© 2018 IJSRST | Volume 4 | Issue 2 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

Design of Multistage Three Roller Pipe Bending Machine

Payal Mane[1], Dr. C. C. Handa[2], V. N. Mujbaile[3]
[1]MTECH Student of Mechanical Engineering Department KDKCE, Nagpur, Maharashtra, India
[2]Professor of Mechanical Engineering Department KDKCE, Nagpur, Maharashtra, India
[3]Assistant Professor of Mechanical Engineering Department KDKCE, Nagpur, Maharashtra, India

ABSTRACT

This paper deals with designing of a multistage three roller pipe bending machine. The present three roller pipe bending machine, its parts and working was studied. The machine is modelled in using the software. Then the design calculations done and the stresses were calculated. The CAD model of multistage pipe bending machine was then developed. This paper demonstrates the design, Data accumulation, and Calculations of the multistage three roller pipe bending machine.

Keywords : Pipe Bending Machine, CAD

I. INTRODUCTION

A three roller pipe bending machine is a mechanical jig having three rollers used to form a metal bar into a circular arc. The rollers freely rotate about three parallel axes, which are arranged with uniform horizontal spacing. Two outer rollers, usually immobile, cradle the bottom of the material while the inner roller, whose position is adjustable, presses on the topside of the material.

1.1 Single stage three roller pipe bending machine

Three roll bending may be done to both sheet metal and bars of metal. If a bar is used, it is assumed to have a uniform cross section, but not necessarily rectangular, as long as there are no overhanging contours, i.e. positive draft. Such bars are often formed by extrusion. The material to be shaped is suspended between the rollers. The end rollers support the bottom side of the bar and have a matching contour (inverse shape) to it in order to maintain the cross-sectional shape. Likewise, the middle roller is forced against the topside of the bar and has a matching contour to it.

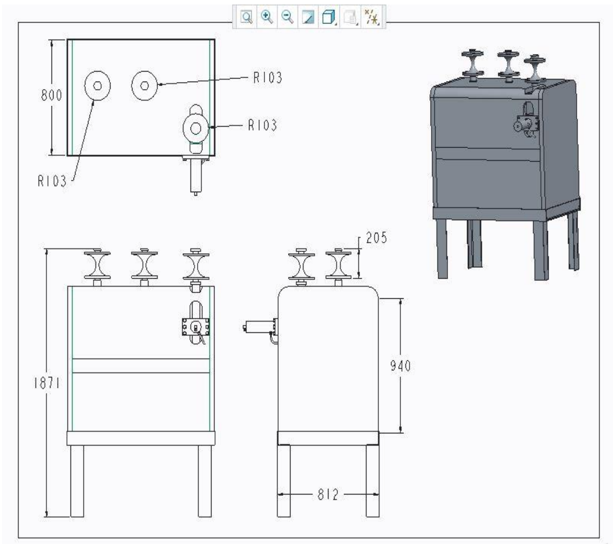

Figure 1. Sketch of single stage three roller pipe bending machine

After the bar is initially inserted into the jig, the middle roller is manually lowered and forced against the bar with a screw arrangement. This causes the bar to undergo both plastic and elastic deformation. The portion of the bar between the rollers will take on the shape of a cubic polynomial, which approximates a circular arc. The rollers are then rotated moving the bar along with them. For each new position, the portion of the bar between the rollers takes on the shape of a cubic modified by the end conditions imposed by the adjacent sections of the bar. When either end of the bar is reached, the force applied to the centre roller is incrementally increased, the roller rotation is reversed and as the rolling process proceeds, the bar shape becomes a better approximation to a circular arc, gradually, for the number of passes required to bring the arc of the bar to the desired radius.

1.2 Multistage three roller pipe bending machine

A three roller pipe bending machine have two stages of roller on the each shaft. In this machine two pipes can be feed into the roller at a time, so that the machine will bend both the pipe together. a single stage three roller pipe bending machine rolls the pipe, similarly multistage three roller pipe bending machine will bend two pipes. Since the machine will bend two pipes in the same time required for bending single pipe, the output of the machine will increase with time as well as cost minimization.

