A PROJECT REPORT ON

DESIGN AND DEVELOPEMENT OF FOUR ROLL SHEET METAL BENDING MACHINE

Submitted as fulfilment towards the Bachelor Degree in the field of

Manufacturing Engineering

GUJARAT TECHNOLOGICAL UNIVERSITY

Chandkheda, Ahmedabad

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CENTRAL INSTITUTE OF PLASTICS ENGINEERING AND TECHNOLOGY- AHMEDABAD. 2017- 2018

CIPET – INSTITUTE OF PLASTIC TECHNOLOGY,

Department of Manufacturing Engineering

CERTIFICATE

This is to certify that the report on "DESIGN AND DEVELOPEMENT OF 4 ROLL BENDINGMACHINE" submitted by us in fulfilment of the requirement for the award of Bachelor degree in Manufacturing Engineering of Gujarat Technological University, Ahmedabad during the academic year 2017-18 of the CIPET – INSTITUTE OF PLASTICS TECHNOLOGY, Ahmedabad is a record of his own work carried out under my supervision and guidance. The matter embodied in the preliminary project report has not been submitted elsewhere for a degree.

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DECLARATION

I hereby declare that the project/ dissertation entitled, "**DESIGN & DEVELOPMENT OF FOUR ROLL SHEET METAL BENDING MACHINE"** was carried out and written us under the guidance of Mr. Nirmal Patel, Director, M/s Krishna Engineering and Mr. Mukund Pandey, Assistant Professor, Department of Manufacturing Engineering CIPET – INSTITUTE OF PLASTICS TECHNOLOGY, Ahmedabad. This work has not been submitted elsewhere for the award of any degree or diploma.

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ACKNOWLEDGEMENT

Quality is never an accident.... it is always the result of an intelligent effect. There must be a will to produce a superior thing. All we need in this world is hard work and confidence and the success is sure. Success is not a one man phenomenon but it is the result of working together we take this opportunity to express our gratitude towards everybody who has rendered cooperation in making this Seminar report on **"DESIGN AND DEVELOPEMENT OF 4 ROLL BENDING MACHINE"** a success.

On this occasion we could not miss out thankful acknowledgement to the management of M/s Krishna Engineering and our guides, Mr. Nirmal Patel, Director, M/s Krishna Engineering and Mr. Mukund Pandey and Head of Department Dr. Sandip Mirza our Vice Principle nominated Dr. Ajay Nema for their able guidance and valuable suggestions.

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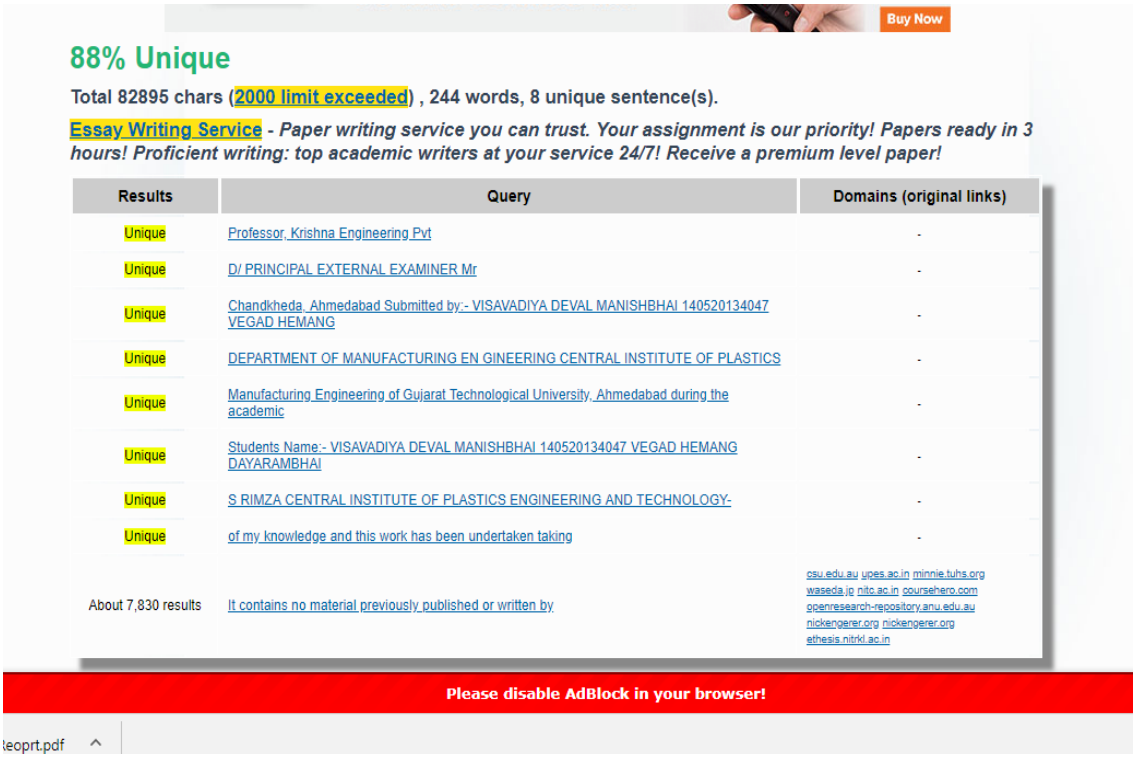

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ABSRACT

Metal forming can be defined as a process in which the desired size and shapes are obtained through plastic deformation of a material without any significance loss of material. Bending is a metal forming process in which linear, planar shapes are transformed into a curvilinear 3D shapes. In similar line manufacturing industries use "Roller forming" which is a continuous bending operation in which a long strip of metal is passed through consecutive sets of rollers, until the desired cross sectional profile is obtained.

Roller bending process can be used to deform a sheet or plate to hollow shapes of constant continuous cylindrical, elliptical shapes or continuously varying cross sections like cone frustum. Cylindrical and conical shells are the basic components used for the various engineering applications like cylindrical tanks, boiler chambers, heat exchanger shells, pressure vessels, tunnels, etc. This metal rolling machine is used largely in pharmaceutical industry for machine manufacturing.

Roller forming process can be performed using many materials such as carbon and alloy steels, aluminium alloys and titanium alloys. Rolling machines with both three and four rolls are indispensible to the production of cylinders with various curvatures.

While there are many rollers forming machines in the industry and are commercial sold, many of the existing machines do not meet many customized tasks of the specific industrial needs. In addition the machines are not cost effective. Therefore, the industry ends up in using alternate fabrication processes in realizing the above mentioned shapes. There is a serious dearth of cost-effective customized roll bending machine and hence this dissertation work focusses on the design of a cost effective and adaptive roll bending machine particularly catering to the small scale industry requirements where the features and functions of the roll bending are not sacrificed but the design of the machine is done in a way that the cost is kept to a minimum. This work dwells on the new design concepts which will try to solve many of the problems and bring out unique solutions which are realizable from the off the shelf components in the market by proposing various design concepts and working out the pros and cons of each of the machine in terms of its functions, capabilities, capacity and the cost. It is intended to develop a design which is low in cost to the conventionally available commercial roll bending machines.

CHAPTER 01

INTRODUCTION

1.1 Roll Bending Machine:

Metal forming can be defined as a process in which the desired size and shapes are obtained through plastic deformation of a material without any significance loss of material. Bending is a metal forming process in which linear, planar shapes are transformed into a curvilinear 3D shapes. "Roller forming" which is a continuous bending operation in which a long strip of metal is passed through consecutive sets of rollers, until the desired cross sectional profile is obtained.

Bending:

Bending is one of the most common forming operations. Bending is usually defined as the deforming of the sheet metal along the straight line around a straight axis called neutral axis, result in the plane surface at an angle to the original plane. Bending is a manufacturing process that produces a V-shape, U-shape, or channel shape along a straight axis in ductile materials, most commonly sheet metal. During bending the top layers are subject to tension and the bottom layer are subjected to compression.

Rolling Process:

In metal working, rolling is a metal forming process in which metal stock is passed through one or more pairs of rolls to reduce the thickness and to make the thickness uniform. Rolling is the process of reducing the thickness or changing the cross section of a long work-piece by compressive forces applied through a set of rolls.

The metal sheet is not cut and no material is removed. For this reason, roll bending of metal sheets is one of the chip less sheet metal forming methods. Roll bending is used if a metal sheet panel is to be given a larger, smooth radius, which we can only produce in our press brake with step bending.

Rolling is classified according to the temperature of the metal rolled. If the temperature of the metal is above recrystallization temperature, then the process is

known as hot rolling. If the temperature of the metal is below the recrystallization temperature, the process is known as cold rolling.

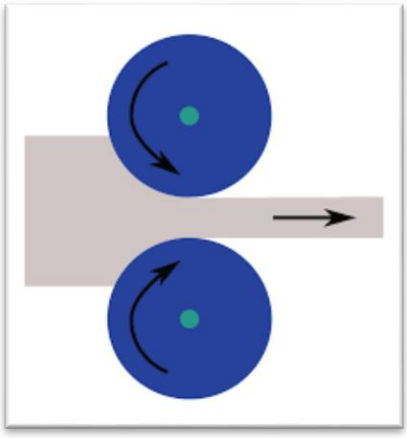


Figure 1.1 : Rolling Process

In terms of usage, hot rolling processes more tonnage than any other manufacturing process, and cold rolling processes the most tonnage out of all cold working processes. Roll stands holding pairs of rolls are grouped together into rolling mills that can quickly process metal, typically steel, into products such a structure steel (I-beams, angle stock, channel stock, and so on), bar stock, and rails.

Most steel mills have rolling mill divisions that convert the semi-finished casting products into finished products into finished products.

Roll bending machine works on the principle of metal forming process in manufacturing. It is used to forms cylindrical, elliptical or conical parts from the simple planar sheet. A metal strip is inserted at either side of the machine and with the help of roller it will be out in the desired shape. Roll bending machine can be operated by manually, NC controlled or CNC controlled.

Roll bending machine is generally used for large production, in government appliances, in job work production, etc.

1.2 Types of Bending Machine:

Generally there are three types of machines are available. The machines are divided by the number of rollers used in the machine to bend the sheet.

1) Two roll bending machine

2) Three roll bending machine

3) Four roll bending machine

1.2.1 Two Roll Bending Machine:

This type of Machine contains 2 solid rolls. Top roll is static and the force for plate rolling process is applied by bottom roll. This is an ideal machine for fast production. It is widely used for making small diameter components like submersible pump body. Mostly this machine is suitable for rolling lower thickness sheets.

Fig.1.2.1 Two Roll Bending Machine

1.2.2 Three Roll Bending Machine:

This is one of the most commonly used machine is sheet metal bending industry for rolling heavy steel plates. These types of sheet Bending Machine is made up using 3 rolls. Top roll is static and the force for plate rolling applied by 2 side rolls. One side roll is used for pre-pinching so it is called pinch roll. This machine is ideal for pre pinching operation.

This sheet rolling machine is suitable for high thickness heavy steel plates and making components of large diameters. Any kind of Heavy fabrication work is performed by this machine like Storage Tanks, Pressure Vessels, Wind Mills Shells etc.

In 3 roller sheet bending machine sheet is bent with the help of load acting on upper roller, which is movable. 3 roller sheet bending machine mainly consist of following parts: 3 rollers (upper roller and 2 bottom rollers), motors, gears, power screw, and frame. Bending operation is done by applying load (force) with the help of upper roller, which is movable. It can be moved by adjusting the power screw manually. Two bottom rollers are fixed which acts as a support for holding the metal sheet. When upper roller moves in a clockwise direction, bottom rollers simultaneously move in anticlockwise direction. Motor is used in sheet bending

machine for providing power transmission. Gear drives are used for minimize the rpm transferred from motor to the assembly (machine).

Fig.1.2.2 Three Roll Bending Machine

Spur gears are used in 3 roller sheet bending machine. Spur gears used are made up of cast iron. Square threaded power screw is used to change the position of upper roller. This operation is totally manual. Frame is a fixed rigid support used for supporting the assembly and also prevent machine from vibrations.

1.2.3 Four Roll bending machine:

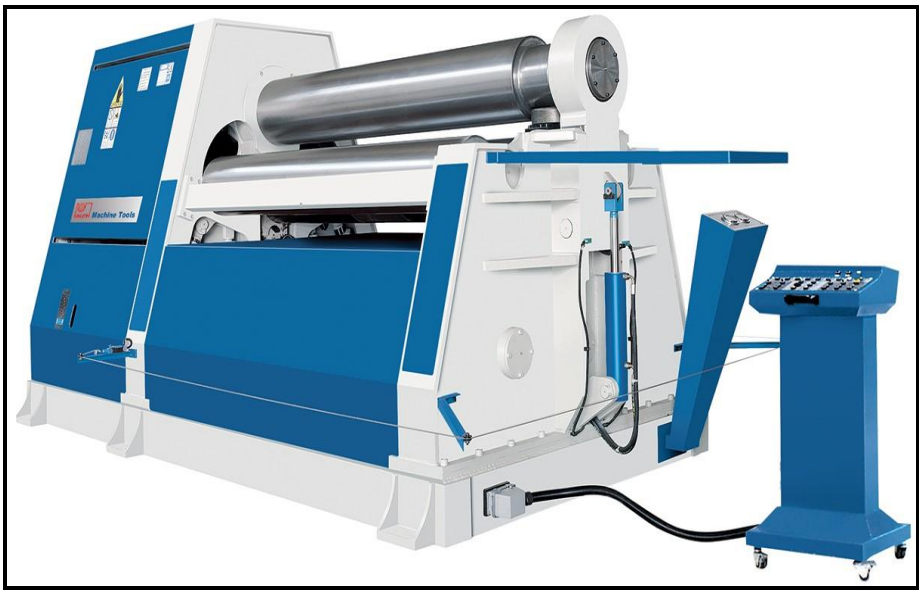


Fig.1.2.3 Four Roll Bending Machine

The four roll bending machine is the latest version of the bending machine. In this there are four roll used for bending the metal sheet. In which the upper roll is remain fixed and the lower roll is move up and down in order to set the thickness of the introduced sheet. The side two rollers are use for the support and positioning to bend sheet. The side roll are also used for the pre pinch of the machine. They also direct the sheet which is to be bent. It also facilitates to the auto removal of the final part.

- **Process & construction of four roll bending machine:**

The mechanism of machine is as follow:

a. The base frame:

All machine frames are designed for maximum stability under bending forces, including asymmetric loads and torque. A very compact design and the fact that no dynamic process forces will be inducted into the foundations allow for low machine pit constructions costs.

b. Rotational top & bottom drive:

Roller drives are defined by the installed maximum power and torque. The bigger maximum torques will be the bigger bending steps can be during roll bending which typically allows for shorter production times.

Fig.1.2.4 Roller final shape

c. During every bending process the machine's top roller will carry the heaviest load resulting from the bending forces induced by the bottom and side roller. The top roll's diameter thus becomes a critical parameter which will determine both minimum bending diameter and roll deflection under load. A smaller roll will allow smaller bending diameters but also bigger roll deflection.

d. Side roll positioning will define the resulting bending diameter. The bending forces created during the process will be guided from the side roller carriage onto the machine frame. The longer these guiding areas, the lower material stress will be, thus reducing wear and tear and improving machine precision and longevity.

e. The bottom roller and it's installed maximum bottom roller force define how long the remaining flat ends will be during pre-bending. Bottom roller force and achievable flat ends are the most important characteristics in determining the capacity of a plate bending machine.

1.3 Need of Project:

The bending machine is very useful for the sheet working industries. It is very useful machine and used in many fields. Bending machine is required for many purposes like in transportation, railways, home appliances, etc there are so many uses of parts which can be produced by the bending machine. It is also use in pharmaceuticals industries and wind tower, bush & bush bearing, cylindrical storage tank. Bending machine is widely used for making small diameter components like submersible pump body. There are also many fields which are covered by the metal forming and the bending sheet. As there are so many advantages of the machine, and it gives much precision works, the price of the machine is very high that small scale industries cannot afford it. While it is also required the special purpose machine for the making the conical shape.

Small scale industries cannot afford the machine thus they are using the hydraulic press for bending the sheet. It is very time consuming process and also the precision is depended on the skill of the operator. The hydraulic press gives very low production and the finishing of the product is also not good. The bending process done by the hydraulic press is required many passes to get the final shape of the product.

1.4 Scope of project:

If the cost-effective bending machine is to be produced it will be very helpful for many industries related to sheet metal working. If the bending machine is available at low price and it will be constructed for general purpose machine, then it will be very useful for small scale industries. They can install the bending machine at low cost of installation. The productivity of industries will increase drastically. Operator can gives its best output of its skill with the help of bending machine.

1.5 Objective of Project:

Roll bending is the machine which roll a different kind of metal sheet in to a round or conical shape. It can be known as a roll bending machine or rolling machine as well as plate roll bending machine. Our main objective is to design development & make cost effective of roll bending machine. The objective of the machine is to give the proper requirement of the shape to industry, because early the industrialists, small scale industry going to do a pre bend the plates or sheet on a hydraulic press for pre punching purpose and then loaded on sheet bending machine. Apart from this performing operation on different machine, the small scale industry wasting his time to do a work that is not happening on the machine as well as they need two different machine for the bending of sheet. If our objective is accomplished then the loading &unloading of the plates or sheets from the hydraulic press as well as from the plate rolling machine that procedure cannot occur.

Thus the aim of our project is to modified the machine which is gives good finishing in case if the thickness of sheet is less then 4mm and again design machine with necessary development. And also provide the cost effective 4 roll bending machine which can helps the small scale industries. Another object of our project is to provide the general purpose 4 roll bending machine which can easily form the conical and cylindrical parts.

1.6 Methodology of Project:

a. Industrial survey
b. Selection of work
c. Problem identification
d. Think on area of solution

e. Gives best possible solution

1.7 Advantages & Disadvantages:

A) Advantages:

There are so many advantages of this machine like

a. Easy plate alignment using one of the side rolls as a stopper

b. Automatic minimization of the flat end length

c. Guaranteed rotation traction on work piece even for very thin sheets

d. Easy cone rolling and cone pressing using angled side roll positions and cone bending accessories.

e. Easy plate and precise edge handling allows for work piece tack welding on the machine,

f. Very good calibrating capability for apple- or pear-shaped work pieces

g. The productivity will be increases,

h. It will give the precision work,

i. Ease of processing,

B) Disadvantages:

a. The only disadvantage of the machine is the price of the bending machine.

1.8 Application:

Sheet bending machine is mainly used to deform or shape metals into desired shapes and sizes. The metal is subjected to higher stress causing it to deform because of disturbance in its yield and tensile strength. A strong force is applied on a metal part to be shaped causing it to deform in a particular direction. For metal to be casted into customized irregular shape, a sequence of operations are to performed on the metals with these sheet bending.

1.9 Outline of Project:

1.9.1 Introduction

In this part the forming process is explained. Gives the information about the roll bending machine, types of this machine and how it works.

1.9.2 Literature review

In this part the necessary material that will help better in understanding the bending machine construction and its mechanism is given. Research papers are included in this part.

1.9.3 Design Specification

In this part the all parts of the machine are explained and also gives the selection criteria of the specific parts.

1.9.4 Design Calculation

In this part the necessary calculations for design and selection of the parts are given and explained.

1.9.5 CAD/CAE SIMULATION

In this part the modelling of the bending machine is shown and explained its basic construction. It also includes the analysis data of the machine.

1.9.6 Conclusion

In this part the final result of the project and its application is given.

CHAPTER – 02

LITERATURE REVIEW

For our project purpose we study different patent and papers and also refer several books. From that we found patents somewhat is related to our project. For study the bending machine and its mechanism in detail we study some patent on the bending machine, hydraulic panel, planetary gear mechanism, speed transmission, etc.

Some related patent which we study is mention below:

Patent – 1

Programmable plate bending machine

Patent no. - US5187959A

Author - Orzio M Davi

Abstract - A roll bending machine for bending plates or iron sheets with a programmable work cycle a central processing unit (CPU) by suitable sensing means controls the working positions of the rolls of the bending machine adjusting them according to programmed data which can be modified each time by an operator or automatically, according to the characteristics of the plate being worked. The use of a three-point sensing device enables the diameter which the machine is conferring to the plate, to be controlled, intervening to make the necessary corrections.

Patent - 2

Hydraulic System

Patent no. - US3635021A

Author - Kenneth G Mcmillen, Wendell E Miller

Abstract - Pump controls having a sensor valve that operates between two positions to control the displacement of a pump in response to pressure differentials caused by flow through a variable orifice. Override of the sensor valve is provided by a pressure and displacement sensitive valve thereby limiting the input torque of the pump.

Patent - 3

Change Speed Transmission

Patent no - US2870655A

Author - Harvey w Rockwell

Abstract - This invention relates to change speed transmissions and particularly to a change speed transmission employing friction contact plates to effect a shift to a different speed ratio.

It is desirable in many applications where power is transmitted through a shaft to provide a way of changing speed ratios without having to un-clutch the power source and shift gears. For examples, such a change speed transmission may be desired in tractors-drawing heavy loads where it can be used in combinations with a standard clutch and torque converter or it may be desirable to use the unit in an electric motor drive involving a series wound motor to prevent the motor from running away during a shifting operation.

