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Design and Fabrication of Three Roll Metal Bending Machine

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Abstract- This research presents the design and performance test of three roll metal bending machine (shaft design). The main purposes of this research are to construct a three roll metal bending machine and to do the performance tests. The aim of this project is to develop a portable metal bending machine to bend sheet into curves and the other curvature shapes. In this research, shaft diameter is calculated by using ASME code equation. Mild steel shaft is selected for design to obtain high strength. The estimated diameter of rotating shaft is 31.75mm and main shaft is 25.4mm. Pillow block bearing UCP205 is selected. The estimated value of Factor of Safety is 3.32. Therefore, the determination of research design is totally safe. As a lot of time is consumed when metal bending is made by hand, so using bending machine will save the waste time. The size of machine is small and it is convenient for portable work. No skill worker is required to operate the machine.

Indexed Terms- Diameter of Shaft; Bending Moment; Stresses; Bearing Selection

I. INTRODUCTION

Bending is a process by which material can be deformed by plastically deforming the material and changing its shape. The material is stressed beyond the yield strength but below the ultimate tensile strength. The surface area of the material does not change very much. Bending usually refers to deformation about one axis. Bending is a flexible process by which many different shapes can be produced. Standard die sets are used to produce a wide variety of shapes. In this research, the manual power bending machine is designed instead of robotic system to bend the material. By using manual bending machine, the design consumes no electrical power. So, cost is less compared to electrical power hydraulic systems benders. Choosing the suitable material for the components is very important because it will affect the overall cost of the machine and the product quality. So, the design of bending machine is simple construction, easy to control and requires little maintenance.

This bending machine is used to bend sheet metal into curve or another curvature shape. The size of the machine is very convenient for portable work. It is fully made by steel. Moreover, it is compact and so easy to be carried and used at any time and any place. In various fabrication works as well as in architectural work pipes are used in artistic ways. Various types of bending machines are used for metal bending. Majority of the machines are manually operated and operating force is magnified using mechanical advantage from an appropriate system. Moreover, most of the bending machines use roll bending type. This type of machine has three rolls, one roll is fixed and the other two rolls are adjustable. The metal rod needs to put in the roller and then rolls around it until the desire shape is acquired.

II. MAIN COMPONENTS AND FUNCTIONS

A. Base Frame

Figure 1. Construction of base frame

All components are set up in base. Base frame must resist the applied load of all components and the compression of main shaft while bending. Figure 1 shows the desired base frame which is used in three roll metal bending machine.

B. The Roller

The rollers freely rotate about three parallel axes, which are arranged with uniform horizontal spacing.

Figure 2. The roller to support the shaft

The rollers in figure 2 are freely rotate about three parallel axes, which are arranged with uniform horizontal spacing. Two bottom rollers can be adjustable and the middle roller is connected with small plate that can be movable. Two bottom rollers are then rotated moving the bar along with them.

C. The Pillow Block Bearing

Figure 3. The block bearing for machine

The block bearing in figure 3 is pedestal used to provide support for a rotating shaft. It is bolted to a foundation securing it, while the shaft and the inner ring of the bearing are free to rotate.

Figure 4. Main shaft of bending machine

The main shaft is connected with small plate that is joined with the middle roller. By handling the shaft, the middle roller can compress the bar by moving up and down. Figure 4 illustrates the main shaft of the three roll metal bending machine.

D. The Supporter Shaft

Figure 5. The supporter shaft of machine

These shafts are joined with the base, small plate and large plate. One of these shafts can move the middle roller. Figure 5 shows the supporter shaft of the three roll metal bending machine.

III. METHODOLOGY

A. Specification Data for Design Estimation

Table 1. Specification data for bending machine

Name	Symbol	Value	unit
Diameter of main shaft	D_{MS}	25.4	mm

Diameter of roller	D_R	31.75	mm
Diameter of supporter shaft	D_S	25.4	mm
Speed of Handle	N	72	Rev/min
Weight of main shaft	W_S	11.8	N
Distance between bottom rollers	d	406.4	mm

The table 1 describe the required dimensions of the components which is used in three roll metal bending machine.

B. Equations for Design

For simple bending without applied tension and where the radius of curvature is more than several times the sheet thickness, the neutral surface approximately coincides with the middle surface. The internal bending moment for the power law material can be derived by the following equation,

$$M_{int} = K'(\frac{t^{n+2}}{\rho^n (n+2)2^{n+1}})b \qquad (1)$$

The external bending moment can be determined from the following equation;

$$M_{ext} = F((1-\frac{x}{l}))x \qquad (2)$$

The top roller load can be calculated as follows;

$$F = K(\frac{t^{n+2}}{\rho^n (n+2)2^{n+1}})(\frac{l}{lx - x^2})b \qquad (3)$$

The maximum width can be calculated from the following equation;

$$b_{max} = \frac{F_{max}(l - \frac{x}{l})x\rho^n (n+2)2^{n+1}}{K.t^{n+2}} \qquad (4)$$