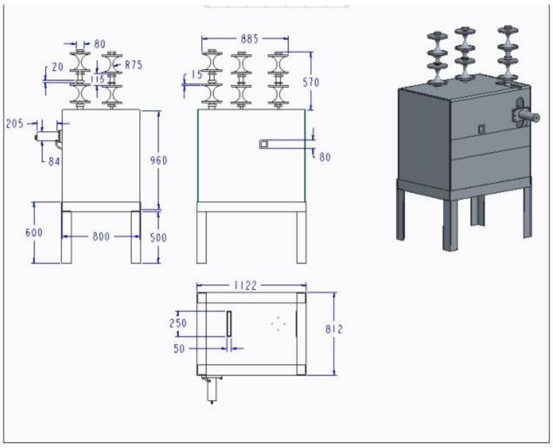

Figure 2. sketch of multistage three roller pipe bending machine

The plastic deformation of the bar is retained throughout the process. However, the elastic deformation is reversed as a section of bar leaves the area between the rollers. This "spring-back" needs to be compensated in adjusting the middle roller to achieve a desired radius. The amount of spring back depends upon the elastic compliance (inverse of stiffness) of the material relative to its ductility. Aluminium alloys, for example, tend to have high ductility relative to their elastic compliance, whereas steel tends to be the other way around. Therefore aluminium bars are more amenable to bending into an arc than are steel bars.

A three roller pipe bending machine is power driven. The machine takes power from electric motor. This power is transmitted through number of gears to the roller. So the gear design is the main part of the machine. There are ten gears that transmits the power to the roller. Here, the speed, number of teeth, diameter of the gear are to be calculated. And also the force required for bending the pipe is calculated. The stresses that are acting on the gears are also determined. A multistage three roller pipe bending machine is to be designed for increasing the production rate, so that the increasing demand is met. If we use more machines for pipe bending it will not only increase the investment cost but also increase number of labours required for the operation. So keeping all this in mind the machine is designed for cost minimization.

II. METHODS AND MATERIAL

Data Accumulation

A three roller pipe bending was designed, thus, it requires the data of existing pipe bending machine. So the related data is collected from the industry. First, measurement of the pipe that is to be bended is measured. Then the motor, its speed, power, etc are taken. Then the number of labours, time required for the operation, number of pass required, etc are taken. Also the measurement of roller and other parts are taken.

2.1 Calculations

For three roller pipe bending machine, load and stress was calculated. The spur gears are designed and its dimensions was calculated. The formulas used for calculations are given below.

2.1.1 Load On Pipe

$F=2*(4EI/RL)$

a) Power Requirement

A gradual application of effort will bend the pipe quite smoothly. This means that very small velocity will be required. An available motor capacity standard is therefore selected and reduced to appropriate speed output.

Choosing a motor of 1.5 kW;

Power (P) = Force (F) x Velocity (V) ;

Thus, $V = P / F$

b) Speed Reduction (Spur Gear Design)

Minimum number of teeth on the pinion;

$Tp = 2Aw / G\sqrt{} 1 + 1/G (1/G + 2) \sin 2\theta - 1$ (Shigley and Mischke, 1989)

Where G = Gear ratio / Velocity ratio; and θ = pressure angle, 20

Aw = Fraction by which the standard addendum is multiplied, 1m for θ =20

Thus, we choose Tp from standard table (Shigley and Mischke, 1989)

Number of teeth on the gear, $Tg = 2Tp$

But centre distance between the gears, $L = Dg/2 + Dp/2$

Where Dg = Diameter of gear, and Dp = Diameter of pinion

$Dg / Dp = 2$; $Dg = 2Dp$; $L = 2Dp / 2 + Dp / 2 = 3/2 (Dp) = 1.5 Dp$

$Dp = m Tp$; where m is the module

$m = Dp / Tp$; Use standard value, m = 2.5

Pitch Circle Diameter of gear, $Dg = 2Dp$

c) Face Width of the Pinion and the Gear

Pitch line velocity, $V = \pi DpNp / 60$

For medium load shock condition and between 8~10 hours of service per day (Khurmi and Gupta, 2004);

Service Factor, Cs = 1.54 and 2.369 for non-enclosed gears.

Tangential Tooth Load, $WT = Cs (P/V)$

Velocity Factor, $Cv = 4.5 / 4.5 + V$

Since the pinion and the gear are of same material, the pinion is weaker. For 20o involute teeth;

Lewis Form Factor, $Yp = 0.154 – (0.912 / Tp)$

Thus, design tangential tooth load; $WT = \delta Wp \times Cv \times b \times \pi \times m \times Yp$

Where δWp is the safe stress of the pinion, 140 MPa and b is the face width of both pinion and gear.

But minimum face width is taken as (9.54 ~ 12.5)m ;

Thus, let minimum face width, $b = 9.54 \times m$

d) Power Transmitted

$P = WT \times V$

Check for Static and Dynamic Loading

Flexible endurance limit for steel, $\delta s = 252$

Static load or endurance strength, $Ws = \delta s \times b \times \pi \times m \times y$

Power that can be transmitted due to static loading is;

$Ps = Ws*V$

If Ps is greater than P, the design is safe from the standpoint of static loading.