Patent - 4

Integrated DC Servo Motor & Control

Patent no. - US5912541A

Author - Robert A. Bigler, Punita Pandit Bigler

Abstract - An integrated motion control device having a controller mated to a motor body with a set of rigid, electrically conductive signal pins. The motor is direct-current and preferably brushless, and has Hall sensors within the motor body and an encoder at a back end for precisely determining rotor position. Signals from the Hall sensors and encoder are fed to a microprocessor contained in the controller and including a PID filter for servo control of the motor. The controller contains an amplifier for driving the motor and a power supply for providing appropriate levels of DC power to various elements of the controller and motor. All electrical signals between the motor and controller are transmitted via the pins, eliminating wiring harnesses of the prior art and related signal noise and wiring problems. The motor body and controller are affixed with a few screws allowing the controller to be removed from the motor while the motor remains connected to an application. Communication ports are provided at a rear of the controller for connection to a computer or peripheral devices, and can be

used to daisy-chain and synchronize a number of interconnected motors and controllers.

Patent - 5

Roll Bending Machine with Selective Digital Control Device

Patent no. - US6044675A

Author - Orazio Maria Davi

Abstract - An automatic roll bending machine for bending metal sheets, sections and the like. The machine includes two or more bending rolls and a driver for causing rotation and/or changing the working positions of the rolls. The driver is operatively connected to an electronic control device that includes a programmable process unit provided with a movable digital control device that includes a programmable process unit provided with a movable digital control board which can be manually operated by an operator for remotely controlling in a selective manner the movements of each roll and for performing automatic execution of a bending cycle.

Patent – 6

Rotary hydraulic motor

Patent no. - US3586466A

Author - Albin R Erickson

Abstract –A rotary hydraulic motor including body structure and a vaned rotor journaled therein defining a plurality of the pressure chamber sections for reception of fluid under pressure from a common source, and valve means for controlling flow of fluid under pressure to one or a given plurality of said chamber sections selectively.

Patent – 7

High torque, low speed hydraulic motor

Patent no.- US4457677A

Author –William H. Todd

Abstract –A high torque, low speed hydraulic motor is disclosed which comprises a gerotor type rotary displacement assembly which is composed of an outer ring and an internal, eccentrically mounted star. The outer ring of the

assembly is fixed to and rotates with the drive shaft, and the inner star is held against rotation by a universal shaft linkage. A fluid valve is provided for the gerotor assembly which comprises a timing plate and a spool having cooperating flat faces, and the two faces are adjustably biased together to permit control of fluid leakage therebetween.

Patent – 8

Planetary gear

Patent no. – US6364805B1

Author – Rudolf Stegherr

Abstract –

A planetary gear arrangement includes a gear housing, a first shaft and a second shaft locatedcoaxially opposite each other, an internal geared wheel, a sun wheel torsionally fixedly connected tothe first shaft, a planet carrier that forms a rotatably supported constructional unit together with thesecond shaft, and several step planets that are rotatably supported in the planet carrier. Each stepplanet includes two connected planet wheels with different effective diameters, whereby the largerplanet wheels intermesh with the sun wheel, and the smaller planet wheels intermesh with the internalgeared wheel. Each planet wheel is arranged as a separate unit and is rotatably supported on bothsides in the planet carrier respectively via at least one roller bearing, with high stability under load.The two planet wheels of each step planet are coupled to each other in a torsionally fixed manner viaan additional shaft that engages each planet wheel in a positive-locking manner in the circumferentialdirection.

Patent – 9

Variable speed hydraulic pump

Patent no. – US6863502B2

Author – Michael B. Bishop, Roger R. Pili, Bruce E. Knuth

Abstract –The invention provides a variable speed hydraulic pump designed to operate at a maximumhorsepower throughout its pressure range by adjusting motor speed according to motor loadparameters. In particular, the variable speed hydraulic pump includes a hydraulic pump unitcoupled to a variable speed electric motor by a drive unit and to a hydraulic fluid tank forpressurizing and

pumping hydraulic fluid when operated by the motor. A motor controller iselectrically connected to the motor to supply drive signals to the motor based on electricalcharacteristics of the drive signals which are dependent on the load exerted on the motor.Suction from the load is provided by both the main pump and a bidirectional superchargingpump by reversing the direction of the motor and shifting a 4/3 valve to connect the mainpump inlet to the load and its outlet to tank. In addition, the controller reduces the motorspeed at the maximum rated pressure to just maintain the pressure, to reduce the amount offluid pumped through the maximum pressure relief valve.

Patent – 10

Gearbox

Patent no. – US20030220169A1

Author – Robert Norman

Abstract –A joint may have a multi-stage planetary gearbox between the stationary housing and therotary housing. To accommodate different gear ratios, the rotary housing may be joined to thestationary housing by a releasable attachment. This allows portions of the planetary gearboxto be replaced so that, for instance, the last stage may be chosen as either a simple orcompound differential planetary stage. To allow for different capacities, a quotient of a sumof all teeth of a sun gear of a stage and of the ring gear with which the planetary gears of thestage mesh to both the number three and the number four yields an integer. In this way, thestage may be provided with either three or four planetary gears. The gearbox may have a ringgear common to a plurality of simple planetary stages. Where the final stage is a simpleplanetary stage, the carrier may be provided with a flange extending around, and bearingmounted to, the common ring gear. To reduce weight and increase robustness, the planetarygears of a stage are retained on their carrier by a bumper ring provided between carriers. Anangle sensor may be provided between the stationary and rotary housings.

Patent – 11

Roll bending machine

Patent no. – US777816A

Author – Yasutaka Inoue

Abstract –The invention relates to a roll bending machine consisting of two rolls capable of adjustingthe radius of curvature of the pressured roll, having a rotatable endless belt between thepressured roll and the works, forming the works not only into ring-shaped products of adesired diameter but also into involute-curved, spiral-shaped, elliptical-shaped, triangular-shaped (rounded), rectangular-shaped and other sophisticated curved products, providing auniform finish to the works, meeting the size tolerance and desired diameter accuracy,eliminating any damage to the works.

Patent – 12

Drive system for a bending machine

Patent no. – US4893489A

Author – Benjamin Mason

Abstract –An improved bending machine with three rollers which may be driven at different speedsand/or with differing torques. A control system receives signals indicative of the position andspeed of rotation of one or more of the rollers. The control system is connected to amechanism for adjusting the position, rotational speed and torque of at least one roller so thatcommands can be given to vary these parameters. Thus, the machine can be readily andaccurately adjusted to produce bends of differing dimension in a strip workpiece.

Patent – 13

Automatically controlled machine for roll metal sheets

Patent no. – US4796449A

Author – Jean G. Berne

Abstract –The machine incorporates at least two central rollers appropriately driven, and adjustable inheight in order to disengage a finished object. In combination with the central rollers, siderollers are positioned in space by means

of jacks. The positioning is permanently registeredby sensors working in connection with a computer and probes positioned between the centralrollers and the side roller for providing information compared to instructions from thecomputer in order to correctly position the side rollers.

Patent – 14

Solenoid valve for fluid flow

Patent no. – US7163188B1

Author – Gregory E. Sisk

Abstract –A solenoid valve is provided that comprises a valve body having an inlet and an outlet, and amovable member for moving a valve element away from a valve seat to open the valve. Themoveable member engages and moves the valve element away from the seat to an openposition when the solenoid is actuated. When the solenoid is not actuated, a biasing springmoves the moveable member to disengage from the valve element, which returns to a closedposition. The moveable member does not transfer any impact force to the valve element onclosure of the valve member, so that the valve may be operated a significant number of cycleswithout failure.

Patent – 15

Power divider gearbox with a planetary differential gear drive

Patent no. – US4446756A

Author – Faust Hagin, Hans J. Drewitz

Abstract –A power divider gearbox including a planetary differential gear drive, comprising dualplanetary gears which mesh with two sun gears having different diameters and with aninternal ring gear, wherein the planetary differential gear drive divides the incoming powerinput transmitted to the power divider gearbox through an input shaft into a mechanicalbranch and into a hydraulic branch (displacement machine) and in which the last-mentionedbranch is connected to the internal ring gear of the planetary differential gear drive.

CHAPTER – 03

DESIGN SPECIFICATION

3.1 Implementation:

As per our objective we have to design the 4 roll bending machine and for that we have to study and consideration of the parts of the machine in which we can save the cost of the machine. We decided to make cost effective machine by the proper selection of the machine parts.

We decide to study and re-selection of the drive mechanism of the machine like motor and the hydraulic system. Also do proper selection of the programming and control of the machine. Then for further justify the cost we also done the re-selection of the roller material and also keep the machining value as low as possible.

For that we done the work step by step and complete the right selection of the parts.

3.2 Selection of Motor:

Motor is a machine, especially one powered by electricity or internal combustion that supplies motive power for a vehicle or for another device with moving parts. A motor converts electrical energy into mechanical energy. The reverse of this is the conversion of mechanical energy into electrical energy and is done by an electric generator.

Its action is based on the principle that when a current-carrying conductor is placed in a magnetic field, it experiences a mechanical force whose direction is given by Fleming's Left-hand Rule and whose magnitude is given by F = BIL Newton.

We use the motor for our machine to drive the roller and give the motion to them. As the roller is used to bend the sheet and thus it is must rotates at very low rpm. Because the high speed of roller can damage the sheet and also gives rough and uneven surface. So as the speed of roller is lower, higher the surface finish and fine part can be produced.

The roller also requires much power to bend the sheet and thus we need the power full motor which can produces high torque. The roller is also stops at any time and again starts at any time and it should not take much time for this action.

According to our requirement to find the exact motor we studied the different types of motor and the function of particular motor. So we can find perfect motor for bending machine. We studied different AC & DC motors.

- **Types of Motors:**

1. Alternating Current (AC) Motors.

2. Direct Current (DC) Motor.

- **Types of AC Motors:**

1. Synchronous Motors:

A synchronous electric motor is an AC motor in which, at steady state, the rotation of the shaft is synchronized with the frequency of the supply current; the rotation period is exactly equal to an integral number of AC cycles.

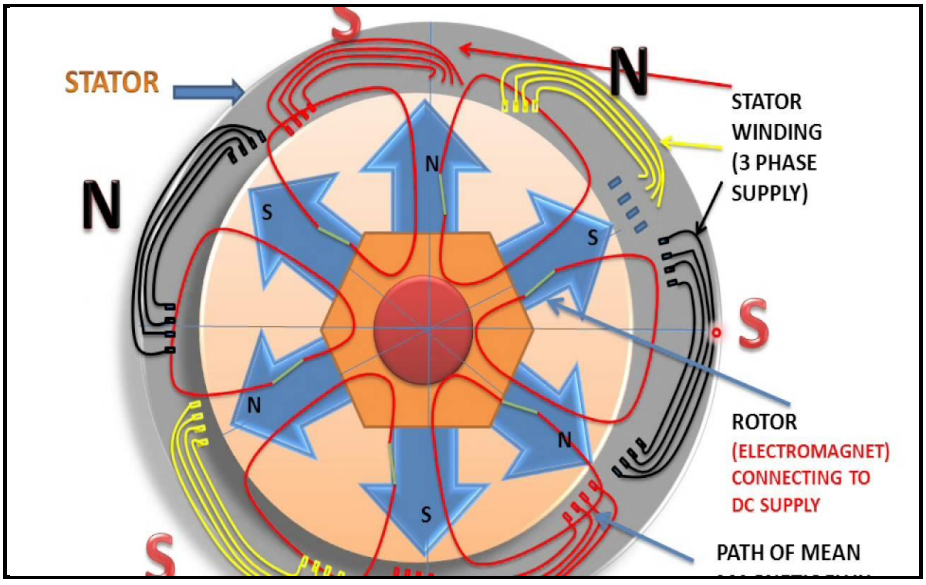


Fig.3.2(a) Synchronous Motors

Because its speed remains constant under varying loads, it is used for driving continuously-operating equipment at constant speed. These motors have the rotor (which is connected to the load) rotating at the same speed as the speed of rotation of the stator current. In other words, we can say these motors don't have slip with respect to the stator current. They are sometimes used no to drive the load but instead act as "synchronous condenser", to improve the power factor of the local grid to which it is connected to. They can also act as stepper motors.

Uses: Synchronous motors find applications in all industrial applications where constant speed is necessary. Improving the power factor as Synchronous condensers. These kind of motors are used even in high precision positioning devices like modern robots, ammonia and air compressors, motor-generator sets, continuous rolling mills, paper and cement industries.

2. Squirrel Cage Induction Motors:

This motor is quite simple but rugged and possesses high overload capacity. It has a nearly constant speed and poor starting torque.

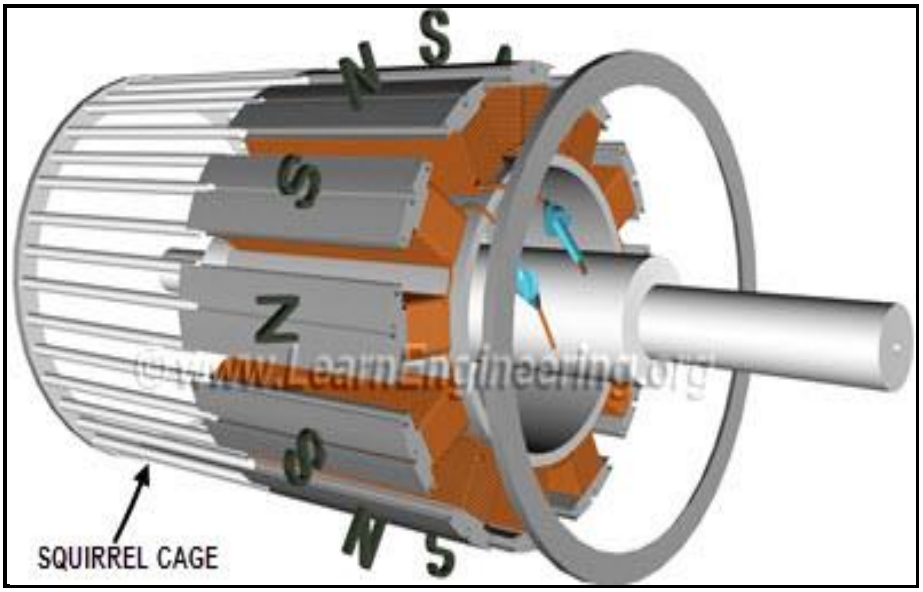


Fig.3.2(b) Squirrel Cage Induction Motors

Uses: Squirrel cage induction motor is used for low and medium power drives where speed control is not required as for water pumps, tube wells, lathes, drills, grinders, polishers, wood planers, fans, blowers, laundry washing machines and compressors etc.

3. Double Squirrel Cage Motor.

I t has high starting torque, large overload capacity and a nearly constant speed.

Uses: It is used for driving loads which require high starting torque such as compressor pumps, reciprocating pumps, large refrigerators, crushers, boring mills, textile machinery, cranes, punches and lathes etc.

4. Slip Ring Induction Motors:

It has high starting torque and large overload capacity. The speed of slip ring induction motor can be changed up to 50% of its normal speed.

Uses: The Slip ring induction motor is used for those industrial drives which require high starting torque and speed control such as lifts, pumps, winding machines, printing presses, line shafts, elevators and compressors etc.

Thus for our machine we have to select the motor of high torque and low speed. The motor available in market has the minimum rpm is 1440 and we required approx 20 rpm speed of the roller. Thus we reduce this rpm to our necessary rpm by applying proper gearbox.

- **Types of DC motors:**

1. Brush DC motor:

A Brush DC Motor provides precision control of speed, driven by a direct current. Noted for a particularly high ratio of torque to inertia, the Brush DC Motor has the potential to supply threeto four times more torque than it's rated torque. If needed, it can even provide up to five times more, without stalling. The Brush DC Motor consists of six different components: the axle, armature/rotor, commutator, stator, magnets, and brushes. The Brush DC Motor offers stable and continuous current, using rings to power a magnetic drive that operates the motor's armature. Perhaps one of the earliest used motors, the Brush DC Motor is commonly used because of the ability to vary the speed-torque ratio in almost any way.

Uses:The Brush DC Motor has a simple construction, therefore may not require a controller. When a controller is chosen,it is typically a simple and inexpensive drive design.

2. Brushless DC motors:

Some of the problems of the brushed DC motor are eliminated in the brushless design. In this motor, the mechanical "rotating switch" or commutator/ brushgear assembly is replaced by an external electronic switch synchronized to the rotor's position. Brushless motors are typically 85–90% efficient or more (higher efficiencies for a brushless electric motor, of up to 96.5%, were reported by researchers at the Tokai University in Japan in 2009), whereas DC motors with brushgear are typically 75–80% efficient.

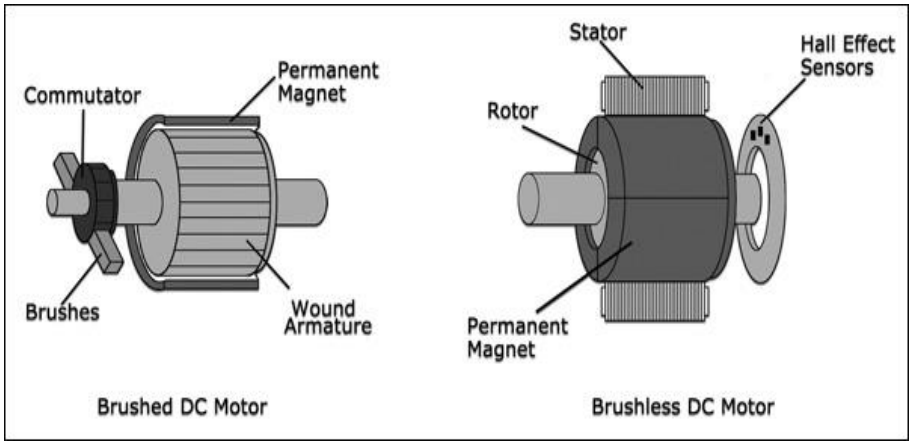


Fig.3.2(c) Brushless & Brushed DC motors

Uses: Larger brushless motors up to about 100 kW rating are used in electric vehicles. They also find significant use in high-performance electric model aircraft.

Brushless DC motors are commonly used where precise speed control is necessary, as in computer disk drives or in video cassette recorders, the spindles within CD, CD-ROM (etc.) drives, and mechanisms within office products such as fans, laser printers and photocopiers.

3. Stepper Motor:

The unique feature of a stepper motor is that the shaft rotates in definite steps, one step being taken each time a command pulse is received. When a definite number

of pulses are supplied, the shaft rotates through a definite known angle. The rotor of a stepper motor is gear shaped and it can be of ferromagnetic material or permanent magnet. Multiple toothed poles on which field coils are wound are arranged around the gear shaped rotor. The stator poles are magnetised in the appropriate manner by using a microcontroller or microprocessor or by other means.

First, one pole is magnetised by supplying the corresponding field coil. This toothed pole then aligns the rotor teeth due to magnetic attraction. Rotor teeth are slightly offset from the next pole.

At the next step, first pole is demagnetised and the second is magnetised. This causes the rotor to rotate in a fixed angle to align with the second pole and offset with the previous pole. This was the basic working principle of a stepper motor. The rotor can be made multiple stacked to achieve more steps. Also, different types of stepping (like full step, half step or micro step) can be used for achieving more steps.

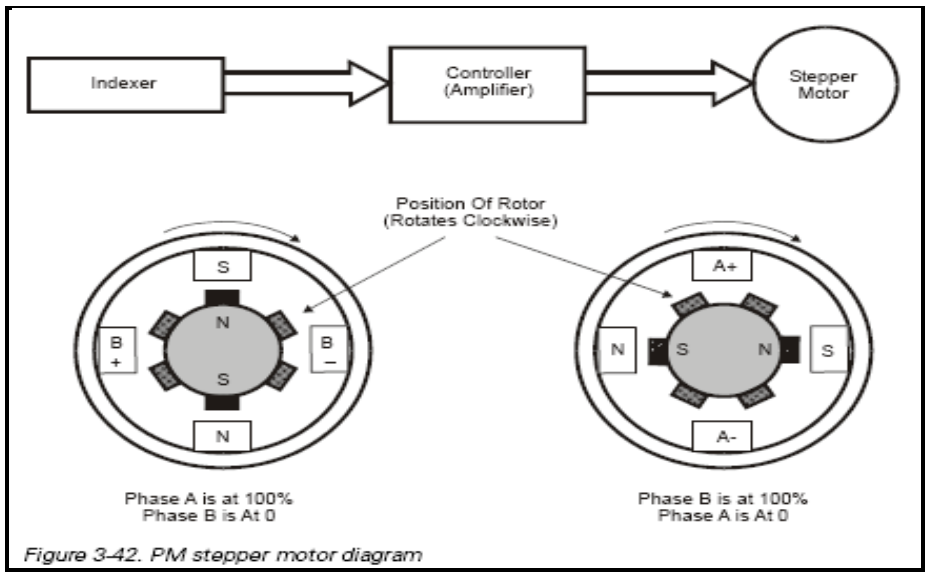


Fig.3.2(d) Stepper motor

Applications:

a) Industrial Machines – Stepper motors are used in automotive gauges and machine tooling automated production equipment.
b) Security – new surveillance products for the security industry.

c) Medical – Stepper motors are used inside medical scanners, samplers, and also found inside digital dental photography, fluid pumps, respirators and blood analysis machinery.

d) Consumer Electronics – Stepper motors in cameras for automatic digital camera focus and zoom functions.

