Design of Motorized Roll Bending Machine: Concept

Mr. Shete Yogesh Shreekrushna

Abstract— Nowadays, need of variety of operations goes on increasing due to increase in both demand and productivity. So to fulfill these kind of needs we have to develop more productive machineries. The main purpose of the research paper is to explain the design and developed hydraulic powered roller bending machine. It is used for Construction, Aerospace, and Automobiles & Industrial. It's time consumption process. It reduces human effort and also required low less skill to operate this machine. We are designing hydraulic powered roller bending machine with use of roller, bearing, hydraulic jack, & support (frame). The objective of the subject is to make new design of manually and hydraulically operated roller bending machine and stress acting on Metal after bending of Metal. The Metal bending machine is use to bend Metal in different angle shape and curvature as requirement of work. The machine is useful to bend different thickness Metal as per the requirement of shop. The machine is fully portable type and less weight and easy to assemble and disassemble. The can operate unskilled operator.

Keywords: Roll Bending Machine, Induction Motor, Hydraulic Bottle Jack

I. INTRODUCTION

Due to increase in globalization it is very important to produce goods with high precision and high accuracy or reliability. Metal bending machine is mostly use in fabrication industry generally using bending machine produce U-shape and V-shape. In the design of metal bending machine we use only three rollers for the bending of Metal in different angle due to the number of compost use overall cost of machine low and machine portable type the weight of the machine is less than is very full portable. Our project is to design and construct a bending machine. This machine used to bend Metal into curve or other curvature shape. The size of the machine is very convenient for portable work. In various fabrication works as well as in architectural work Metal are use in different ways. To bend these Metals into these artistic forms is not easy thing to be done manually. Using a particular machine specially developed for bending of Metal help. Choosing component material is very important, because it will affect the overall cost of the machine and product quality. With this consideration, we will design this machine with the maximum quality and low cost, In Metal during bending operation stress concentration is occur in bend area of Metal the bend section may be damage during service in particular case where significant validity and thickness version exist which are introduce during menacing process and operation time. Hence the acceptance of Metal depends on magnitude and shape of Metal. In Metal bending process the thickness of Metal is change. The acceptability of Metal bend is depending on magnitude and shape imperfection. Then we also study on failure analysis of Metal bend in these we assume Metal bend is uniform thickness.

II. CONSTRUCTION

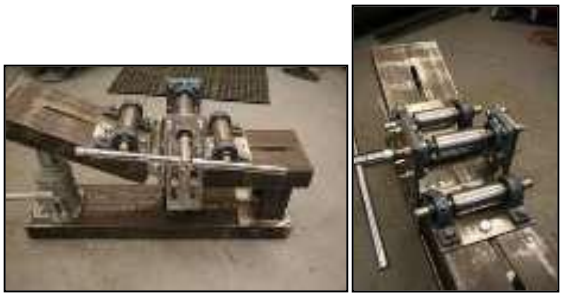

Fig. 1: Construction of bending machine

The model of this project consists of following components,

Bending Rollers	Induction Motor
Bearing	Hydraulic Bottle Jack
Base Frame	Drive Mechanism
Joints & Fasteners	Supporting Frame

III. CONSTRUCTIONAL DETAILS

A. *Bending Roller*

Bending is to be done on sheet metal or metal bars, thus we are going to use solid steel bars as a roller. These rollers must have to meet some specific requirements of physical properties and mechanical properties like Strength, toughness, resilience etc. so the selection of the material for roller is one of the prime factors of design.

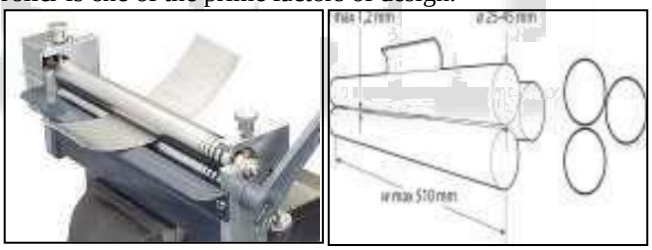

Fig. 2: Bending Rollers

B. *Induction Motor*

Here in this concept, we are going to use induction motor for improving productivity and to minimize human interference which leads to the continuous operation with constant speed. If the speed for each rotation remains constant, it will help to distribute load uniformly and hence reduce surface rupture or other phenomenon.