Also Dynamic Load, $WD = WT + [2/V (bc + WT) / 2/V \sqrt{bc} + WT$

But from table (Khurmi and Gupta, 2004), C = 228, and tooth error, e = 0.02

Power that can be transmitted from this dynamic load, $PD = WD \times V$

Since PD is greater than P, the design is safe from the standpoint of dynamic loading.

e) Design of Pinion Shaft

Load acting between the tooth surface ;

$WN = WT / \cos \theta$

Weight of pinion,
$Wp = 0.00118 \times Tp \times bm2$

III. RESULTS AND DISCUSSION

Resultant load acting on the pinion;

$WR = \sqrt{WN2 + WP2 + 2WNWPCos\ \theta}$

Bending Moment due to this resultant load;

$MB = WR \times Dp/2$

Twisting Moment on pinion;

$MT = WT \times Dp /2$

Equivalent Moment, $ME = \sqrt{MB2 + MT2}$

But equivalent twisting moment is given by;

$TE = (\pi / 16) \times 40 \times Dp^3$;

Diameter of pinion hub = 1.8 Dp

Length of hub = 1.25 Dp

Minimum web thickness = 1.8m (use web thickness = 10 mm).

Design of Gear Shaft
Normal load acting on the gear, WN = 1181.8N

Weight of gear, $Wg = 0.00118\ Tgbm^2$

Resultant load acting on the gear; $WR = \sqrt{WN2 + Wg2 + 2WNWg\ Cos\ \theta}$

Equivalent moment, $ME = \sqrt{MB2 + MT2}$

But equivalent twisting moment, $TE = (\pi/16) \times 40 \times Dg^3$

Diameter of gear hub = 1.8 Dg

Length of gear hub = 1.25 Dg

Minimum web thickness = 1.8m (use web thickness = 12 mm)

f) Torque
$P = 2\pi NT/60 = 2^* \pi^* 4^* T/60$

Machine Specifications

Sr. no.	Part name	Dimensions
1	Gear	Diameter=86 mm, no. of teeth=36
2	Pinion	Diameter=43 mm, no. of teeth=18
3	Shaft	Diameter=20 mm,
4	Pinion hub	Diameter=77 mm, length=54 mm
5	Gear hub	Diameter=154.8mm,length=107.5 mm
6	Roller	Diameter = 206 mm, speed = 22.5 rpm

IV. CONCLUSION

Thus, the design of multistage pipe bending machine is carried out. Dimensions, power and stresses on the machine are also found out. The finite element analysis of the machine will help in validating the results.

V. REFERENCES

[1]. "Review paper on design of multistage three roller pipe bending machine for C. B. Industry

Nagpur"-Payal Mane, C.C. Handa, V. N. Mujbaile, department of mechanical engineering, KDK college of engineering, Nagpur

[2]. "Development of a hydraulically operated pipe bending machine"-olafimihan. E. O-Department of Mechanical Engineering, LadokeAkintola University of Technology, Ogbomosho, Nigeria

[3]. "Study of portable 3 roller pipe bending machine" Prashant P.Khandare1 , DhiralN.Patel2 , Mayur K.Aher3 , Ravi S.Parbat4 , Prof. Swapnil S. Patil5 1,2,3,4Scholar student of B.E(mechanical engg.)Pune University.

[4]. "Review on Design and Analysis of Portable Rolling and Bending Machine"-Pooja K. Borkar1 Prof. Pankaj H. Meshram2 1M.E. Scholar 2Assistant Professor 1,2Department of Mechanical Engineering 1,2 JCOET, Yavatmal

[5]. "Experimental design and fabrication of a portable hydraulic pipe bending machine"-Mohan Krishna S. A.- Department of Mechanical Engineering, Vidyavardhaka College of Engineering, Mysore-570002, Karnataka, India

[6]. "Research Paper of Manually Operated Pipe Bending Machine"-N. N. JADEJA-Assistant Professor, Government Engineering College, Bhavnagar- 364002

[7]. "Justifying, Selecting and Implementing Tube Bending Methods"-GREG MILLER President/Owner bnubular Solutions, Inc. Medina, Ohio

[8]. (Khurmi and Gupta, 2004) International Journal of Engineering and Technology (IJET)-Volume 4 No. 5, May, 2014 ISSN: 2049-3444 2014-IJET Publications UK. All rights reserved. 308

[9]. International Journal of Engineering and Technology (IJET)-Volume 4 No. 5, May, 2014 ISSN: 2049-3444 2014-IJET Publications UK. All rights reserved. 308