For our purpose of high torque low speed motor we have find many motor which are available in market. We have two most suitable options for our machine is servo motor and simple ac motor.

We further study on our need of machine and also compare the price of both motor and we get to know that there is huge difference in between two. We get the ac motor near about 15000rs and the starting range of the servo is 50000rs.

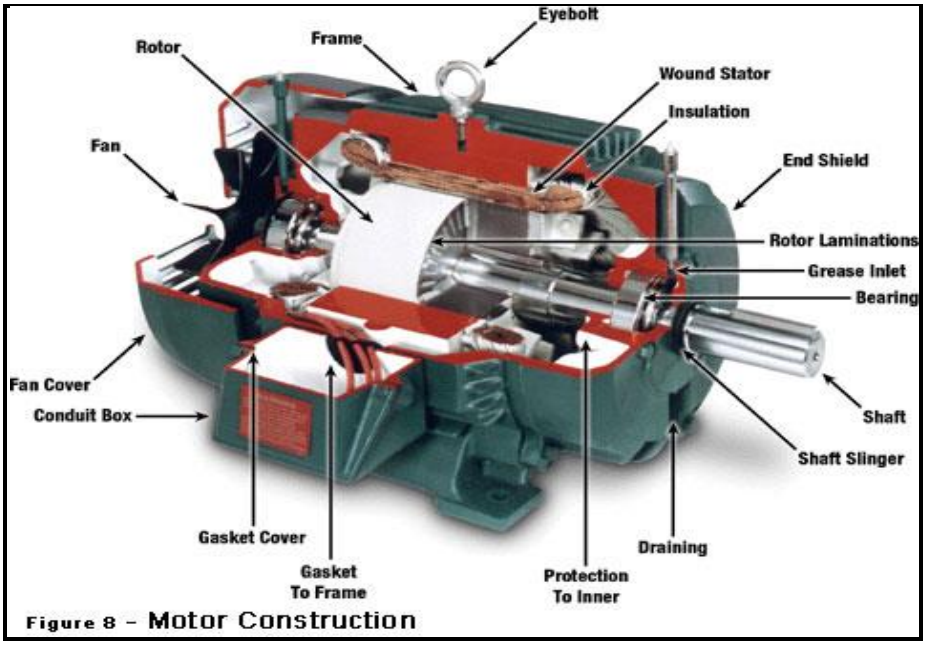


Fig.3.2(e) Motor construction

Thus we study on the application of our machine and get to know that the machine does not require too much precision for drive the roller. Thus we select the normal ac motor for our machine which also helps in keep low manufacturing cost of the machine.

The lead lower roller is big in size compare to side roller and it also performs main work in the bending of the sheet and required much force to bend the sheet

while the two side rollers are small in size and used to support the bent sheet and also direct the sheet. Thus they have no need of that much high power. Thus we select the heavy 440v motor for the lead lower roller and select 220v motor for side rollers.

We select the 3 phase motor because of the industrial purpose.

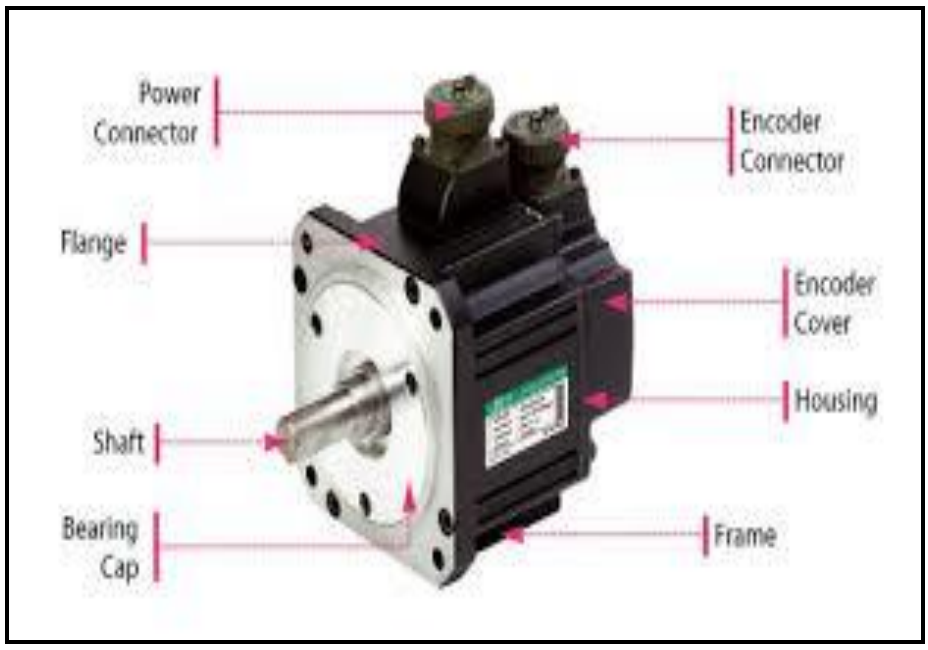


Fig.3.2(f) Parts of motor

3.3 Selection of Hydraulic System:

A hydraulic drive system is a drive or transmission system that uses pressurized hydraulic fluid to power hydraulic machinery. The term hydrostatic refers to the transfer of energy from flow and pressure, not from the kinetic energy of the flow.

- Pascal's law is the basis of hydraulic drive systems. As the pressure in the system is the same, the force that the fluid gives to the surroundings is therefore equal to pressure*area. In such a way that, a small piston feels small force and a large piston feels a large force.

As the same a hydraulic pump with a small swept volume that asks a small torque, combined with a hydraulic motor with a large swept volume that gives a large torque. In such a way a transmission with a certain ratio can be built.

By throttling the fluid between the generator part and the motor part, or by using hydraulic pumps and/or motors with adjustable swept volume, the ratio of the transmission can be changed easily. In case throttling is used, the efficiency of the transmission is limited. In case adjustable pumps and motors are used, the efficiency, however, is very large.

A hydraulic drive system consists of three parts: The generator (e.g. a hydraulic pump), driven by an electric motor, a combustion engine or a windmill; valves, filters, piping etc. (to guide and control the system); and the actuator (e.g. a hydraulic motor or hydraulic cylinder) to drive the machinery.

- **Basic Components:**

There are six basic components required for setting up a hydraulic system:

1. A reservoir to hold the liquid.

2. A pump to force the liquid through the system.

3. An electric motor or other power source to drive the pump.

4. Valves to control the liquid direction, pressure and flow rate.

5. An actuator to convert the energy of the liquid into mechanical force or torque. To do useful work. Actuators can either be cylinders which provide linear motion or motors which provide rotary motion.

6. Piping to convey the liquid from one location to another.

The hydraulic panel selection for any device or machine is selected by the pressure required to generate and from that pressure the size of hydraulic cylinder is to be selected. Thus the hydraulic cylinder size and type is very important for selection of hydraulic panel.

- Hydraulic Cylinder:

Hydraulic cylinders get their power from pressurized hydraulic fluid. A hydraulic cylinder is the actuator or "motor" side of this system. The "generator" side of the hydraulic system is the hydraulic pump which delivers a fixed or regulated flow of oil to the hydraulic cylinder, to move the piston. The piston pushes the oil in the other chamber back to the reservoir.

There are two types of Hydraulic Cylinder:

i. Single acting cylinders

In this, the oil pressure is fed only on one side of the cylinder either during extention or retraction. When the oil pressure is cut-off, these cylinders return to the normal position either by spring or by an external load like momentum of the flywheel are essentially mounted in the vertical position since the return is effected through the force of gravity.

In the case of spring return cylinders, the spring may either be external or internal. Spring size is a function of load and desired operating speed and hence needs careful selection for optimisation.

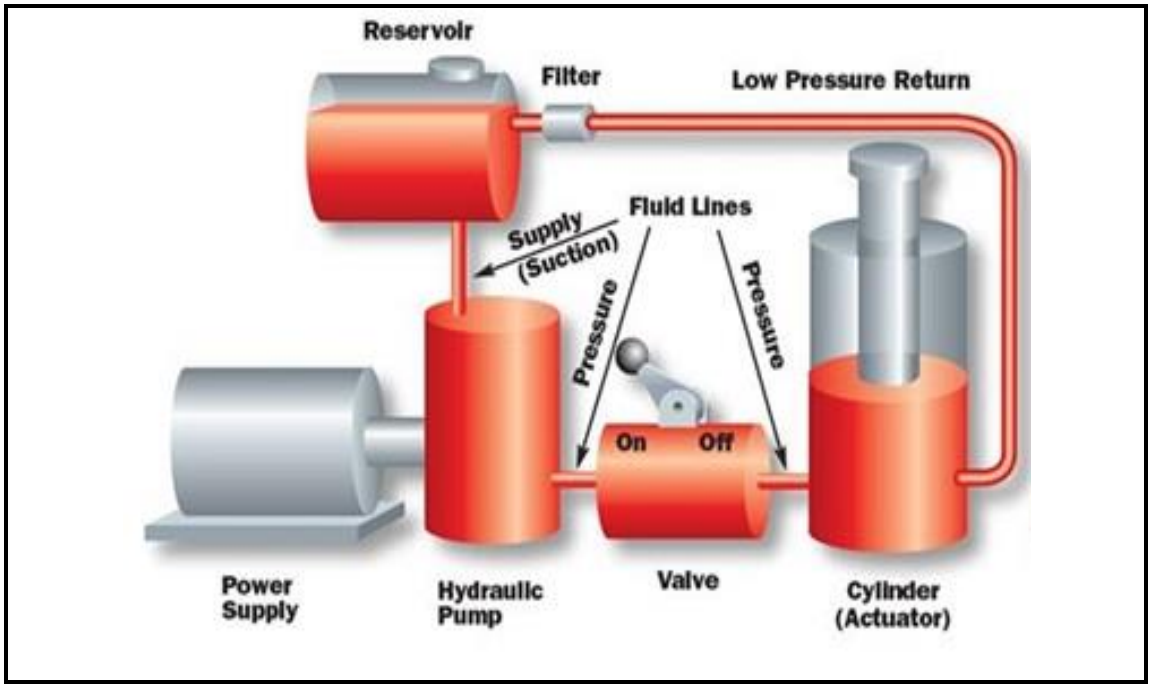


Fig.3.3(a) Hydraulic System

ii. Double acting cylinder

These are operated by applying oil pressure to the cylinder in both directions alternately. Due to inherent mechanical problems associated with the spring, single acting cylinders with spring return are not used in applications using larger stroke lengths. As a result cylinders in various applications are mostly double acting type only.

In order to connect the piston in a double-acting cylinder to an external mechanism, such as a crank shaft, a hole must be provided in one end of the cylinder for the piston rod, and this is fitted with a gland or "stuffing box" to prevent escape of the working fluid. Double-acting cylinders are common in steam engines but unusual in other engine types.

- **Solenoid Valve:**

Initially the sensor senses the process towards the outlet side of the solenoid valve. When it senses that certain quantity of the flow of the fluid is required, it allows the current to pass through the solenoid valve. Due to this the valve gets energized and the magnetic field is generated which triggers the movement of the plunger against the action of the spring. Due to this the plunger moves in upwards direction, which allows the opening of the orifice. At this instant the flow of the fluid is allowed from the inlet port to the outlet port.

A solenoid valve is an electromechanically operated valve. The valve is controlled by an electric current through a solenoid in the case of a two-port valve the flow is switched on or off; in the case of a three-port valve, the outflow is switched between the two outlet ports.

Solenoid valves are the most frequently used control elements in fluidics. Their tasks are to shut off, release, dose, distribute or mix fluids. Solenoids offer fast and safe switching, high reliability, long service life, good medium compatibility of the materials used, low control power and compact design.

Solenoid valves may use metal seals or rubber seals, and may also have electrical interfaces to allow for easy control. A spring may be used to hold the valve opened (normally open) or closed (normally closed) while the valve is not activated.

Materials:

The valve body must be compatible with the fluid; common materials are brass, stainless steel, aluminium, andplastic.The seals must be compatible with the fluid. To simplify the sealing issues, the plug nut, core, springs, shading ring, and other components are often exposed to the fluid, so they must be compatible as well.

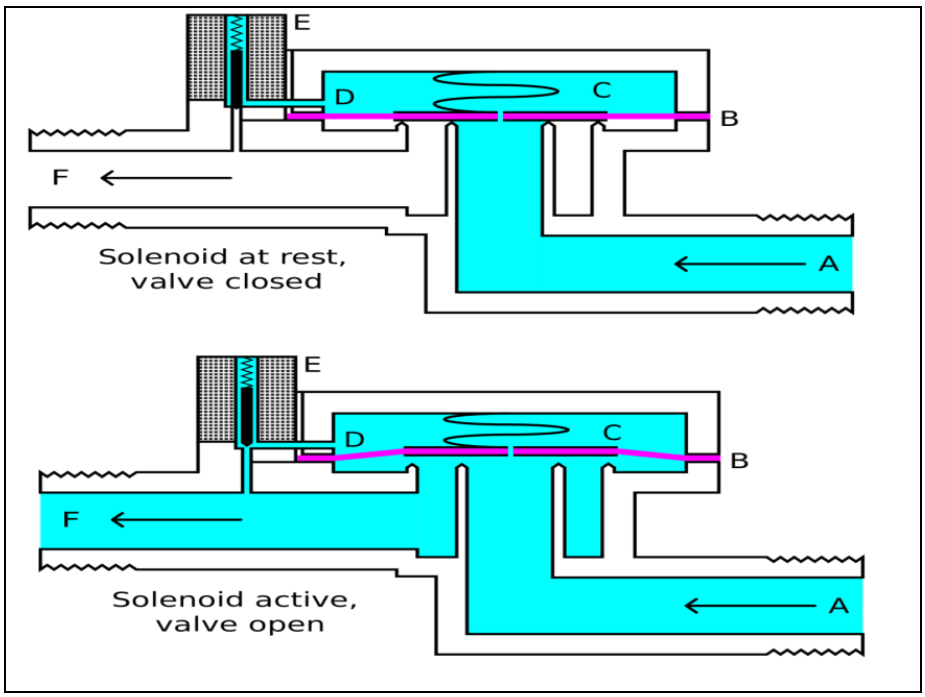


Fig.3.3(b) solenoid valve working

Use:

1. Solenoid valves can be used for a wide array of industrial applications, including general on-off control, calibration and test stands, pilot plant control loops, process control systems, and various original equipment manufacturer applications.

2. Solenoid valves are used in fluid power pneumatic and hydraulic systems, to control cylinders, fluid power motors or larger industrial valves.

3. Domestic washing machines and dishwashers use solenoid valves to control water entry into the machine.

The hydraulic system is use in bending machine to give the feed to the roller and also to lift the roll. The hydraulic system works on the Pascal's low. The hydraulic pump produces the flow. Pressure occurs when there is resistance to flow.

We need of hydraulic cylinder, directional control valve, pressure control valve, and reservoir for the machine.

We need hydraulic cylinder on either side of the rolls which can help us in case of lift the rolls only at one side while bending the sheet in conical shape. There are total tree roll in which we have need to lift them and thus we need six hydraulic cylinders.

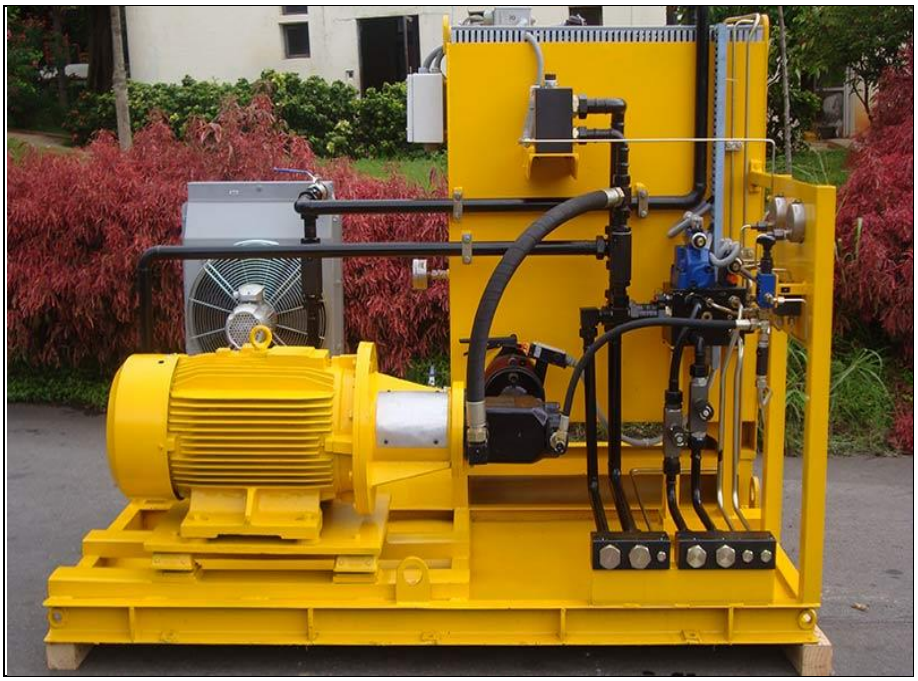


Fig.3.3(c) hydraulic panel

We also the machine facilitate with the easy removal of formed part and for that we provide automatic close and open shutter at the other end of the upper roller where the motor is not mounted. And for that open and close mechanism we need one more cylinder.

Now for bending machine we use all the rollers of 750 mm in working length. And also the main upper and lower roller have 110 mm diameter while the side supporting rollers have 90 mm diameter. And the rollers are made from the EN8 material which has density of 7.85 g/mm^3.

Thus from this data we get the load of roller, force required to lift the roller, force required to bend the sheet, etc.

Based on this data we will find the load which has to be lifted and also find the required pressure which is need to lift that load. And decide the required size of the cylinder, piston, volume of oil required, etc. From that data we select the proper hydraulic panel for the machine.

The required calculation for selection of the hydraulic panel is discussed in the design part of the report.

3.4 Roller:

The roller is the main component which carried out the bending process of the sheet. In the bending machine the roller can be defined by two ways. First is by the material of that roll is made or the shape of the roll.

3.4.1 Material of roller:

In general for manufacturing of roller the tool steel are widely used. The roller is must able to bend the sheet in single pass and also have to withstand against the forces acting against them.

The roller must have hardened and tough enough to produce good surface finish. In some large machines the length of the roller is long and also there is no support to the roller in between two ends. Hence in such condition the roller should not bend under the effect of gravity or its own load. Thus these all factors affect the roller life. For the economic machine the roller life is also important thing.

Thus selection of the roller material is also important part for making the machine cost effective. For select the proper material for our roller we studied several tool steel materials and check their properties, hardness, cost, etc. And compare them.

We studied on EN8, D3, EN9, EN31,C45. About the properties, price, chemical composition, etc.

- **Price:**

  EN9 -50rs per kg

  C45 - 45 to 60rs per kg

  EN8 – 40rs per kg

- **Hardness:**

  En9 – 45 HRC

  En8 – 52 HRC

  C45 – 40 HRC

- **Chemical Composition:**

Carbon Composition							
Material	**C%**	**Si%**	**Mn%**	**P%**	**S%**	**Cr%**	**Mo%**
En31	1.30	0.30	0.50	0.024	0.025	1.40	-
En9	0.50	0.25	0.70	0.05	0.05	-	-
En8	0.45	0.32	0.8	0.05	0.05	-	-
D3	2.10	0.65	0.45	0.021	0.03	11.50	0.22
C45	0.43	0.20	0.65	-	-	-	-

Thus after studying the all material we decide to make the roller from EN8 tool steel. The required properties which we require for good bending that all are in EN8.

Fig.3.4.1 Metal rods

Advantage of using EN8 tool steel:

1. En8 carbon steel is a common medium carbon and medium tensile steel, with improved strength over mild steel, through hardening medium carbon steel. EN8 carbon steel is also readily machinable in any condition.
2. EN8 steel are generally used in the as supplied untreated condition. But en8 steels can be further surface-hardened by induction processes, producing components with enhanced wear resistance. Steel en8 materials in its heat-treated forms possesses good homogeneous metallurgical structures, giving consistent machining properties.
3. Key features: Availability Round bar, square bar, hexagon and plate Engineering Steel • Unalloyed medium carbon steel • Reasonable tensile strength • Can be flame or induction hardened • Readily machinable • Moderate wear resistance if heat treated.

3.4.2 Shape of roller:

The rollers used for the bending machine are generally produced in cylindrical shape or else conical shaped roll are used in machine.

In general the cylindrical rollers are used to produce the cylindrical shape and the conical rollers are used to produce the conical shape. The cylindrical roller can be produce the conical shape by set them at specific angle but the conical rollers cannot produce in case of cylindrical shape and can only used to produce the conical shape.

In special purpose machine which is make only to produce conical part in such type of machine the conical roller is used. While in general machine to produce normal cylindrical shape the cylindrical rolls are used.

3.4.3 Process on roller:

The roller used in the machine is first machined out to its final shape and size. Then other machining processes carried out on the end of the roll to make them fitted in the base frame. Once all the processes carried out on the roller then for the fine surface and high hardness we need to harden the roll.