Fig. 3: Induction motor

C. Bearing:

Fig. 4: Bearing

Bearing is necessary to support the rollers in this concept. Bearing is a mechanical element provides support and also helps to reduce friction during rotations. There is variety of bearings available for every mechanism. The selection of bearing should be done on the basis of load applied and area of application.

D. Hydraulic Bottle Jack

Hydraulic bottle jack is used to provide pressure over material undergoes bending during operations. This can be done manually but there will be some limitations arise for applying forces. We have selected this kind of hydraulic unit because of its ease in handling and availability with least price.

Fig. 5: Hydraulic Bottle jack

E. Drive Mechanism

Drive mechanism for this project is nothing but the unit which helps to transfer power or torque from motor to driving roller.

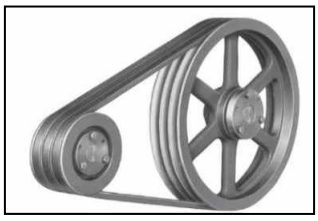

Fig. 6: Drive Mechanism

This is necessary for obtaining better rolling option. We are going to use Belt & Pulleys for the same. In this type we are using V Belt and grooved pulley of the dimensions given in next chapter.

F. Fasteners & Hinge

Fasteners are used for mounting of bearings on base frame and guide frame.

Fig. 7: Fasteners and Hinge

Hinge is used for mounting of guide frame, which is mounted over the hydraulic jack and applicable for producing reasonable bending forces.

IV. DESIGN DATA

A. Selection of V Belt:

We have,

1) Type of driving unit – Motor (1 hp)
2) Operational hours per day – less than 10 hrs
3) Power transmitted – 1hp / 0.75kW
4) Input Speed – 1440 rpm
5) Output Speed – 200 rpm

B. Calculations:

1) Correction Factor = 1 (from PSG design data book)
2) Design power

$$\text{Design Power} = F_a \times \text{Transmittedd Power}$$
$$\therefore \text{Design Power} = 0.75\text{kW}$$

3) According to chart in V. B. Bhandari, cross section for above details is "A"
4) For the same, Minimum pitch diameter is

$$d = 75\text{mm} \dots\dots\dots\dots\dots (\text{Standard})$$

5) For large pulley,

$$D = d \times \frac{\text{Input Speed}}{\text{Output Speed}}$$
$$D = 75 \times \frac{1440}{200} = 540 \text{ mm}$$

But, as per the preferred data, nearer diameter is $D = 560$ mm

6) Pitch Length of Belt, consider centre distance to be 300mm

$$L = 2C + \frac{\pi(D+d)}{2} + \frac{(D-d)^2}{4C}$$
$$\therefore L = 1793.47 \text{ mm}$$

As per the reference data, $L = 1750$ mm

7) Corrected centre distance, C = 265.65 mm
8) Correction Factor = $F_c = 1$
9) Arc of contact,

$$\alpha_s = 180 - \sin^{-1}\left(\frac{D-d}{2C}\right) = 114.0978$$

10) Correction factor, $F_d = 0.81$
11) Number of Belt,

$$N = \frac{P \times F_a}{P_r \times F_c \times F_d} = 0.91 \approx 1$$

C. Determination of Bending Stress

This is important to determine the bending stresses for the selection of roller material and also to determine the capability of the machine. This is also useful to selection other particulars such as Bearing, Motor, torque transmitted to roller, Roller Diameter, Material of roller etc.

Bending Stress can be calculated as follows,

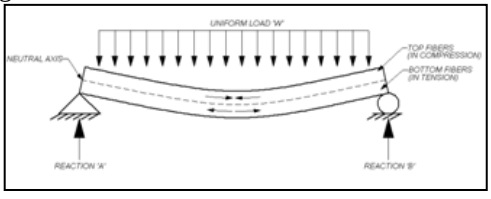

Fig. 8: Bending Stress

When a member is being loaded similar as shown in the figure, bending stress or flexural stress will occurs. Bending stress is more specific type of Normal stress. The stress at the horizontal plane of the neutral is Zero. If the force acting like shown in figure, force from upper side is generally forms Compressive stress, and the stress occurs at the bottom is normal tensile stress.
This stress will be calculated by using,

$$\sigma = \frac{My}{I_x}$$

Where, σ – Bending Stress in N/m^2
M – Moment of Neutral Axis Nm
y – Perpendicular distance to neutral axis in m
I_x – Moment of inertia around Neutral axis in m^4
Maximum Bending Stress can be given by,

$$\sigma_{bmax} = \frac{M_c}{I}$$

With reference to above details, we have determined required strengths of roller material for avoid failure and these values as,
Tensile Strength = 580 N/mm^2
Yield Strength = 400 N/mm^2
Minimum Elongation = 21 %
Yield Stress = 295 N/mm^2
Hardness = 179 BHN
Izod Impact value = 55 N-m

