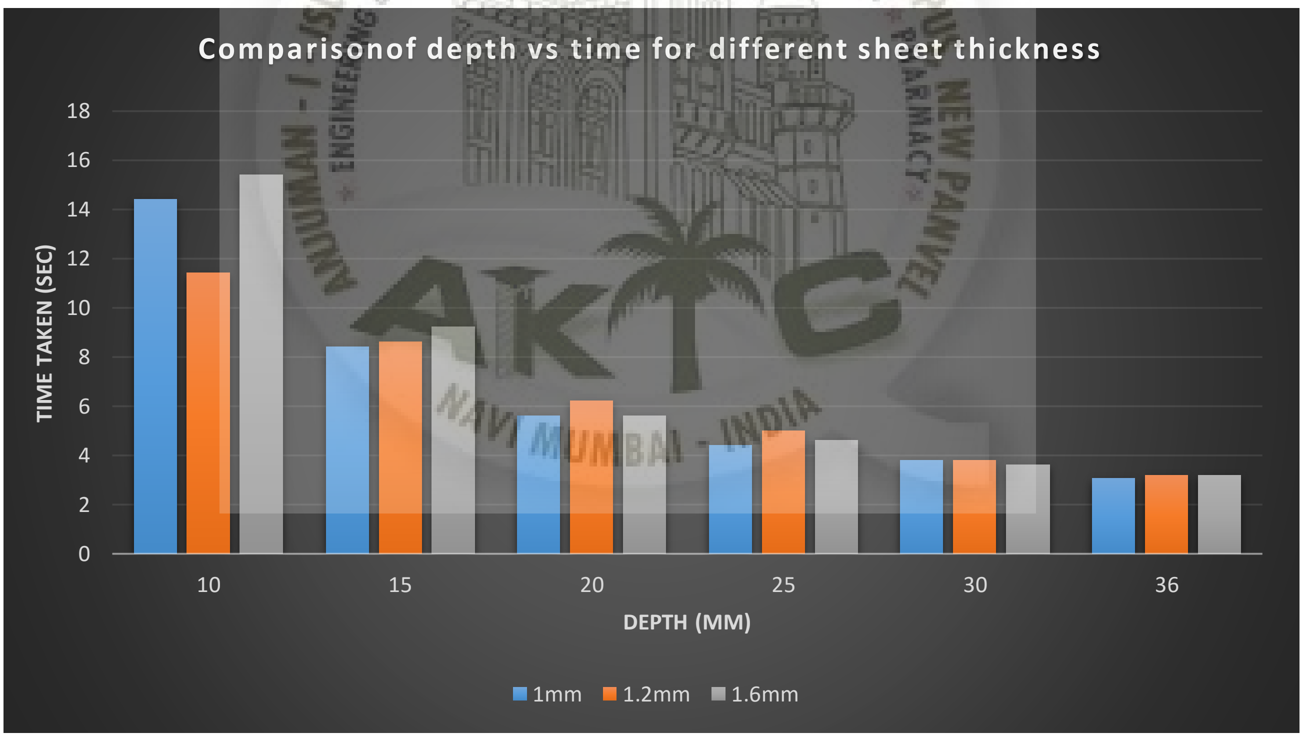

Table11.1. Comparison of time taken for varying depth for different thickness of sheet

12. PRODUCTIVITY CALCULATION

Sample calculation,

For our project

Time taken = 15.41 sec (for one pass)
= 61.64 sec (for four passes)

Total Allowances allowance = loading and unloading + relax allowance + interference

= 50% of normal time + 20% of normal time + 20% of normal time
= 0.5 x 30.82 + 0.2 x 30.82 + 0.2 x 30.82
= 27.738

Standard time = normal time + total allowances + machine setting time
= 61.64 + 27.738 + 10 sec

[FOR SHEET LENGTH = 1210 MM AND DEPTH = 10MM]

Factors	**SURAJ ENGINEERING (PUNE)**	**BHAVIK ENTERPRISE (AHMADABAD)**	**BENDSOR MACHINE & TOOLS (OUR PROJECT)**
Maximum thickness that can be rolled (mm)	1.6	1.6	1.6
Motor power (HP)	1	2	0.75
Speed (RPM)	20	10	20
Roller diameter (mm)	82	75	75
Adjustment of top roller	Both ends of rolls to be adjusted individually	Both ends of rolls to be adjusted individually	both ends will be perfectly adjusted by single lever
Time taken (sec)	15.41	30.82	15.41
Machine cost (rs)	75,000/-	62,500/-	52,000/-
Productivity (considering the same allowances for each machine)	288 sheets/day	144 sheets/day	288sheets/day

13. COST ESTIMATION

Sr. no	Particulars	Quantity	Approx Cost
1	Rollers	3	5500
2	Roller bush	4	600
3	Side frame	2	3500
4	Tie rod	2	600
5	Cam	2	800
6	Cam shaft	1	600
7	link	2	450
8	Sliding block	2	900
9	Pull type bush	1	650
10	Base	1	950
11	Worm & wheel	1 pair	900
12	Sprocket	3	300
13	Chain	1	400
14	Motor	1	5000
15	Lever	1	300
	Total		21450

Table13.1. Cost estimation

Other cost,

Gas cutting – 500 rs

Key slotting – 430 rs

Painting – 750 rs

Total cost = 23,130 rs

*The cost listed above is excluding machining cost and travelling cost.

14. CONCLUSION

In the long journey of completion of this project we've applied all our theoretical knowledge that we've learnt during our Bachelor of Engineering as well as throughout our student life. We had been given several objectives which we've achieved successfully and with remarkable accuracy considering we've never worked in an industry and never had any experience of working in such environment.

All the components in the machine has been manufactured based on either calculation or standard available in the market for maximum accuracy and increasing machine life which would provide us the competitive edge in the market.

After all the parts being manufactured, we've taken several dry test of the machine and made sure it works according to the design. And then finally we begin analysis on different sheets having different thickness to compare the time taken during production and hence productivity of our machine.

We have encountered many challenge throughout the completion of project but we tackled them all thanks to the good chemistry among we project member and also better supervision at the industry helped us achieving all the objectives.

15. FUTURE SCOPE

- Better sheet ejection method can be made
- Movement of top roll can be entirely controlled by switch.
- Problem of pre bending of sheet edges in pyramid type can be solved.
- Sheet can be rolled completely in one pass with good accuracy irrespective of radius required.

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