Roller Grinding:

The length of rolls may vary from a few centimetres up to six meters or more. Throughout the length, a high finish is required. For example, these rolls give sheet metal the high finish that's required without resorting to buffing or polishing. Furthermore, the main requirement is that the two rolls running together shouldn't have any distance between them. They should also have a roundness of 0.002 mm and a surface finish of 0.02 microns.

If rolls are to be used for cold-forming metal, then the great pressure between the work and the rolls would cause the rolls to spring apart at the centre. If that happened, the rolled metal would be thicker at the centre than at the edges if the perfectly uniform diameter rolls were used for the purpose. That's why it's desirable for the correct curve of the face of the roll to be carefully calculated. Additionally, roll grinding should occur with a crown or convex surface. Roll grinders usually have provisions for rotating the rolls on their own bearings. For hardened the roller there are several processes have to carried out on the roll.

Hardening:

Hardening uses heat and rapid cooling (quenching) to increase the hardness, strength and/or durability of steel. Heating steel or iron above their upper critical temperatures modifies the crystal structure of the metal to a form called Austenite. With this atomic arrangement the carbon can then freely migrate to a new location. When hardening, the aim is to quickly quench the austenite, thus trapping the carbon atoms in their new positions in the crystalline structure. The transformed structure, called martensite, is extremely hard. In addition, hardening creates important internal residual stresses that can be either beneficial or disadvantageous. Depending on requirements, tempering can be carried out after the induction hardening process.

Induction Hardening:

Induction hardening is a form of heat treatment in which a metal part is heated by induction heating and then quenched. The quenched metal undergoes a martens tic, increasing the hardness and brittleness of the part. Induction hardening is used to selectively harden areas of a part or assembly without affecting the properties of the part as a whole.

With induction hardening, only the material in the heating zone is heated. There's no need to treat the whole mass of the component, thus saving energy. The hardening result depends upon a complex interaction of process parameters such as coil and quench design, material analysis, component geometry, heating frequency and power and quenching cycles. At EFD Induction we have all the expertise required in electromagnetism, power electronics, metallurgy and induction hardening process setup.

Define: A widely used process for the surface hardening of steel. The components are heated by means of an alternating magnetic field to a temperature within or above the transformation range followed by immediate quenching. The core of the component remains unaffected by the treatment and its physical properties are those of the bar from which it was machined, whilst the hardness of the case can be within the range 37/58 HRC. Carbon and alloy steels with an equivalent carbon content in the range 0.40/0.45% are most suitable for this process.

A source of high frequency electricity is used to drive a large alternating current through a coil. The passage of current through this coil generates a very intense and rapidly changing magnetic field in the space within the work coil. The work piece to be heated is placed within this intense alternating magnetic field where eddy currents are generated within the work piece and resistance leads to Joule heating of the metal.

This operation is most commonly used in steel alloys. Many mechanical parts, such as shafts, gears, and springs, are subjected to surface treatments, before the delivering, in order to improve wear behaviour. The effectiveness of these treatments depends both on surface materials properties modification and on the introduction of residual stress. Among these treatments, induction hardening is one of the most widely employed to improve component durability. It determines in the workpiece a tough core with tensile residual stresses and a hard surface layer with compressive stress, which have proved to be very effective in extending the component fatigue life and wear resistance.

Induction surface hardened low alloyed medium carbon steels are widely used for critical automotive and machine applications which require high wear resistance.

Wear resistance behaviour of inductance hardened parts depends on hardening depth and the magnitude and distribution of residual compressive stress in the surface layer.

Hard Chroming:

Hard Chrome Plating is an electrolytic process utilizing a chromic acid based electrolyte. The part is made the cathode and, with the passage of a DC current via lead anodes, chromium metal builds on the component surface. A wide variety of parts can be coated; it requires only the proper fixturing, a large enough bath, sufficient lifting capacity, and adequate power sources.

Hard Chrome Plating offers many attractive properties to the engineer.

1. It is ultra Hard:

850-100Hv(65- 70Rc), harder than most industrial abrasives and steel counter faces. Unusually, it combines this hardness with degree of toughness, so the deposit can stands up to high stress contact.

2. It gives superb substrate adhesion:

Greater than 10,000 psi. Before plating, substrate are subjected to rigorous cleaning, so that the surface to be coated is completely free contaminates. But the ultimate adhesion is achieved in the plating bath itself, with an initial reverse voltage etch which removes any residual surface contamination.

3. It can be applied to a wide variety of substrates:

Covering a wide range of engineering or high alloyed steels (including stainless steel and cast irons), lightweight aluminium alloys or titanium alloys.

4. It provides superb abrasion resistance:

Even under high contact stress. It gives a very low wear rate (at least 100 times better than hardened steels or electro-less nickel) with abrasive products like textiles, paper and food stuffs With thick deposits, it gives excellent wear resistance under high stress contact against sand, coal, cement, limestone, glass fibres, etc.

With abrasion being the most common and destructive wear process found in industry, hard-chrome has the potential to solve many problem in pumps, valves,

bearing, etc. throughout a wide range of industries; including pharmaceutical, chemical, oil and gas, textiles, printing, food-mining, and countless others.

5. The deposition temperature is low:

and with de-embrittlement treatment has little effect on substrate properties. Provided that high strength steels are stress-relieved before plating and heat-treated again afterwards(usually for 3 to 12 hours at about 375*F), there will be few problem with hydrogen embrittlement.

6. It can be applied to a wide range of geometry's;

With careful attention to anode design and fixturing, chrome plating can be applied evenly to flat surface, to fine bores, even with large aspects ratios, to cylindrical like shaft and rollers, and to holes and close tolerance areas.

7. It gives ultra high metal-to- metal sliding wear resistance;

Up to 100 times less wear given by through hardened, carburized or nitride steels in dry sliding situations, and greatly superior to Electro-less Nickel.

8. It has bright, attractive finish

It responds very well to grinding and polishing, providing ideal surfaces for dealing with delicate products (like textiles and paper), for giving low friction, and for high precision parts like lathe beds.

9. It produces very low fiction against polymers, carbon and graphite's This makes it ideal for textiles applications or for seal faces as well as for components like vane pumps. It is the perfect counter face for PM and other polymers which rely on establishing a transfer-film for their best performance.

3.5 Minimum wastage of material:

Generally in industries when any product is produced or any machine is to be manufactured there is much wastage of the material is produced which also affects the final price of that product or machine. When a company or industry is deciding the selling price of the product then it also accounted the price of the wastage material

and also the processes which is done on the machine when it was manufactured. Thus if there is much material is wastage during manufacturing hikes the price of the machine.

Therefore in design of machine we are focusing for the minimum material wastage during manufacture the machine. Also looking for to keep the minimum machining required for machine.

Thus we also try to save the material and keep the manufacturing cost of machine to minimum.

3.6 Selection of the gear box:

The gear box is generally used for change the rotational speed or rpm of the shaft. Generally the ac motors and dc motors rotates on the fix rpm and gives fix output. So we need to change rpm according to our application with the help of gear box. The gear box gives the ratio by which it can increase or decrease the rpm of the shaft.

In the bending machine the roller which bend the sheet are driven by the motor, and in the selection of motor we get to know that the motors are available in the market have minimum 1440 rpm. But in the machine for the smooth and proper bending process we need to keep the rpm of motor as low as possible. We required approx 15-20 rpm of roller. Thus we required reduce the rpm of motor drastically.

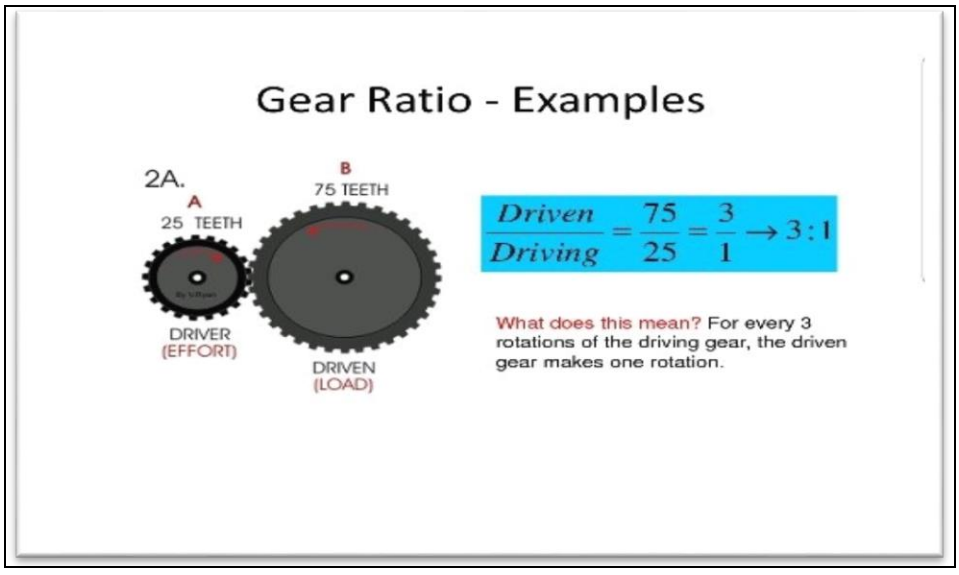


Fig.3.6(a)Gear ratio

For that we need to attach the gearbox with the motor-shaft. Then we started to study about the gearboxes and we get to know that for such huge reduction the conventional gearboxes are not a good option. Further we study about the planetary gearboxes and search about its mechanism. Then we get to know that the planetary gearbox has high reduction ratio and also it boosts the torque. So both qualities are very suitable for bending machine.

We studied about the planetary gearbox mechanism and working.

Planetary Gear Trains are extensively used for the power transmission and are the most critical component. Planetary gearboxes are used frequently to match the inertias, lower the motor speed and boost the torque.

Planetary gear systems normally consist of a centrally pivoted sun gear, a ring gear, and several planet gears found between the sun gear and ring gear.

Planetary gearheads are high-precision, motion-control devices that generate substantial torque for their size, have high torsional stiffness, and low backlash that making them suited for wide-ranging tasks.

Planetary units with helical gears, rather than spur gears, have a larger contact ratio. The contact ratio is the number of teeth in mesh at any given moment. While typical spur gearing has a 1.5 contact ratio, helical gearing more than doubles it to 3.3. Benefits of higher contact ratios.

If an electric motor drives a 13-tooth pinion gear that meshes with a 65-tooth gear, a reduction of 5:1 is achieved (65 / 13 = 5). If the electric motor speed is 3,450 rpm, the gearbox reduces this speed by five times to 690 rpm.

The reduction ratio for the given composite arrangement is product of ratios of each stage**.** Total reduction ratio,

R = R1●R2●R3● ……Rn.

Where, R1, R2, R3, …Rn represents the reduction ratios of each stage of gear train connected in composite. For easier computation it is preferred that the planetary gear ratio shall be an exact integer (3, 4, 6 ...).

If a gearbox contains 4:1, 5:1 and 6:1 gear sets, the total ratio is 120:1 (4 x 5 x 6 = 120). In our example above, the 3,450 rpm electric motor would have its speed reduced to 28.5 rpm by using a 120:1 gearbox.

The reduction ratio in planetary gear train is determined as below:-

(PCD of Ring Gear + PCD of Sun Gear Ratio) / PCD of Sun Gear

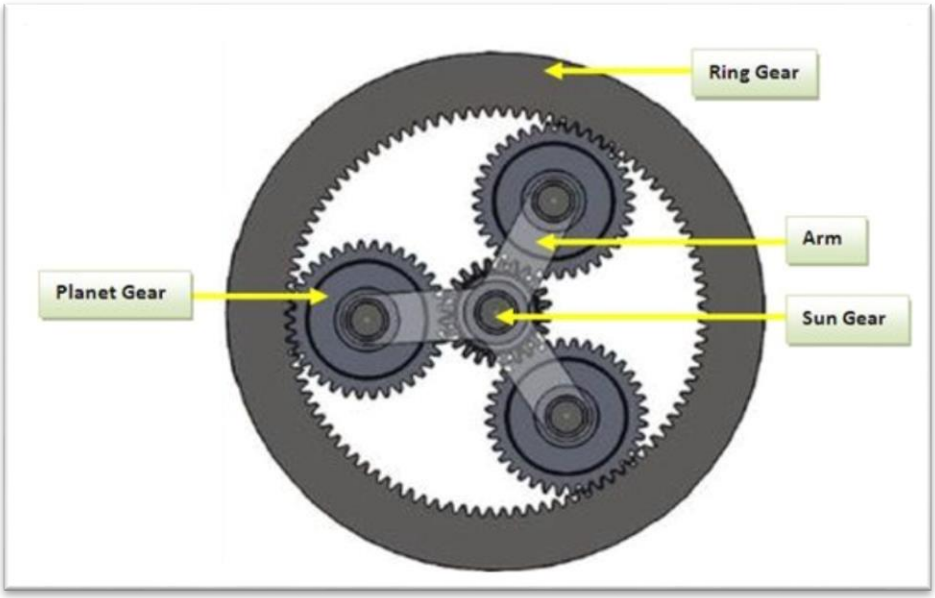


Fig.3.6(b).planetary gear

3.7 Selection of the other main part of machine:

In the bending machine apart from the driving system and controlling system there are some other parts are used for accommodate the roller, motor, hydraulic system the base frame is used. Also for the fitting of the roller in the base frame and getting the required stroke bearing and lever are used. Those all parts are describe below.

3.7.1 Bearing:

Bearing is used in the machine to fit the roller in the machine base frame. It is used in the machine to make the freely rotating movement of the roller in the machine and reduce the friction. A bearing is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving

parts. A bearing is a device that is used to enable rotational or linear movement, while reducing friction and handling stress. There are main four types of bearing by its application.

The motion permits by the bearing is-

a. Axial rotation
b. Linear motion
c. Spherical rotation and
d. Hinge motion.

For the bending machine we required the spherical rotation of the bearing. Thus we used the spherical bearing for the machine.

Spherical Bearing: A spherical plain bearing is a bearing that permits angular rotation about a central point in two orthogonal directions (usually within a specified angular limit based on the bearing geometry). Typically these bearings support a rotating shaft in the bore of the inner ring that must move not only rotationally, but also at an angle.

Fig.3.7.1 spherical Bearing

Spherical bearings can be of a hydrostatic or mechanical construction. A spherical bearing by itself consists of an outer ring and an inner ring and a locking feature that makes the inner ring captive within the outer ring in the axial direction

only. The outer surface of the inner ring and the inner surface of the outer ring are spherical and are collectively considered the raceway and they slide against each other, either with a lubricant, a maintenance-free based liner, or they incorporate a rolling element such as a race of ball-bearings, allowing lower friction.

3.7.2 Base Frame:

The basic structure of the machine consists of two side frames and tie panels. The sides frames (HS Frame & TS Frame) are made of ultrasonically tested alloy steel plates. They are cut to their respective shapes and combined with the help of specially prepared jigs and fixtures. The location of the rolls enables effective absorbing of the total bending power in an egg-formed design making the machine strong and rigid. All parts of the frame are heavily proportioned.

There is no part of the frame exposed to high torsional forces or bending stresses. The frame is of all-welded design and of course stress relieved. They are welded under strict quality control and after full welding they are passed through stress relieving process. All welded parts are properly ground and made free from sharp edges. 4 nos. of main cylinders, swing arm cylinder, swing arm, centralized lubrication pump assembly.

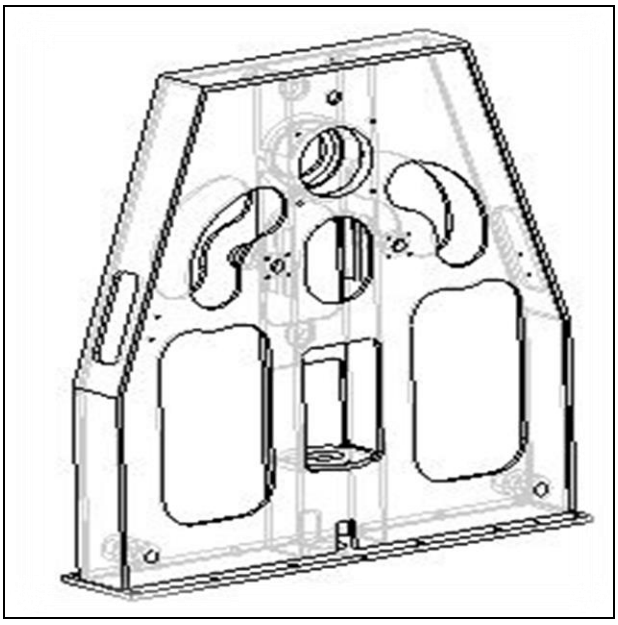


Fig.3.7.2 base frame

Harden guides, top roll supporting arrangement called counter balance system are placed in or supported by these side frames. These side frames are named as HS

Frame and TS Frame. Swing arm is fixed in TS Frame or we can say that swing arm is part of TS Frame.

3.7.3 Lever:

Levers are mechanical devices used use to scale the amount of force and travel in mechanism. Lever is simple machine that makes work easier to use; it involves moving a load around a pivot using a minimum force. A lever amplifies an input force to provide a greater output force, which is said to provide leverage.

The lever is used to lift heavy weight with least amount of effort. Lever is a rigid rod that rotates around one point to move a load by applying a force to a third point. Leaver can be described as a long rigid body with a fulcrum along its length.

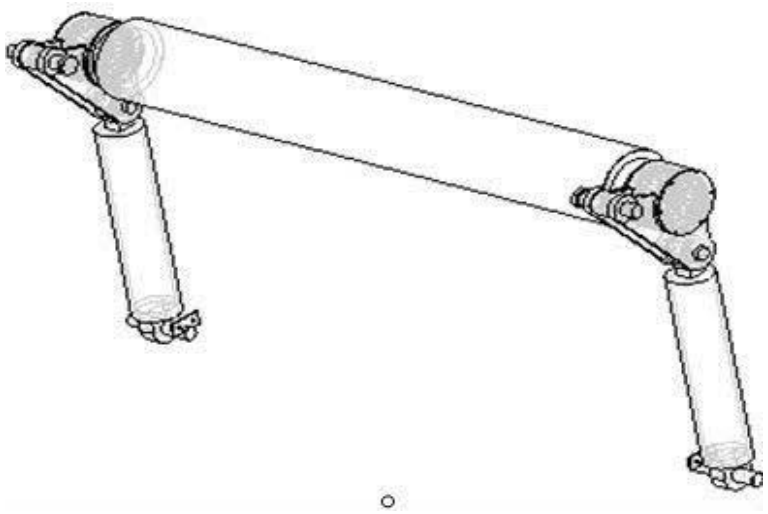


Fig.3.7.3(a) roll connected to lever

Load: The object that lifting

Fulcrum: Point at which the lever pivots.

Effort: The force applied to make the object move.

The ratio of the output force to the input force is the mechanical advantage of lever.

The lever is used in the bending machine to lift the side roller. The fulcrum of the lever is connected with the roller and the one side of the lever is connected with the hydraulic cylinder and another side is fixed with the base frame. This arrangement helps in the circular motion of the side roller.

As the hydraulic cylinder create pressure at the one end of the lever cause it to lift, while the another end of lever is fixed, so the pressure is acting n the fulcrum means roller. Thus the rollers can easily lift towards the lead roller.

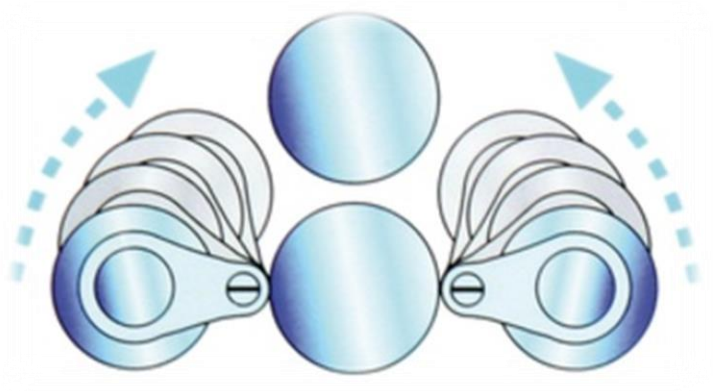


Fig.3.7.3(b)side roll movement

A lever is a beam connected to ground by a hinge, or pivot, called a fulcrum. The ideal lever does not dissipate or store energy, which means there is no friction in the hinge or bending in the beam. In this case, the power into the lever equals the power out, and the ratio of output to input force is given by the ratio of the distance from the fulcrum to the points of these forces. This known as the law of the lever.

The mechanical advantage of a lever can be determined by considering the balance of moments or torque ,T, about the fulcrum.

$$T_1 = F_{1a}, T_2 == F_2 b$$

Where F_1 is the input force to the lever and F_2 is the output force. The distance from fulcrum to the input and output forces are applied to the lever, assuming no losses due to friction, flexibility or wear.

3.7.4 Swing Arm/Cylinder:

Swing Cylinders offer the benefits of precision and maximum clamping force, plus application flexibility through our wide range of products. Their flexible design allows easier connections and precise positioning, plus simple installation and removal. It's high pressure, hydraulic Work holding device used to provide powerful clamping and positioning force to every type of manufacturing process. After the removal of the sheet the swing cylinder fitted with the roller and the external supports

will remove. The roller is tattled fitted with the swing cylinder to make the easy removal and fitted of the swing cylinder.