D. Selection of Bearing

A bearing is a machine element which supports another moving machine element. It permits the relative motion between the contact surfaces of the members, while carrying the load. Due to relative motion between the contact surfaces, some power is wasted in overcoming frictional resistance and if there is direct contact between the rubbing surface rapid where occur for reduce this same lubrication must be provided such as vegetable oil, greases etc.

1) Function of bearings

1) The bearing supports the shaft as the axle and holds it in correct position with respect to frame or casing.
2) The bearing ensures free rotation of the shaft or axle with minimum friction.
3) The bearing takes up the forces acting on the shaft or the axle and transmits them to the frame or casing.

2) Selection of the Bearing from the Manufacturer's Catalogue

The following steps must be adopted in selecting the bearing from manufacturer's catalogue.

1) Calculate the radial and axial load reaction (Fa and Fr) acting on the bearing.
2) Decide the diameter of the shaft on which bearing is mounted.
3) Select the proper size of the bearing suitable for given application, specified with speed and available space.
4) Find the basic static rating (co) of the selected bearing from the catalogue.
5) Calculate the ratio $\frac{F_a}{VF_r}$ and $\frac{F_a}{C_o}$.
6) Find the value of x and y i.e. Radial and thrust factor from the catalogue. These value depends upon $\frac{F_a}{VF_r}$ and $\frac{F_a}{C_o}$.
7) Find the value of load factor or application factor 'ka' from the catalogue.
8) Calculate equivalent dynamic load by using relation.

$$P_e = (XVF_a + YF_a)K_a$$

9) Calculate the approximate life of bearing in hours from the type of bearing; operation and type of machinery that is depend upon application.
10) Calculate the required basic dynamic capacity for the bearing by using relation. $L_{10} = (\frac{C}{P_e})^a$.

3) Life of Bearing

The life of an individual bearing is defined as the total number of revolutions (or the number of hours at the given constant speed) which the bearing can complete before the first evidence of fatigue failure develops on the balls or races.

The bearing life can be defined by rating life. It is also known as l_{10} life of the bearing.

4) Life - Load Relationship

Extensive laboratory testing and subsequent statistical analysis have shown the relationship between the dynamic load c, equivalent load p and the rated bearing life l_{10} can be expressed by the equation,

$$L_{10} = \left(\frac{C}{P}\right)^a$$

Where a = constant
= 3 for ball bearing
= $\frac{10}{3}$ for roller bearing.

If the rating life of the baring is given in hour at some constant speed, then the rating life of the bearing in million revolutions is given by,

$$L_{10} = \frac{L_{h10} \times n \times 60}{10^6}$$

Where, n = bearing speed in rpm
L_{h10} = rating life of bearing in hour at some constant speed
L_{10} = rating life of bearing in million revolutions.
From above considerations and calculation we have selected Bearing designated as, UPC205-16 with following details,

d = 25 mm	D = 52 mm
B = 18 mm	E = 32 mm
r = 1.5 mm	Max. Speed = 8000 rpm
Static Capacity = 2200 Kgf	Dynamic Capacity = 3000 Kgf

E. Selection of Motor:

A selection of motor has been done on the basis of availability, modes of operation, rated power, speed required, cost, and rated voltage.
Our selected motor have following details,

– Power = 1 HP / 0.75 kW
– Electric Supply = 230 V / Single Phase

– Type = Induction Motor
– Rated Speed = 1440 rpm
Direction = Both CW & CCW

V. MATERIAL SELECTION

Sr. No.	Name of Entity	Required Properties	Probable Material
01	Bending Roller	Tensile Strength Hardness Resilience	C 30 0.25-0.35 % C 0.6-0.9% Mn
02	Bearing	Corrosion Resistance Thermal Conductivity Hardness	White Metal, Bearing Steel
03	Base Frame / Support Frame	Tensile Strength Machinability Resilience Hardness Availability	Mild Steel, Plain Carbon Steel, Alloy Steel etc
04	Joints	Corrosion Resistance Strength Reliable Availability	Stainless Steel

Table 1: Material Selection

VI. OPERATION & WORKING

The working of this machine is very simple to perform. The basic principle of operation is to apply pressure over the pipe or metal by using hydraulic system. We are going to use hydraulic bottle jack for this purpose.