Fig.3.7.4(a) swing cylinder

Working:

Swing cylinders allow unobstructed part fixturing and placement. The plunger rod and the attached clamp arm, rotate 90 degrees in either a clockwise or counter clockwise direction, then travel down an additional distance to clamp against the fixtured part. Upon release of clamping pressure, the clamp arm rotates back 90 degrees in the opposite direction to allow for part removal and new part placement. Clamp arms are used to transmit the force generated by the swing cylinder to the work-piece.

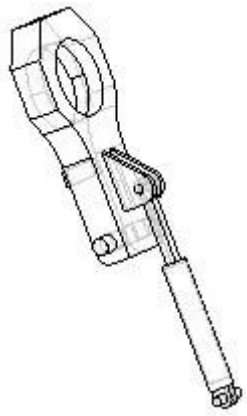


Fig.3.7.4(b) swing arm with cylinder

Clamp arm design attaches to the hydraulic swing cylinder, allowing parts to be clamped at various distances from the hydraulic cylinder. Clamp arms are available in a variety of lengths, or you can use custom machining dimensions to create your own clamp arm configuration.

3.8 Selection of the control system:

Now we complete the selection of the drive system of the machine, the second step is to selection of the proper programming and the proper machine control system.

The bending machine is generally operated by the three methods.

1. Manually operated
2. NC operated
3. CNC operated

3.8.1 Manual operated sheet bending machine:

In this operation, the labour rotates the roller with the help of small lever. For that a wheel is attached with the shaft of gear. This gear is again attached with two other gears which are connected with the two rollers.

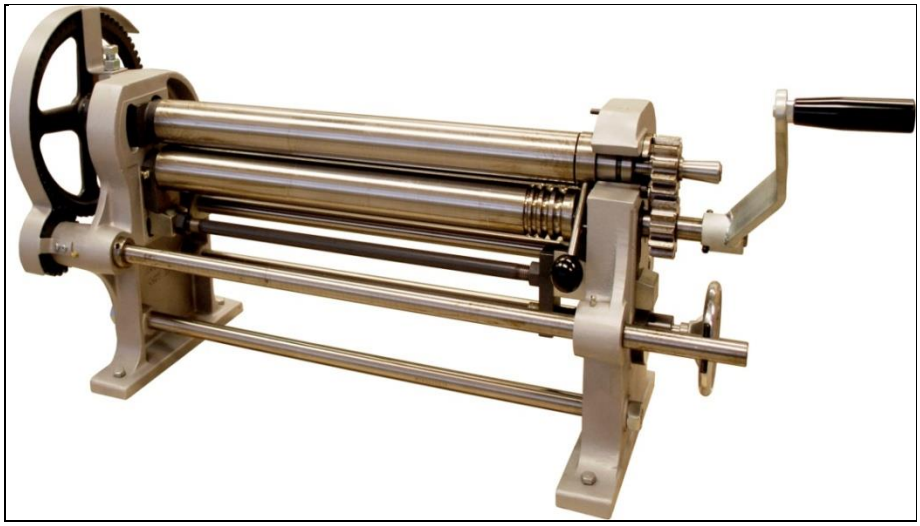


Fig.3.8.1 Manual operated sheet bending machine

The outer wheel is designed such that, hallow pipe must grip the wheel. Handles are welded to the outer side of wheel. Here hallow pipe grip the wheel and it

is rotated clockwise and anticlockwise in direction. In this the gear is attached with wheel, rotates the two other gear and these gears rotate the two rollers.

When these two rollers are rotated, because of friction between rollers & sheet inserted in between upper one roller and lowers two rollers, upper roller is also rotated. Now upper roller is set according to the thickness of the sheet. For this purpose in both side of body where rollers end are placed, screw arrangements are given which tight or loose the work piece. In this process the sheets are rotate in clockwise & anticlockwise direction in number of times according to the length of sheet & thickness of sheet.

3.8.2 NC operated sheet bending machine:

The NC operating machine reduces the intereverse of the operator. Thus lead the accuracy and the fine process. This is the automation of the system.

All the parameter of the process enters in the system in the form of the program. The program saved in the NC system and according to them the system works. This leads the uniform process for all time and eliminates the human errors.NC operated machines are manufactured at low price compare to CNC and also gives the best work and accuracy.

Fig.3.8.2 NC operated sheet bending machine

This type of NC control system can be integrated to machines easily and they present operational opportunities with their ply back and direct programming abilities. By recording first rolling process program will make rolling hundreds of plates possible as same as the first recorded one.

3.8.3 CNC operated sheet bending machine:

In order to automation of the machine we have two choices for the programming machine. One is the NC controller and another one is the CNC.

Fig.3.8.3(a) CNC operated sheet bending machine

CNC machines have great advantages of pitch and maintaining pitch matching during rolling. Mechanical machines always develop play after certain usage. But in case of CNC, the pitch matching is done electronically. Therefore, corrective action is taking place continually to maintain the same pitch matching electronically.

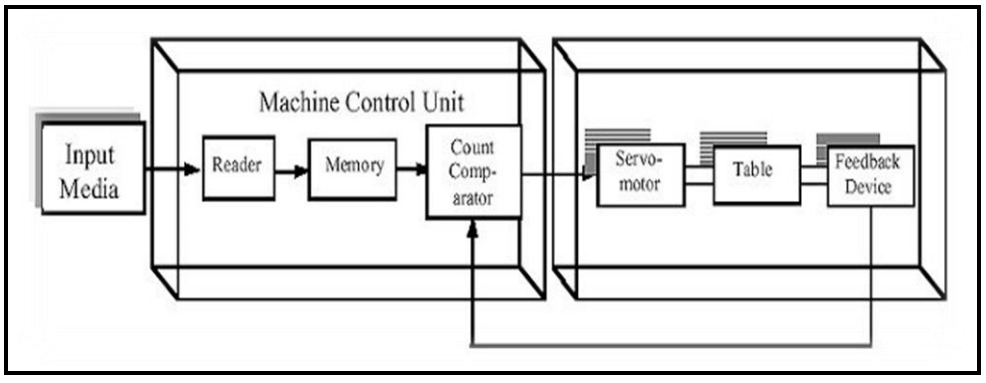


Fig.3.8.3(b) CNC system

In these two methods, the CNC is the advanced technologies and have greatest features and because of such automation the cost of the CNC is very high and also it carry much precious operation. But as per our necessary the NC controller can gives the best work at the low price. Thus we select the NC control for our machine.

3.9 Machine Manufacturing Cost

Sr. No.	Component	Cost/Piece	Nos.	Cost
1.	Roller	5000	4	20000
2.	Motor	5000	3	15000
3.	Planetary Gearbox	6200	3	18600
4.	Ms structure	50000	-	50000
5.	Machining	20000	-	20000
6.	Other fabrication	10000	-	10000
7.	Hydraulic Power pack with valve and motor	75000	1	75000
8.	Chrome Plating	20000	-	20000
9.	Spray Colour	2500	-	2500
10.	Bearing	5000	-	5000
11.	Nut-Bolt	2000	-	2000
12.	NC Controller	350000	1	350000
	Grand Total			**598100**

The machine can be manufactured within the cost of 6 lacks andwe can sell it with the margin of 4 lacks. So the selling price of the machine is near about 10 lacks, which is very low compared to other plate bending machine available in the market.

CHAPTER – 04

DESIGN CALCULATIONS

4.1 Design Calculation:

1. The sheet bending capacity:

The capacity of the machine is determined by the diameter of the top roll. In this machine we have the top roll with 90mm in diameter and 750mm in the length.

Thus it is capable to

Max bending diameter of the sheet = 5 × diameter of top roll

= 450 mm

Min bending diameter of the sheet = 1.2 × diameter of top roll

= 108 mm

2. Define the force acting on the roll:
   - In this machine we have the roller for top & bottom is made out from EN8 material and 1000 mm long and it have 110 mm diameter also its working on the 50 rpm speed. The density of EN8 is 7.85 g/mm^2

     The volume of the roller $= \pi r^2$h = 9498500 mm^3

     The mass of the roller = volume × density of the material = 74.56 kg

To drive the roll a dc motor which produces 5 HP and rotates on 1750 rpm which gives torque of 15 N-m. But we require the speed of roller is 10 rpm. Thus we employed the planetary gearbox to reduce the speed drastically.

The relation between torque and gear ratio is given by

Motor torque × Gear ratio = Torque at the wheel

The gear gives the transmission ratio of 60:1 thus this reduction is achieved by the 60 times multiply the torque.

Thus the torque acting on the roll is,

15 × 60 = 900 N-m

Now the force acting on the roll,

T = F × distance

F = T / distance = 1350 N

3. Design procedure of the roller:

Permissible tensile stress: 90 N/mm^2

Permissible compressive stress: 110 N/mm^2

Permissible shear stress: 65 N/mm^2

Power = 5 HP = 3730 W, N = 10 rpm

P = $2\pi NT$ / 60

3730 = 2π × 10 × T / 60

T = 3564 × 10^3 N-mm

In actual practice rollers are subjected to shock and fatigue loading Hence design is accounted by using the factors known as combined shock and fatigue factors. Hence kb=1.5 and kt=1 ……as load is gradual

Bending moment M = F × L / 4

= 1350 × 1000 / 4 = 337.5 × 10^3 N-mm

Equivalent Twisting Moment,

T_e=√Kb × M2 + Kt × T2

= $\sqrt{1.5} \times (337.5 \times (10)3)2 + 1 \times (3564 \times (10)3)2$

= 3588 × 10^3 N-mm

According to max. Shear stress theory,

τ_{max}= 16 $T_e \div \pi d^3$

= 16 × 3588 × 10^3 / 3.14 × 110^3

= 13.74 N/mm^2

Since the value of Ƭmax is less than permissible shear stress.

i.e Ƭmax < Ƭper

Hence, the design is safe.

- In this machine we have the roller for both sides is made out from EN8 material and 1000 mm long and it have 90 mm diameter also its working on the 10 rpm speed. The density of EN8 is 7.85 g/mm^2

  The volume of the roller = πr^2h = 6358500 mm^3
  The mass of the roller = volume × density of the material = 49.9 kg

Permissible tensile stress: 90 N/mm^2

Permissible compressive stress: 110 N/mm^2

Permissible shear stress: 65 N/mm^2

Power = 5 HP = 3730 W, N = 10 rpm

P = $2\pi NT$ / 60

3730 = 2π × 10 × T / 60

T = 3564 × 10^3 N-mm

In actual practice rollers are subjected to shock and fatigue loading Hence design is accounted by using the factors known as combined shock and fatigue factors. Hence kb=1.5 and kt=1 ……as load is gradual

Bending moment M = F × L / 4

= 1350 × 1000 / 4 = 337.5 x 10^3 N-mm

Equivalent Twisting Moment,

$T_e=\sqrt{Kb} \times M2 + Kt \times T2$

$= \sqrt{1.5} \times (337.5 \times (10)3)2 + 1 \times (3564 \times (10)3)2$

$= 3588 \times 10^3$ N-mm

According to max. Shear stress theory,

$\tau_{max} = 16\ T_e / \pi d^3$

$= 16 \times 3588 \times 10^3 \times 90^3$

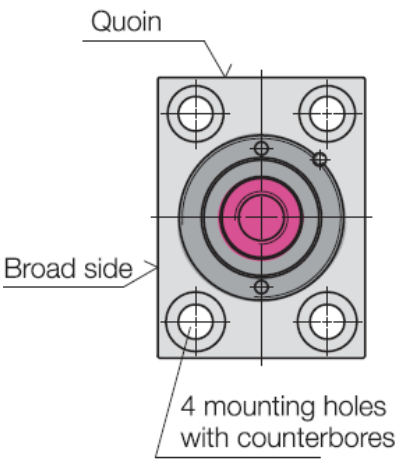
$= 25.01$ N/mm^2

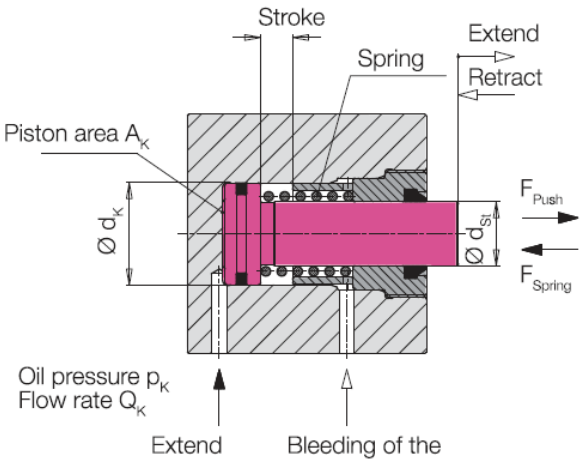
Since the value of Ƭmax is less than permissible shear stress.

i.e Ƭmax < Ƭper

Hence, the design is safe.

Hydraulic System:





Push and Pull forces

If a hydraulic cylinder on the piston side is charged with the pressure p_k, it thus generates the

$$\text{Push force} = \quad F_{push}[kN] = \frac{p_k \times \pi \times d_k^2[cm^2]}{400}$$

If a hydraulic cylinder on the piston rod side is charged with the pressure p_{st}, it thus generates

$$\text{Pull force} = \quad F_{pull}[kN] = \frac{p_{st}[bar] \times \pi \times (d_k^2[cm^2] - d_{st}^2[cm^2])}{400}$$

The relation between push and pull force in hydraulic cylinders amounts approximately

$$F_{push} \approx 1.6 \times F_{pull}$$

Piston diameter :

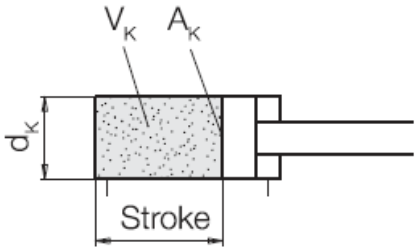
The minimum diameter of a piston, which is required for a necessary push force at astipulted pressure, can be calculated as follows;

$$\text{Piston Diameter} : d_{min}[cm] = \sqrt{\frac{F[kN] \times 400}{\pi \times p[bar]}}$$

Piston area :$A_k[cm^2] = \frac{\pi}{4} \times d_k^2[cm^2]$

Piston ring area :$A_R[cm^2] = A_k - A_{st}[cm^2] = \frac{\pi}{4} \times (d_k^2 - d_{st}^2)[cm^2]$

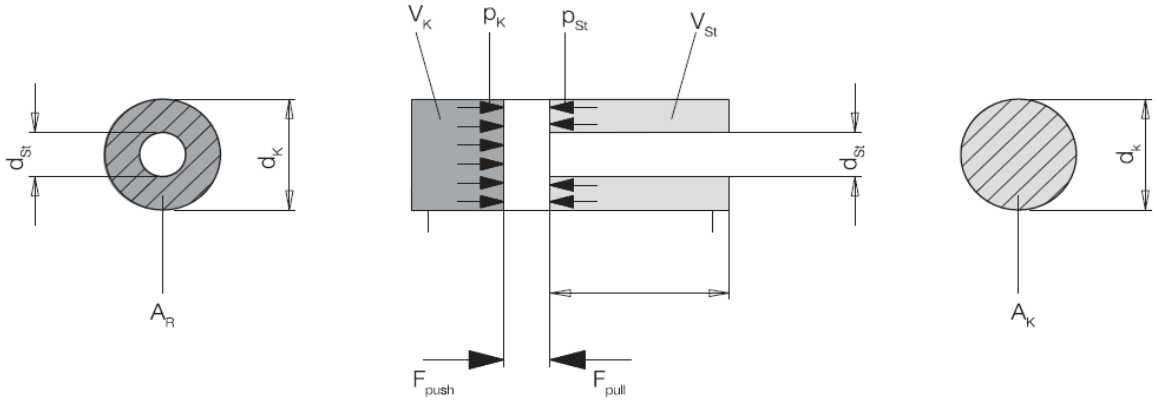
Piston ring area (for rod)----- $A_{st}[cm^2] = \frac{\pi}{4} \times d_{st}^2[cm^2]$



Pressure:

$$p[bar] = \frac{F[kN] \times 100}{A[cm^2]}$$

Oil volume required for the piston stroke.



Cylinder volume, general :$V[cm^3] = A[cm^2] \times stroke[cm]$

Cylinder volume of the piston side V_k : $V_k[cm^3] = d_k^2[cm^2] \times \frac{\pi}{4} \times stroke[cm]$

Cylinder volume of the piston rod side V_{st} :

$$V_{st}[cm^3] = d_k^2 - d_{st}^2[cm^2] \times \frac{\pi}{4} \times stroke[cm]$$

CHAPTER – 5

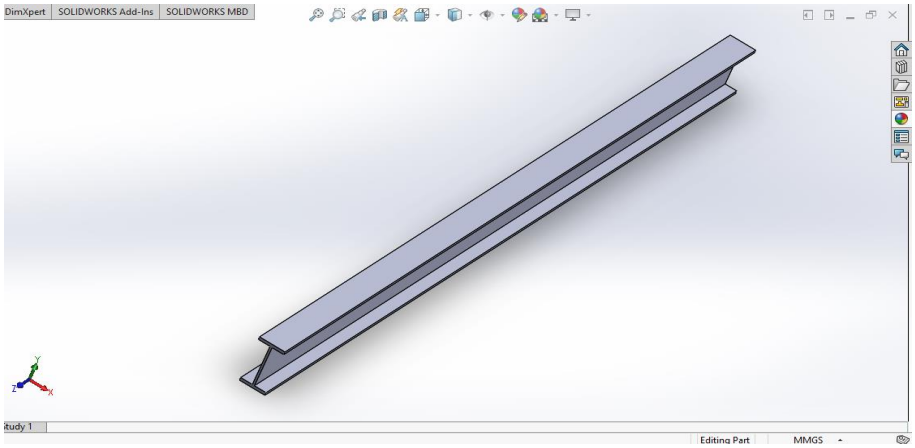
CAD/CAE SIMMULATION

We made the model of the machine in the software of solidworks. The modelling is start with the construction of the base frame.

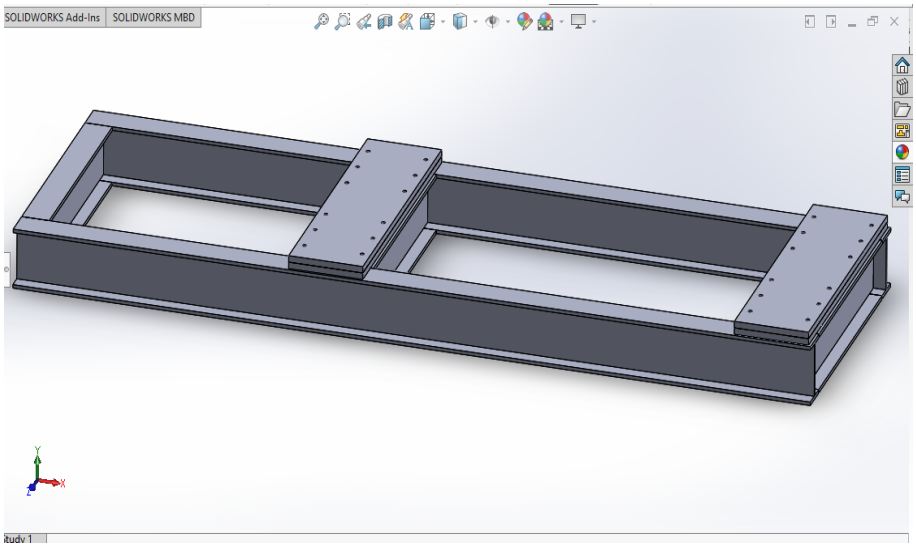
'I' section frame-

Since the machine is heavy and its having the weight of 2 ton, we need heavy frame which can bear such load easily. For construction of frame we select the MS material.

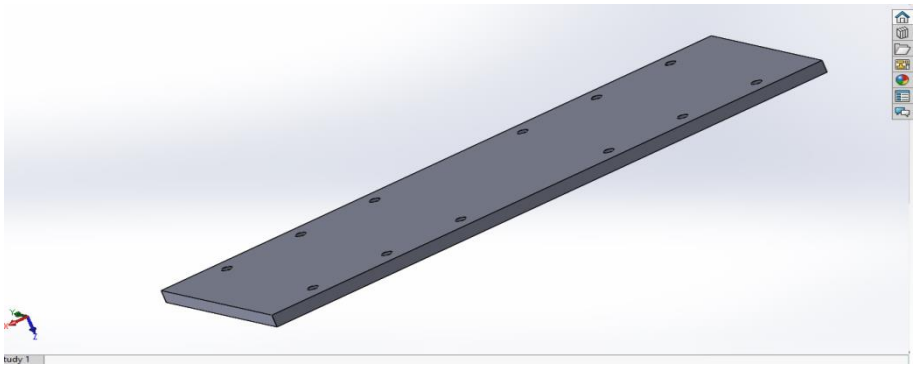
For making the base of the frame there is 'C' section and 'I' section channel. In order to giving more strength we select 'I' section channel for base frame.



The 'I' section channel is shown in the image as above



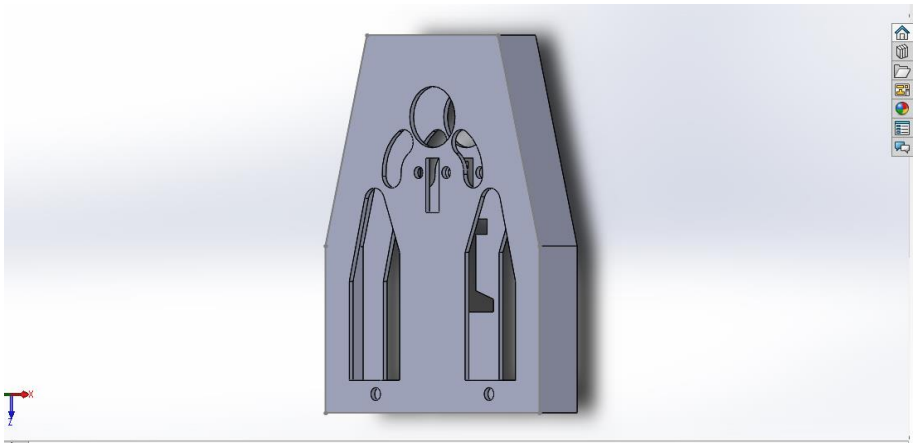
The ‘I’ section rods are joint together with the welding them and construct the base frame.



The tapping plate is used for joining the head and tail frame with the base frame. The tapping plate is used for making easy and strong joint between frames.

Head Frame:

The head frame is also made out from MS material. The gas cutting and welding is used getting the final shape from the MS plate. The thickness of the frame is 15cm. The head frame is shown as below

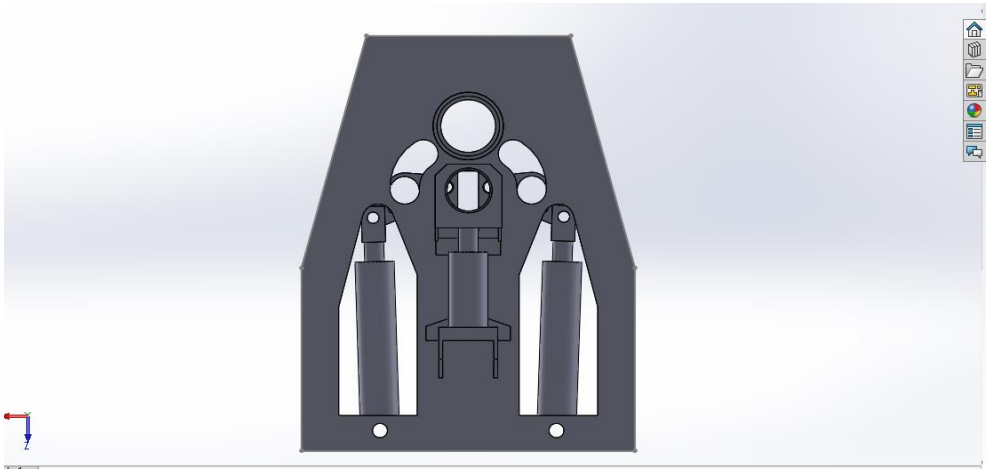


Four rolls are mounted on the head frame. The hydraulic cylinder and lever are also mounted on the head frame. Necessary cuttings are done in the frame for mounting mentioned components with the frame.

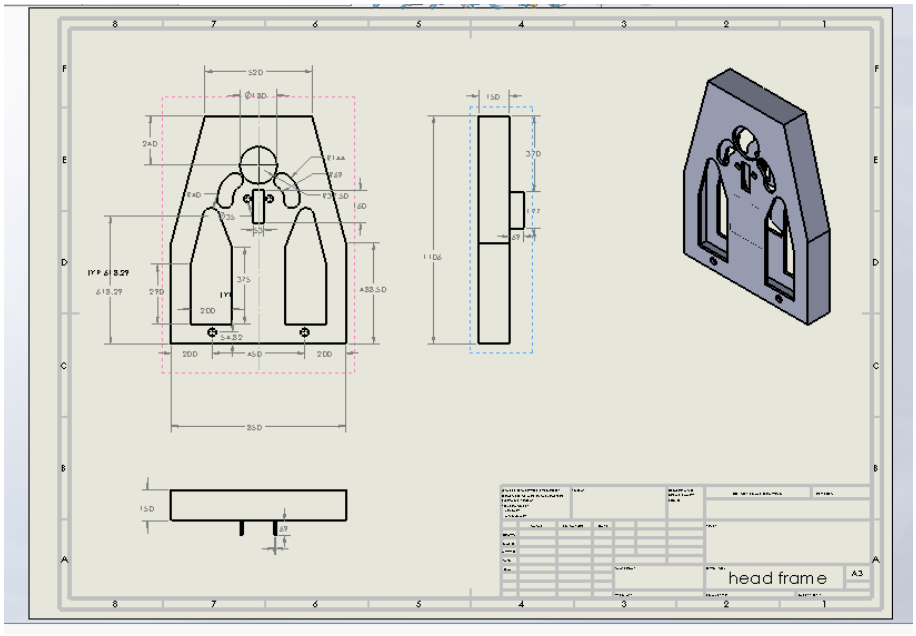
The below fig shows the front side of the head frame with mounting

1. two lever,
2. a bearing head
3. three hydraulic cylinders

4. a cylinder head.

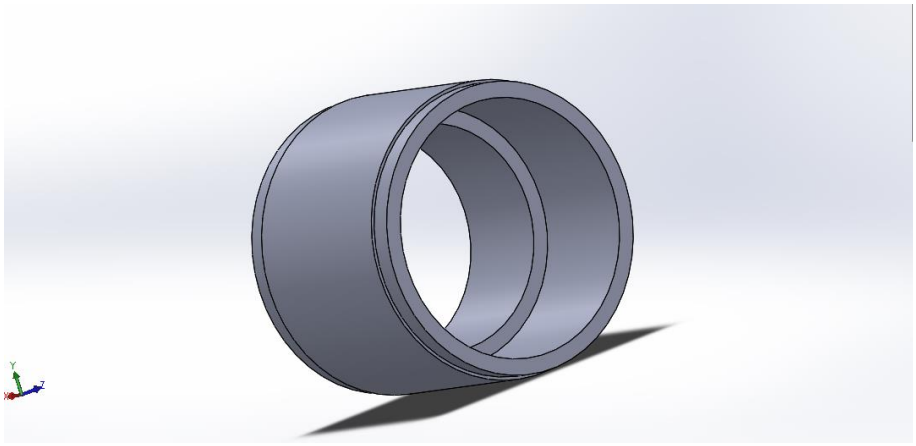


The drafting sheet of the head frame is as below:



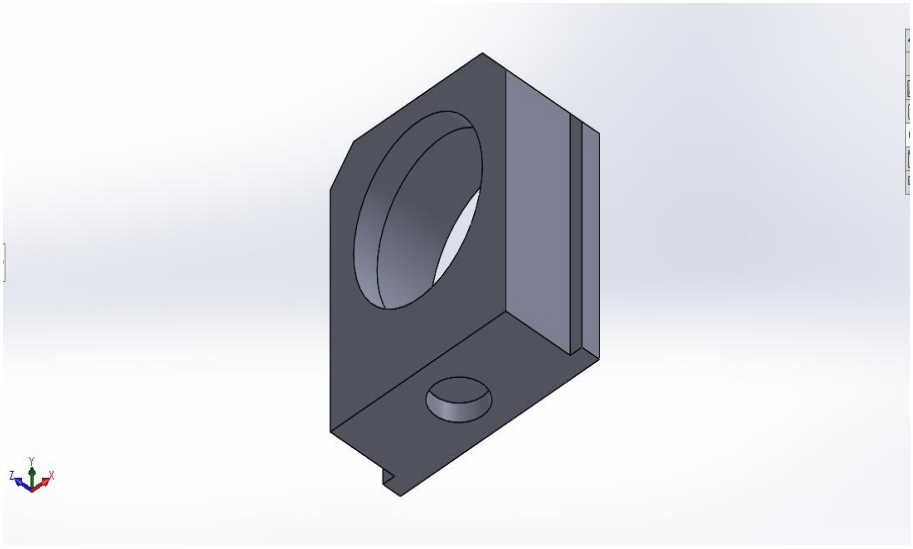
The head frame is fitted in the driving side of the machine. The motors and planetary gear box are fitted with the roller at the head frame side end of the rollers. The hydraulic cylinders are used to lift the lower and side rolls. The lever is used for giving the required stroke to the side roller. The bearing head is used for easy mounting of the bearing in the frame. The bearing which is fitted with one end of the top roller is mounted in the bearing head. The bearing head is shown as below

Bearing head:



The bearing head is fitted in the head frame to free rotating of the roller with respect to the frame.

Cylinder head:

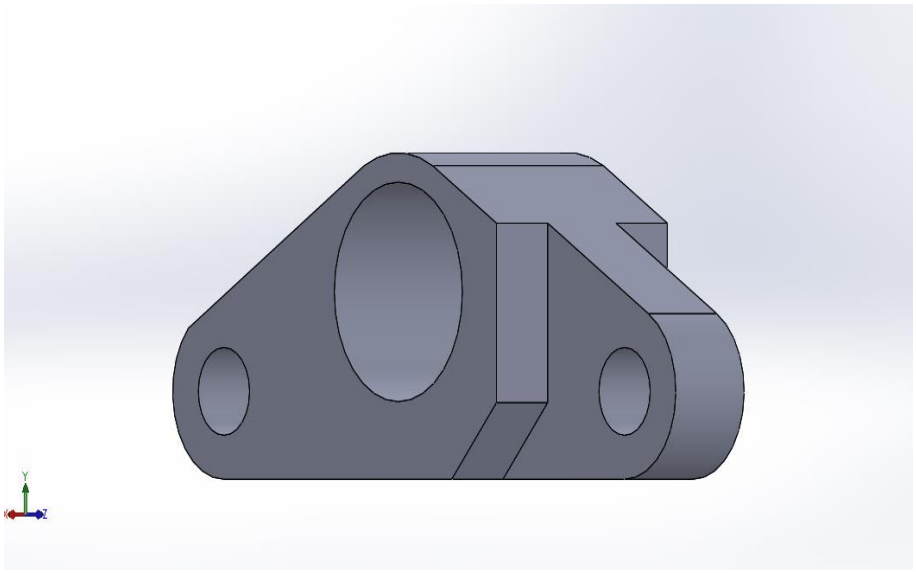


The cylinder head is fitted with the cylinder piston and the cylinder is mounted on the frame with the help of cylinder head. As the hydraulic piston performs the stroke the cylinder head slides up and down with respect to the frame. The cylinder head is also mounted with the lower roll in order to lift the roll. The hydraulic head is shown as below

Lever:

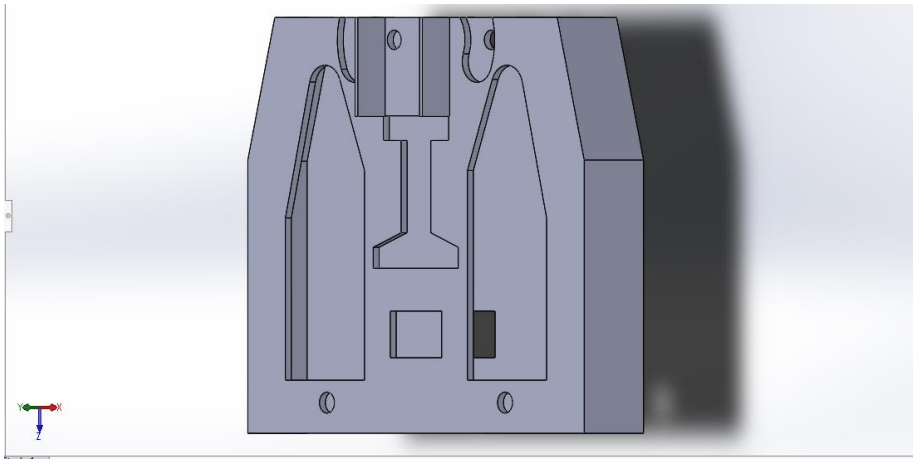
The lever is design is such that it gives the maximum stroke with the minimum travel of the piston. The lever is design that it will guide the roller in the ellipsoid

direction. The lever is fitted with the both end of the side rollers. The lever is shown as below



Half Frame:

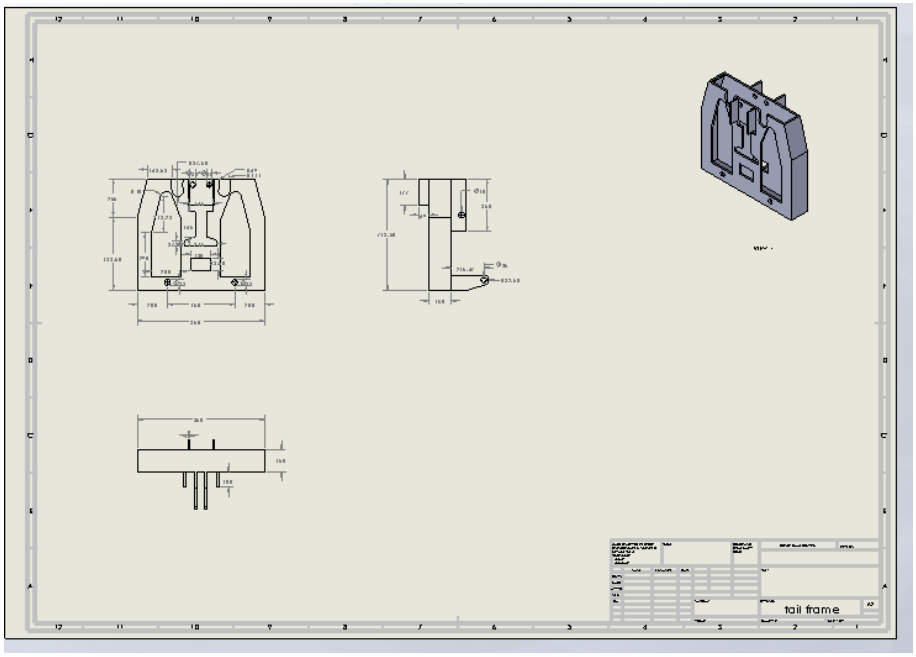
The half frame is designed as below



The half frame is also having the lever, three hydraulic cylinders, hydraulic head are mounted on it same as the full frame.

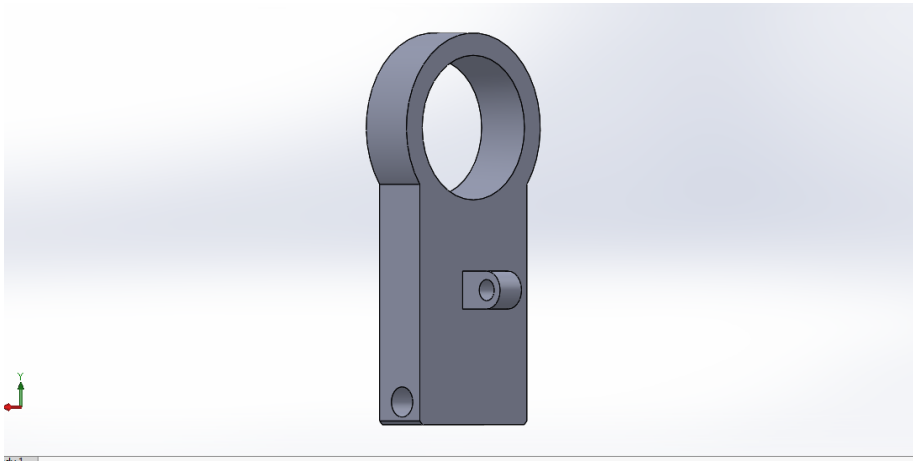
The lower and both side rollers are mounted on the half frame, but the half frame side end of the top roller is not fix with the half frame. This body structure of the frame and design the frame in half is in order to make the easy removal of the form parts.

The drafting sheet of half frame is as below:



Swing-Arm:

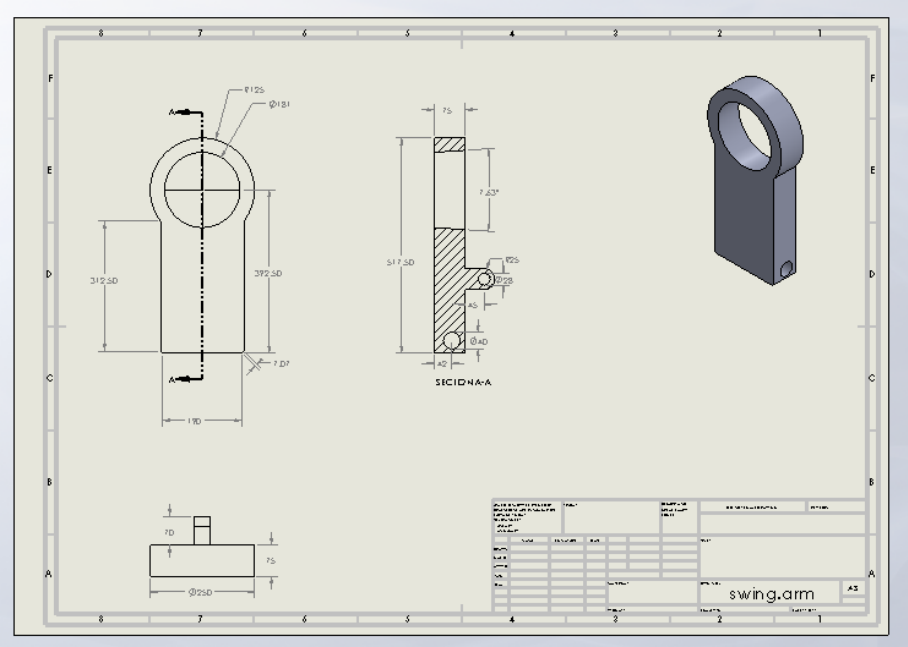
The half frame is also having the swing arm mounted on it. The swing arm is used for the easy removal of the formed parts and it is mounted with the top roller with the help of bearing head. The bearing head of the roller is designed in taper shape making the easy opening of the swing arm. The swing arm is shown as below



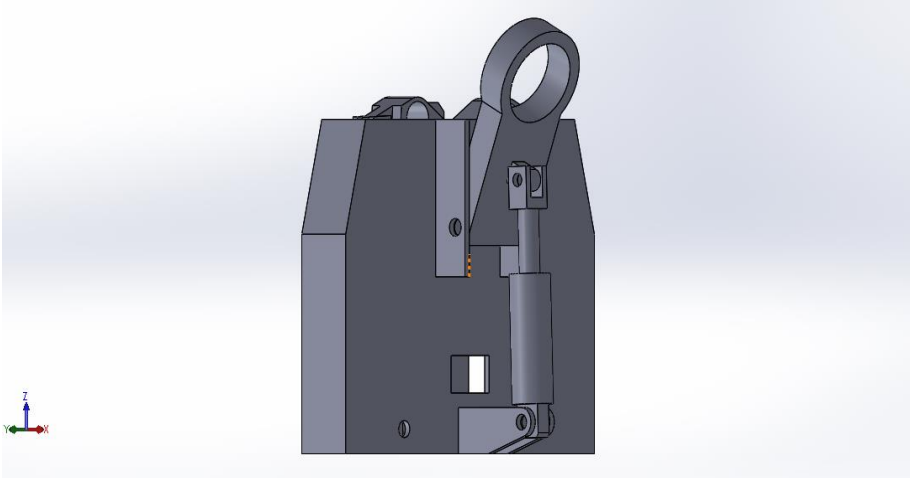
In the starting of process the metal sheet inserts in the machine and the swing arm is in closed position. As the final shape is formed the swing arm opens and the upper roller comes in hanging position and the form part is removed easily from the half frame side. As the part is removed, the swing arm closed and the roller is fitted

with the swing arm. There is hydraulic cylinder is given for the opening and closing of the swing arm.

The drafting sheet of the swing arm is given as below

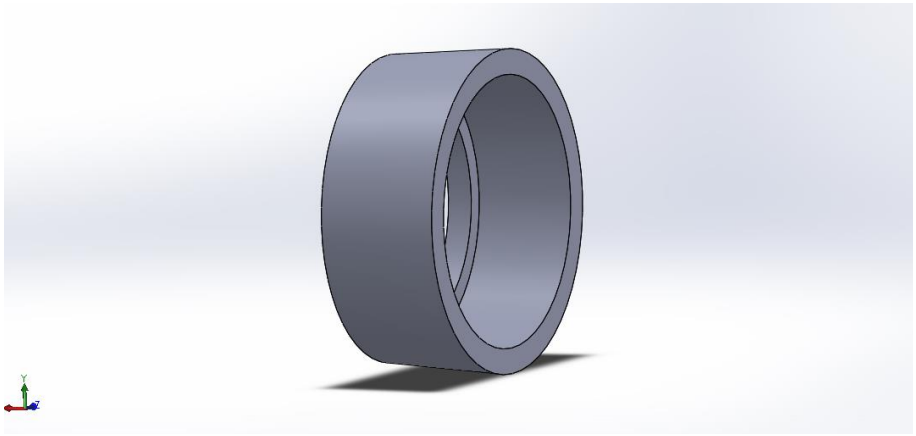


The swing arm is fitted with the half frame is showing as below

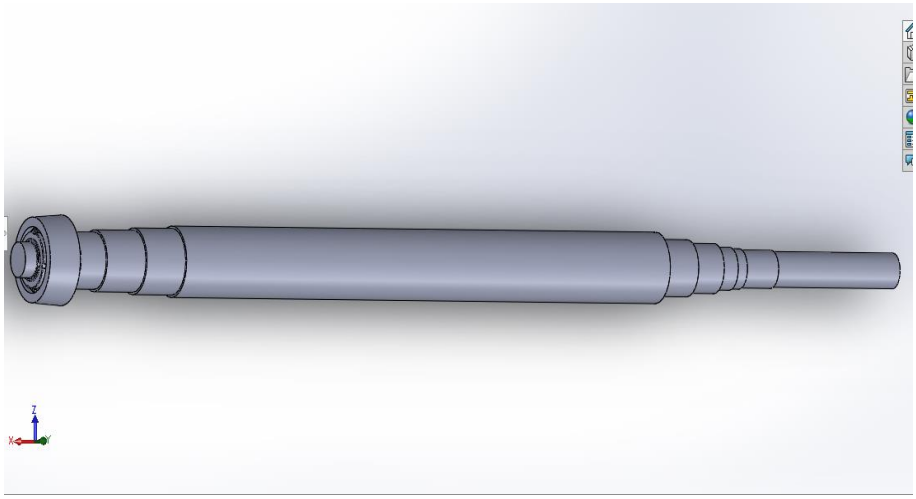


There is bearing head is fixed with the roller and attached with the half frame. It is fitted inside of the swing arm and support the top roll while machine is working. It is designed slight taper on outer surface to make the easy removing of swing arm.