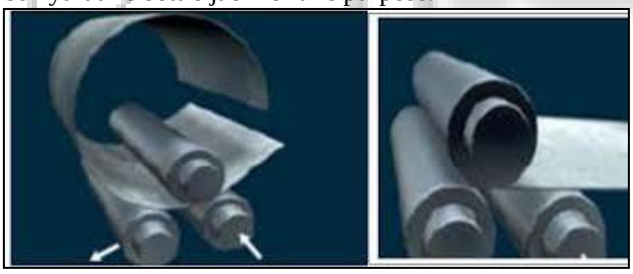

Fig. 9: Working Principle

A pipe or metal undergoing bending operation should insert from one end of the machine through the rollers provided in particular manner as shown in figure above. When this metal got inserted, the rotating operation gets started. After specific rotations the pressure should started to apply in upward direction, which helps to move end side body in upward direction. This movement of end side body results in the formation of deflection of pipe or metal inserted.

VII. CONCLUSION

Addition of motor as a driving element is one of the most positive things in case of this machine. this motor especially selected for the heavy loads and can work effectively with minimum rotations per minutes. So it will definitely helps to improve the productivity with minimal human efforts. Also selection of V belt leads to the minimum sleep and hence there is less chance of accidents will occur. As of motorized operations, it will also raise the area of applications and can bend square tubes, round tubes of both large or small diameters, metal bars of small diameter, metal pipes and also can be useful for sheet metals. This will lead to the greater accuracy and higher productivity of specific plant or industry.

The constant speed of motor also affects the quality of operations. As the speed of rotation remains constant for each time it will helps to spread load uniformly results in better work outcome.

REFERENCES

[1] PSG, “Design Data Book”.
[2] V. B. Bhandari (2012) “Design of Machine Elements” Mc Graw Hill, ISBN.
[3] Hiroyuki Goto, Ken Ichiru, Hidenobu Saitro, Yuu Ishikura And Yutaka Tanaka "Applications with a new 6-dof bending machine in tube forming processes".
[4] Jose Vitor Souze, International Journal of Machine Tools &Manufacture, 2002.
[5] Z. Hu, R. Kovacevic, M. Labudovic, “Experimental and numerical modeling of buckling instability of laser sheet forming”, International Journal of Machine Tools & Manufacture, 2002.
[6] Nayyar, P. E. Mohinder L. (2000). "A1". In Mohinder L. Nayyar, P. E. Piping Handbook (7th Ed) New York: McGraw-Hill. ISBN.
[7] Effect of internal pressure and shape imperfections on plastic loads of pipe bends under in-plane closing moment, T. Christo Michael, A. R. Veerappan, S. Shanmugan, Engineering Fracture Mechanics 105(2013)1 – 15.
[8] Cherniy V. P. 2001. Effect of Curved Bar Properties on Bending of Curved Pipes. Journal of Applied Mechanics, Vol. 68, pp. 650 – 655.
[9] Cherniy. V. P. 2003. The Bending of Curved Pipes with Variable Wall Thickness Journal of Applied Mechanics, Vol. 70, pp. 253 – 259.
[10] YANG Hea, LI Henga, ZHANG Zhiyonga, ZHAN Meia, LIU Jinga, LI Guangjunb, Advances and Trends on Tube Bending Forming Technologies, 2012.
[11] Hiroyuki GOTO, Ken ICHIRYU, Hidenobu SAITO, Yuuishikura, Yutaka Tanaka, "applications with a new 6-dof bending machine in tube Forming processes".
[12] H. A. Hussain, M. Sohail Pervez, Md. Naushad Alam, Atul. P. Ganorkar, "Design and Development of Bicycle Integrated Pipe Bending Machine" 2014.