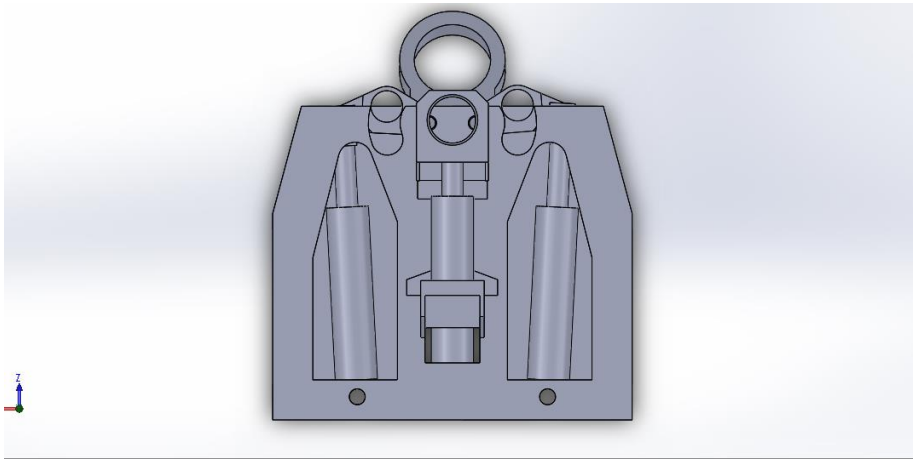
Bearing head:



Top roll with bearing:



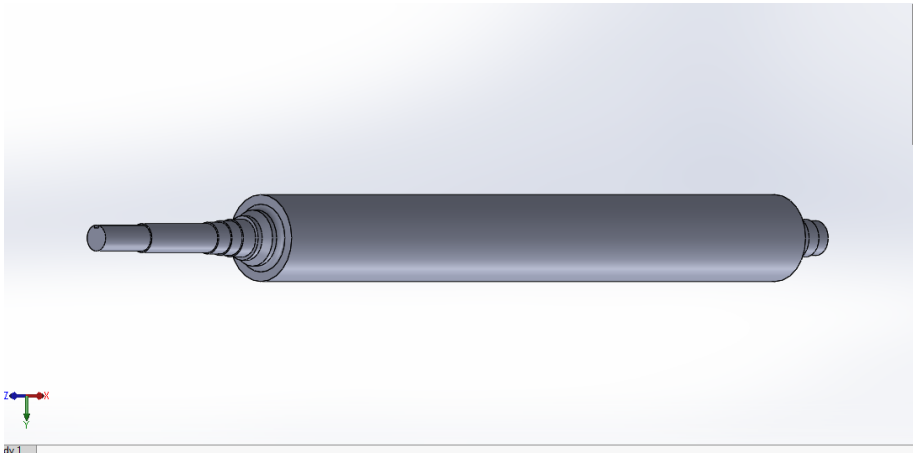
The half frame with all component mounted on it is given below



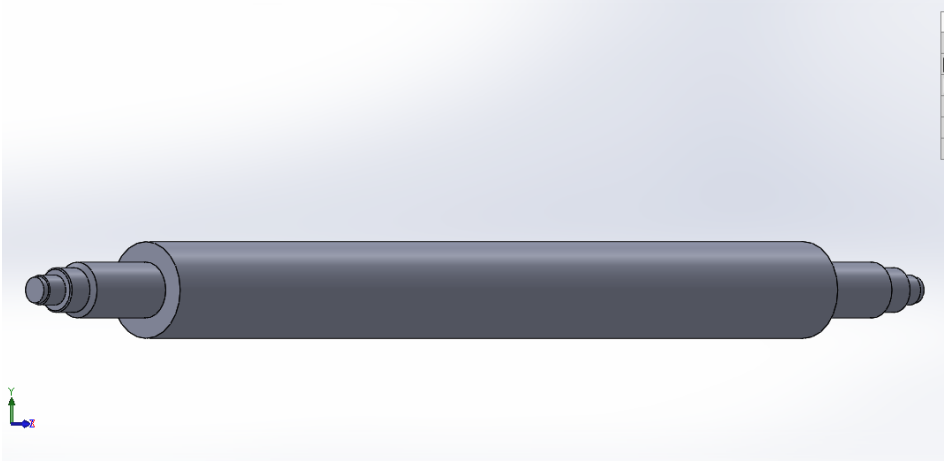
There are four rollers in the machine. The design of them is given as below:

Top roll:

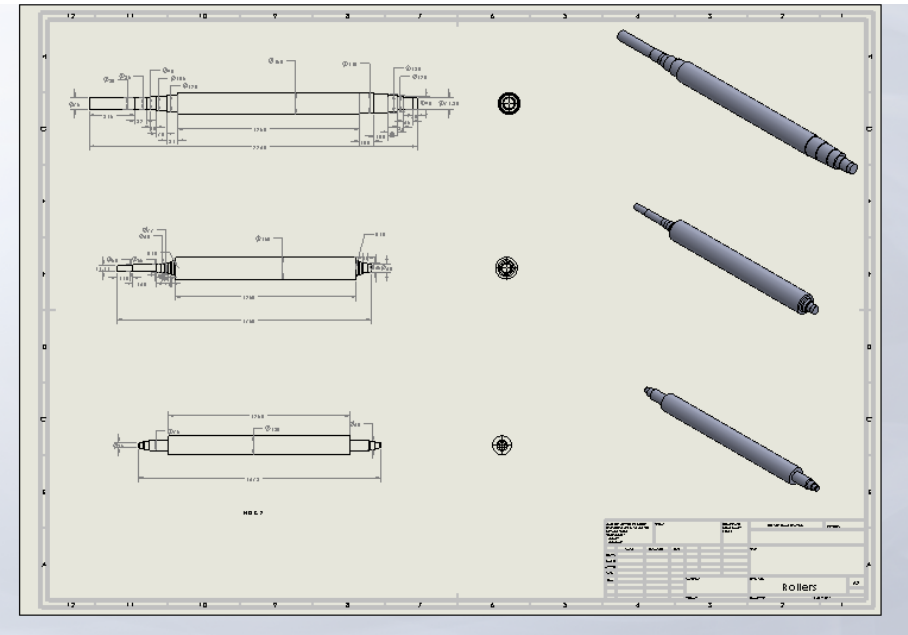
Bottom roll:



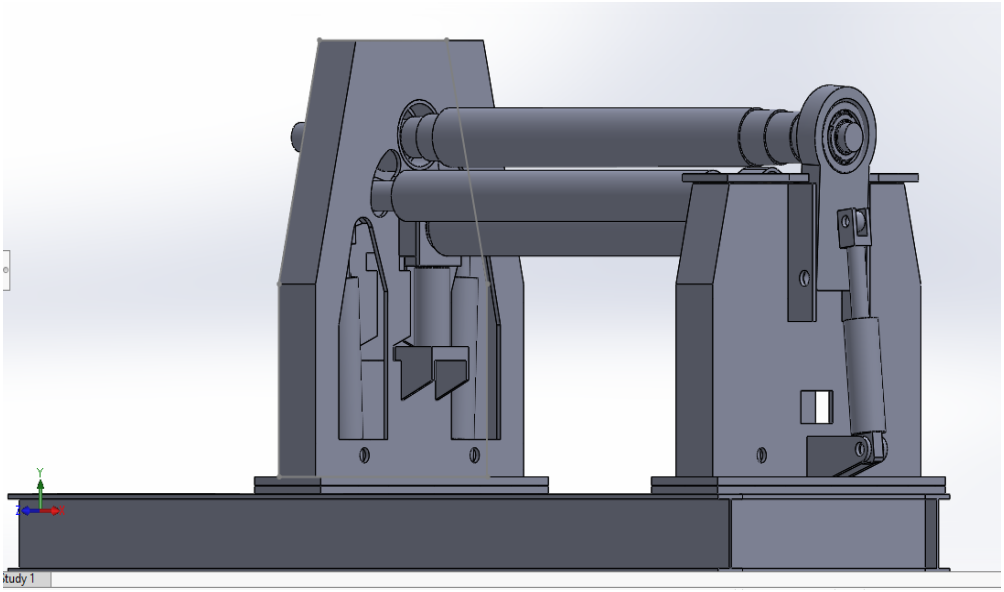
Side rollers:

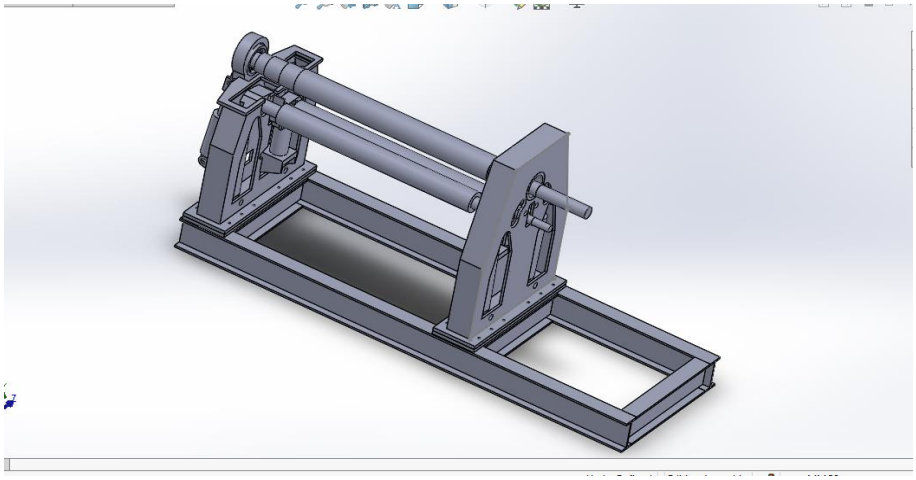


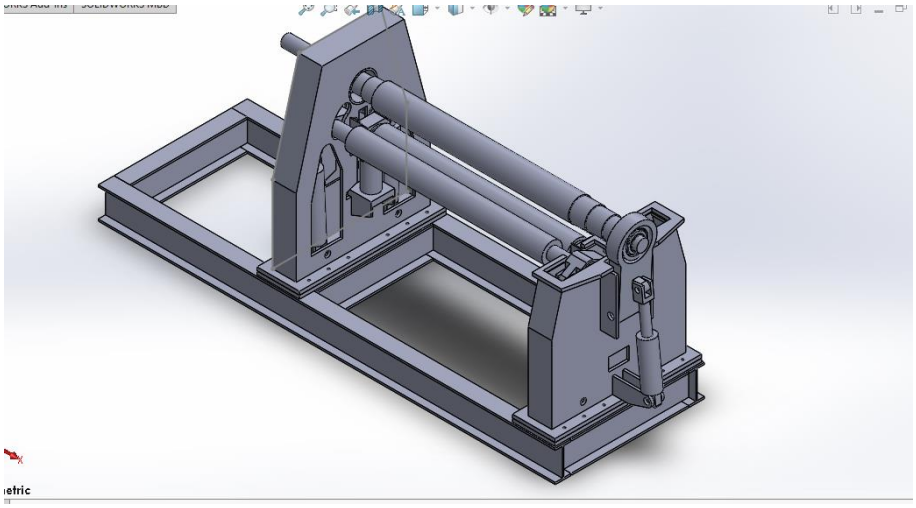
Drafting of all rollers:

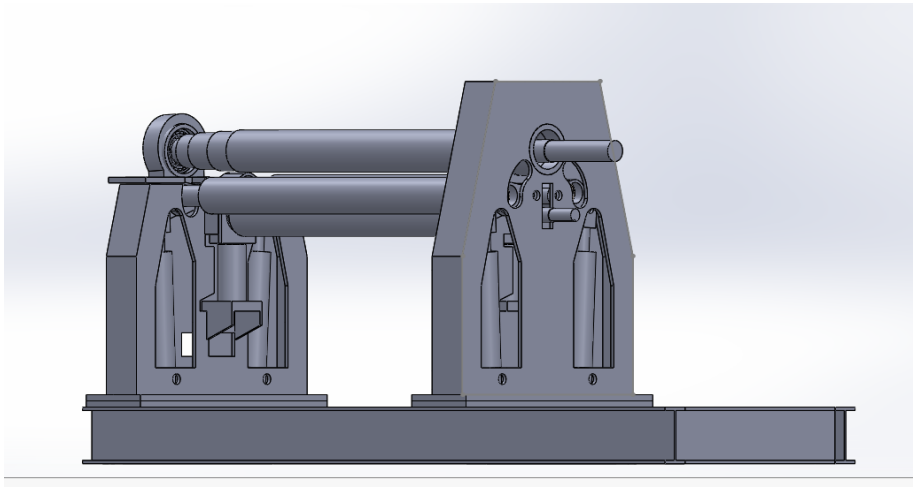


Design of four roll bending machine:

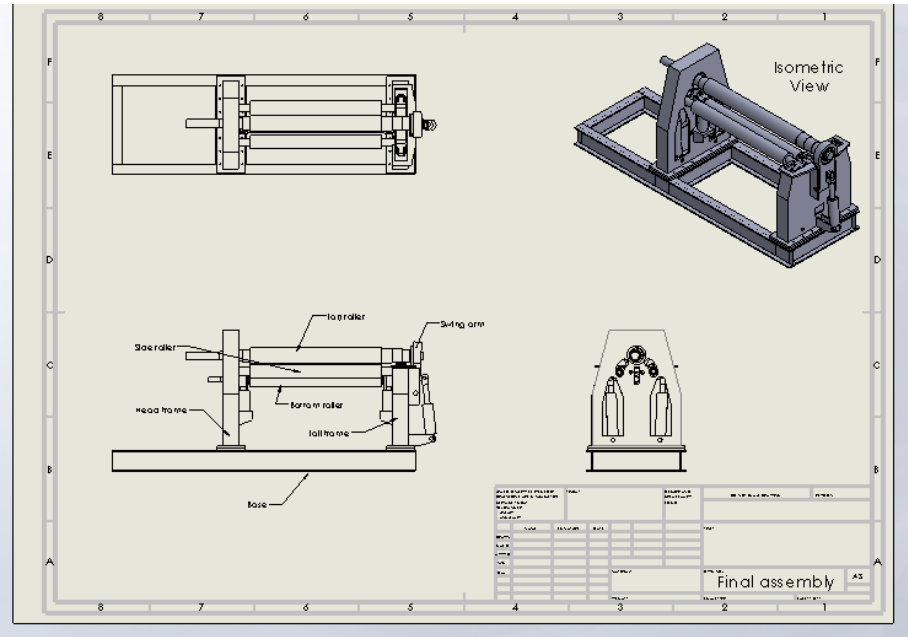








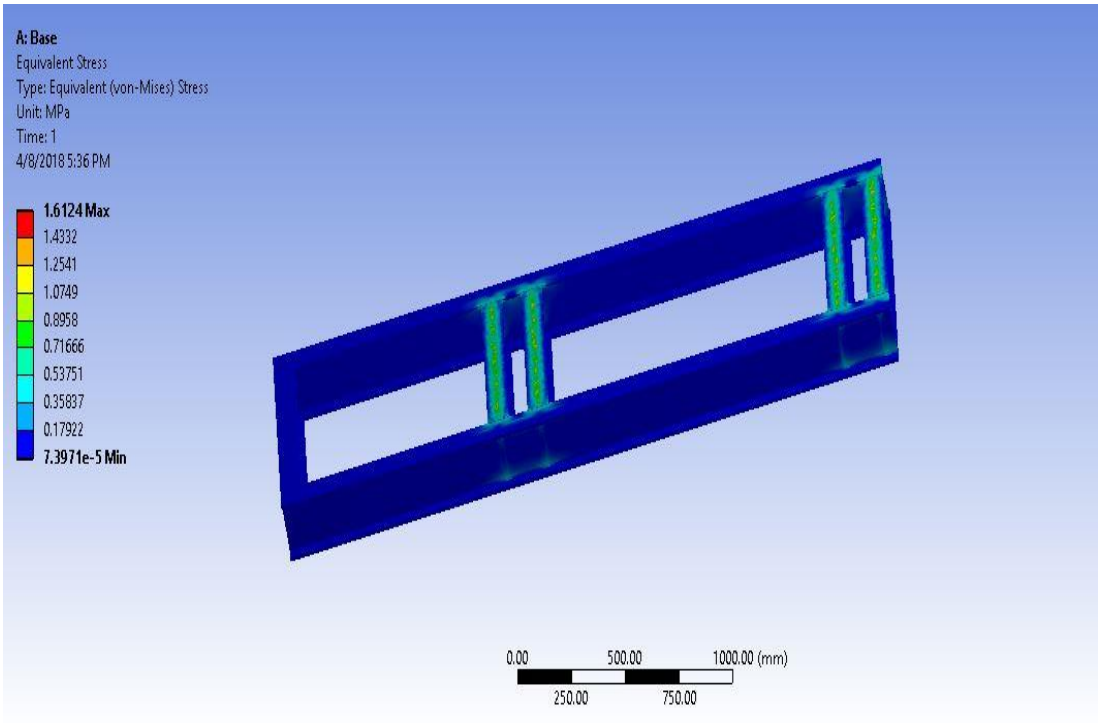
Drafting of machine:



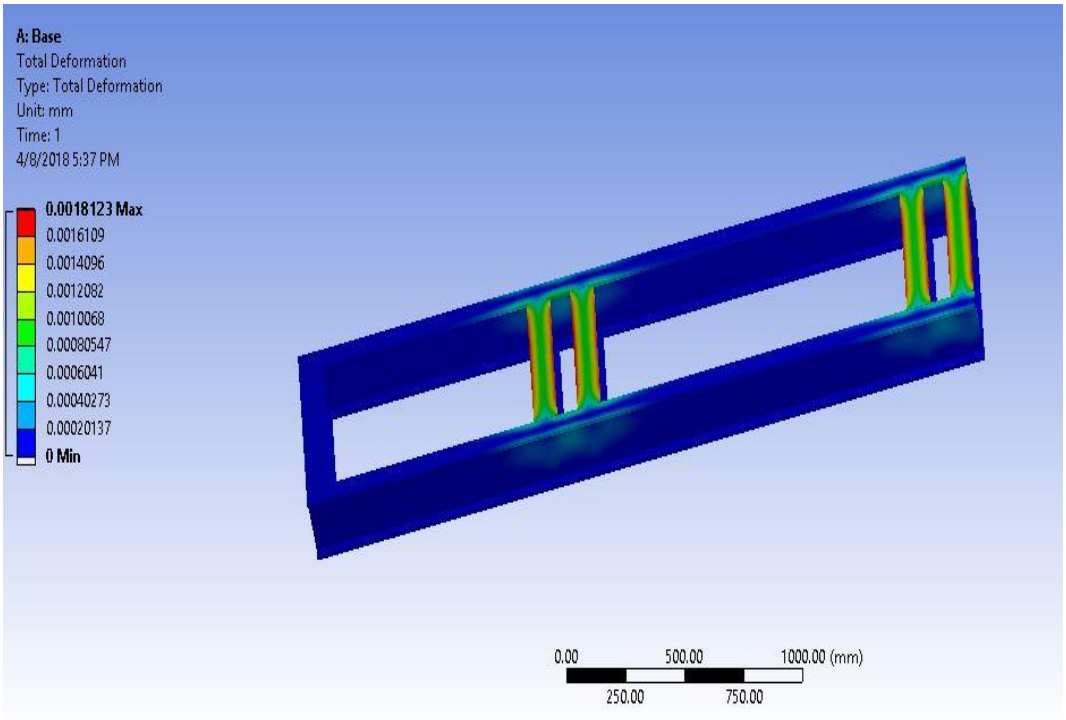
ANALYSIS OF THE MODEL:

Base Frame:

1. Equivalent Stress

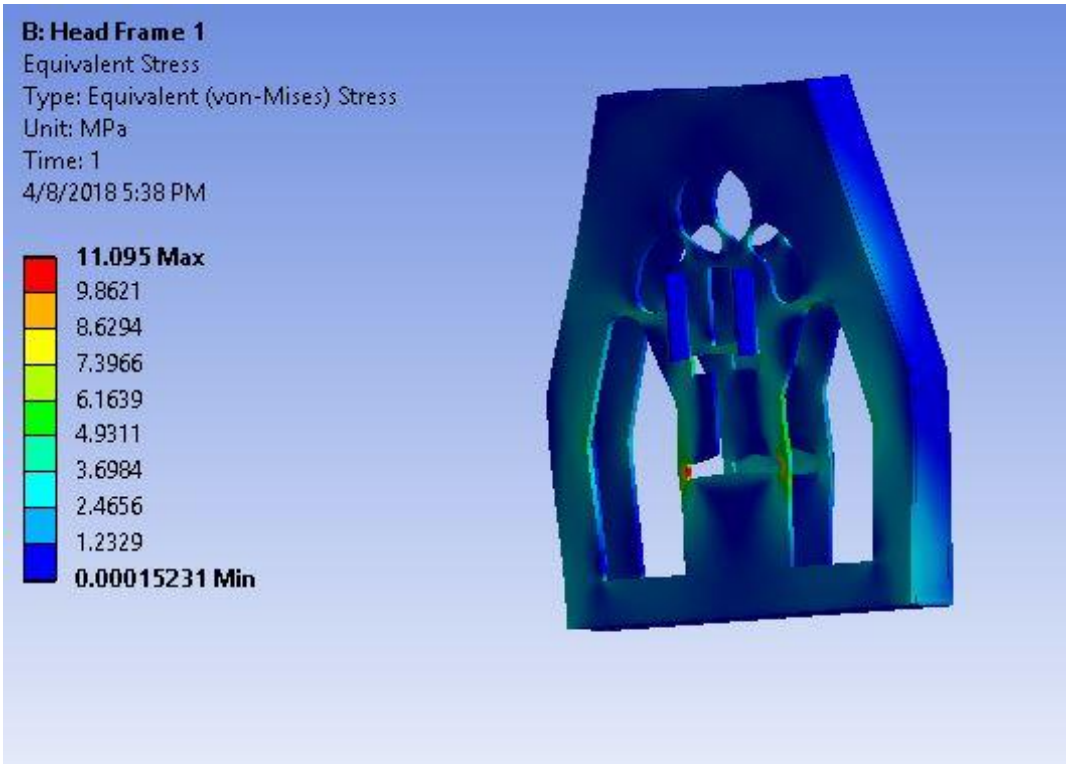


2. Total Deformation:

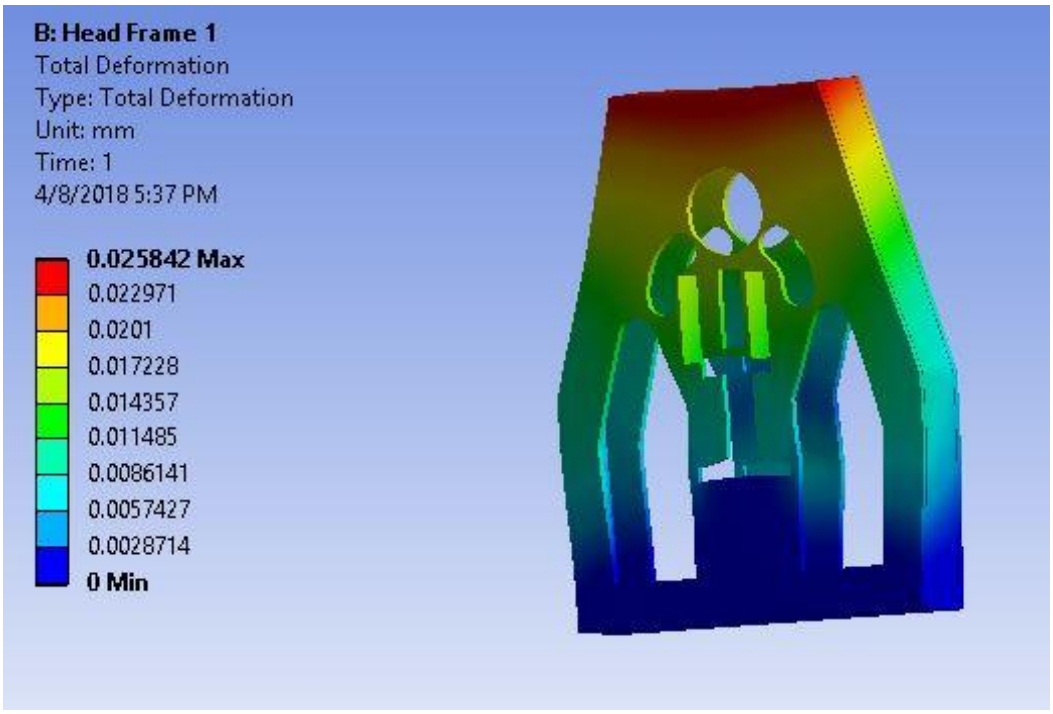


Head Frame:

1. **Equivalent stress**

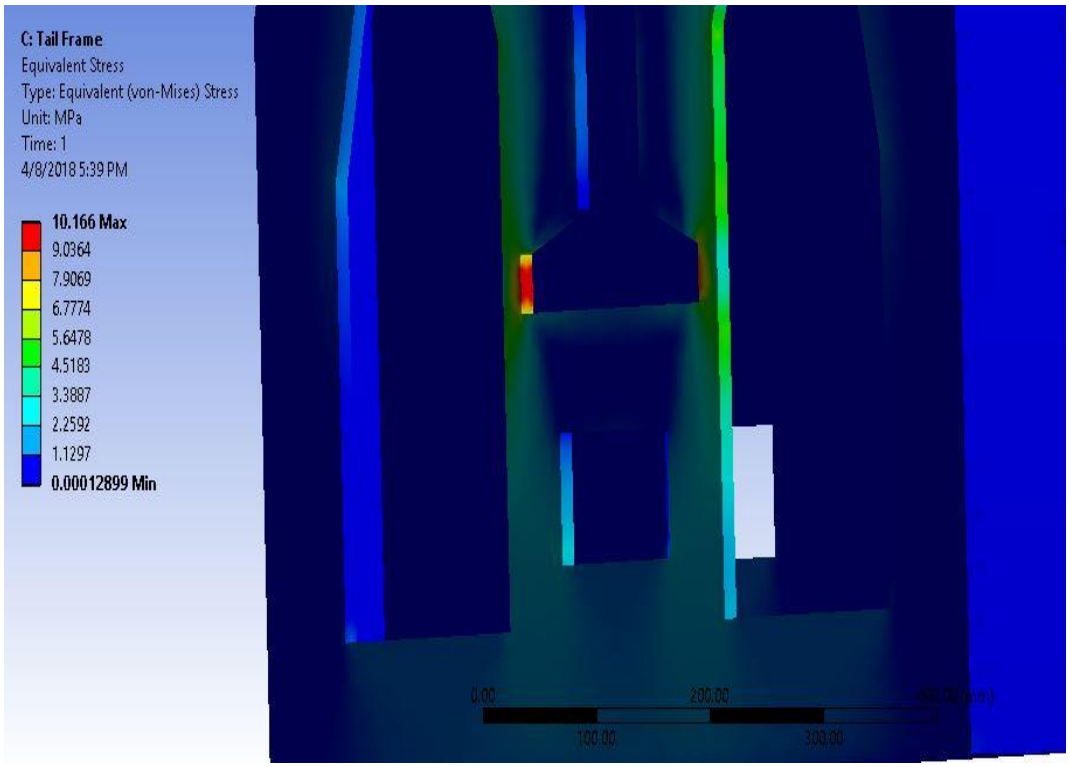


2. **Total Deformation:**

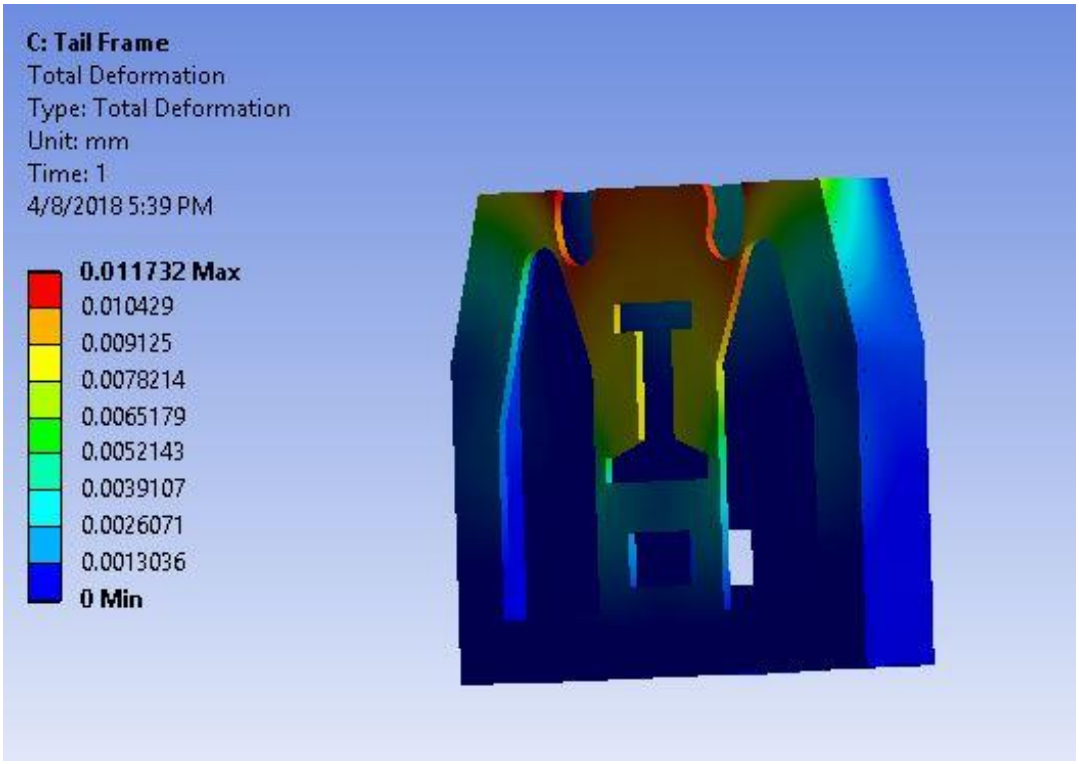


Half Frame:

1. **Equivalent Stress**

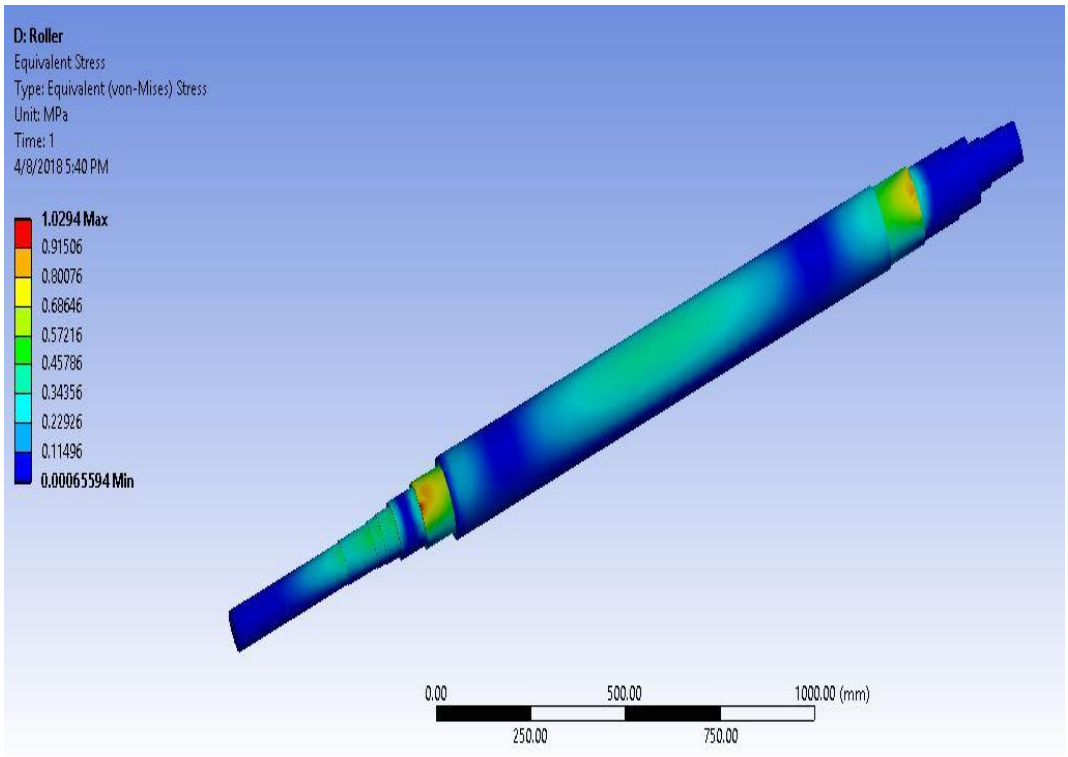


2. **Total Deformation:**

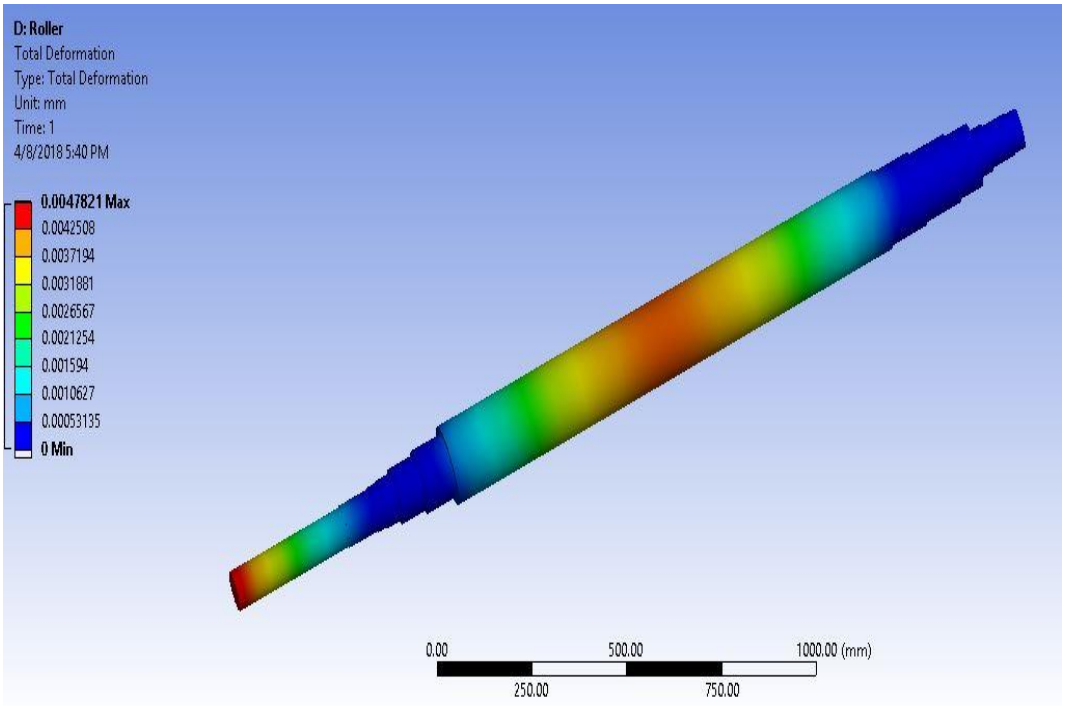


Top Roll:

1. Equivalent Stress

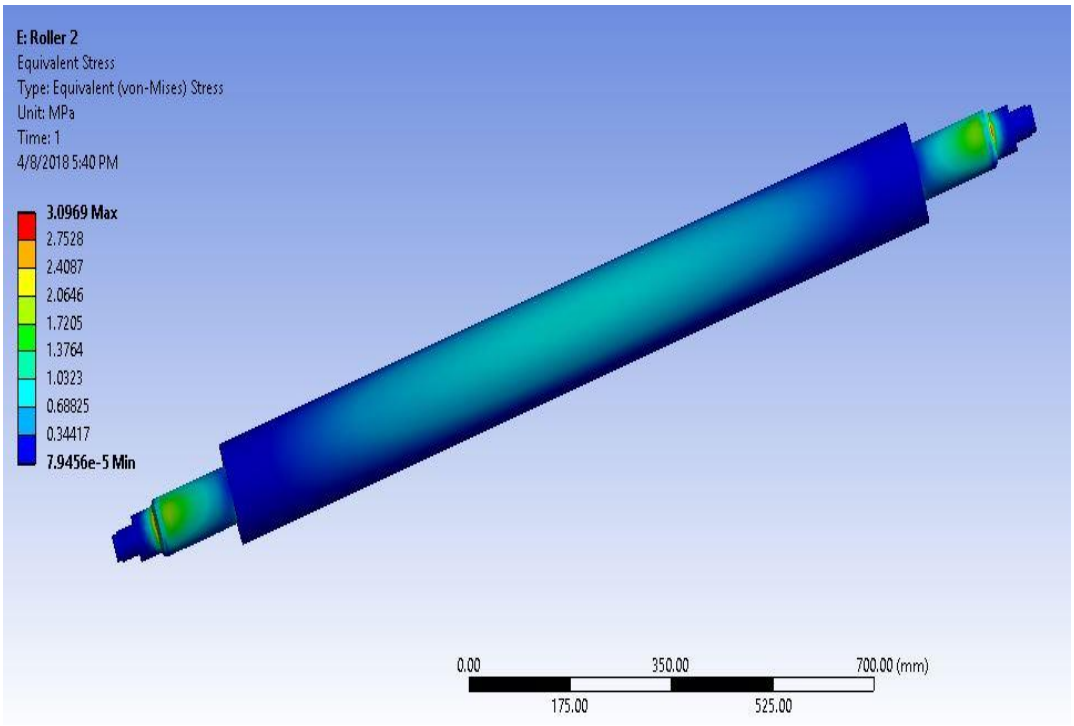


2. Total Deformation:

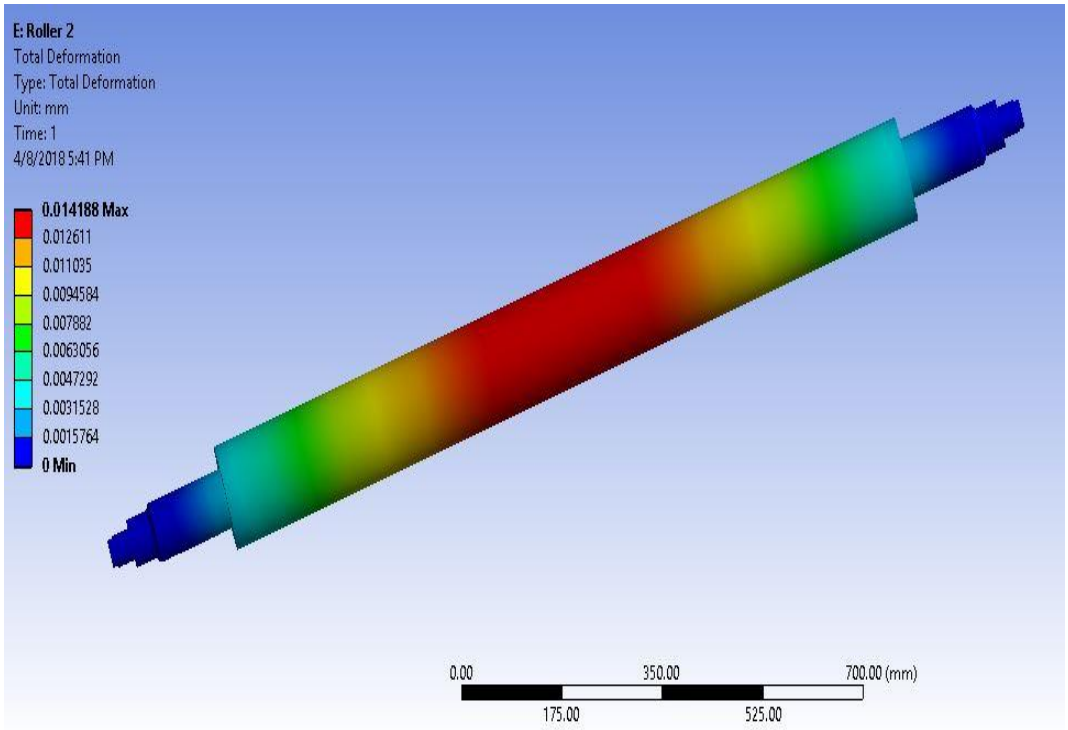


Side Roll:

1. Equivelant Stress



2. Total Deformation:



Conclusion:

As a result it is possible to provide the four roll sheet metal bending machine for small scale industries within minimum cost. The machine price can be reduced to the half of the market price. The machine which can produces all the necessary shapes with easiness. As the machine fulfils all the basic requirement of the industries and also fits in budget, small scale industries can replace their old fabrication methods with less cost. So the machine can easily replace the conventional hydraulic press machine. The machine will also help in increase the production rate drastically. So it is very helpful implement for the small scale industries.

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