According to Euler Bernoulli Bending Theory, the bending moment and shear force can be calculated by using the following relations;

$$M(x) = -EI\frac{d^2 w(x)}{dx^2} \qquad (5)$$

The classic formula for determining the bending stress in a beam under simple bending is as follows;

$$\sigma = \frac{My}{I} \qquad (6)$$

Shaft design consists primarily of the determination of the correct shaft diameter to ensure satisfactory strength and rigidity when the shaft is in loading conditions. Design of shaft of ductile material based on strength is controlled by maximum shear theory. The rotation of shaft is usually subjected to torsion, bending and axial loads. For a solid shaft having little or no axial loading, the ASME code equation is given as follows;

Maximum Torsional Moment;

$$M_t = \frac{\tau_{max} J}{r} \qquad (7)$$

$$d = (\frac{16}{\pi\tau_{max}}\sqrt{(K_b M_b)^2 + (K_t M_t)^2})^{\frac{1}{3}} \qquad (8)$$

For bearing selection, the equivalent bearing load, P can be calculated from the following equation;

$$P = X\ V\ F_r + Y\ F_a \qquad (9)$$

Nominal Life in Revolution, L can be calculated as follows;

$$L = \frac{60NL_h}{10^6} \qquad (10)$$

Relationship between load and life can be calculated from the following equation;

$$L = (\frac{C_r}{P})^p \qquad (11)$$

When the shaft is subjected to axial tensile force, the tensile stress can be calculated from the following equation;

$$\sigma_t = \frac{4P}{\pi d^2} \qquad (12)$$

When the shaft is subjected to pure torsional moment, the torsional shear stress can be calculated from the following equation;

$$\tau = \frac{16M_t}{\pi d^3} \quad (13)$$

The maximum principal stress can be calculated as follows;

$$\sigma_1 = \frac{16}{\pi d^3}(M_b + \sqrt{(M_b)^2 + (M_t)^2}) \quad (14)$$

The factor of safety is;

$$F.S = \frac{S_{yt}}{\sigma_1} \quad (15)$$

The maximum shear stress can be calculated from the following equation;

$$\tau_{max} = \frac{16}{\pi d^3}(\sqrt{(M_b)^2 + (M_t)^2}) \quad (16)$$

The angle of twist θ_r (in radians) can be calculated from the following equation;

$$\theta_r = \frac{M_t l}{GJ} \quad (17)$$

IV. PERFORMANCE TEST AND RESULTS

Table 2. Theoretical results for estimation of shaft

Name	Symbol	Value	Unit
Maximum Torsional Moment	M_t	465671	N-mm
Diameter of rotating shaft	d	31.7	mm
Equivalent bearing load	P	21.58	N
Nominal Life in Revolution	L	330	rev
Tensile stress	σ_t	27256.75	Pa
Bending stress	σ_b	784994.5	Pa
Maximum principal stress	σ_1	74.49	MPa
Factor of safety	F.S	3.32	
Angle of twist	θ_r	784.95	deg

Table 3. Performance test results

Material	Length of material (mm)	Thick-ness (mm)	Testing time (min)	Radius of curva-ture (mm)
Iron	1173	3	20	406.4
steel	2394	11	25	381

Figure 6. Performance test during 15 minutes

Figure 7. Performance test during 20 minutes

The estimated results of shaft for bending machine are shown in table 2. The three roll metal bending machine is tested two times. The bend radius and thickness of the work-piece after bending and time taken to bent are collected from these tests as shown in table 3. The tests are done at 15 minutes, 20 minutes and 25 minutes respectively and the bend radius are measured within different time taken as shown in figures 6, 7 and 8. The test results of curvature of sample are also shown in figures 9 and 10 respectively. It can be seen that the radius of curvature is bended depends on its kind of material.

Figure 8. Performance test during 25 minutes

Figure 9. Test results of iron sheet material

Figure10. Test results of steel sheet material

V. CONCLUSION

Three roll metal bending machine, which is universal forming equipment for rolling metal plate into curve, circle and shapes. Accordingly to the principle of the three-point forming circle, the relative position change and rotational motion of the working roll make the metal produce continuous plastic deformation to obtain the predetermined shape of the work piece. Finally it should be mentioned that at the sideways of the metal bender, roller can be placed to move it easily. Since these metal bender is manual, it has been widely used because of its simple structure, convenient and low cost. This innovation has made the more desirable and economical. This research is designed with the hope that it is very much economical and help full to some industries. Since the design is constructed by manual power, the large diameter or the heavy load cannot be accepted. The bending results are different according to the materials used and load position.

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NOMENCLATURE

M_{int} : Internal bending moment (N-mm)

t : Thickness of Material (mm)

N : Strain hardening exponent

ρ : Radius of neutral plane (mm)

b : Width of material (mm)

M_{ext} : External bending moment (N-mm)

F : Top roller load (N)

G : Modulus of rigidity (N/mm^2)

x : Horizontal distance between bottom and top roller (mm)

l : Distance between two bottom rollers (mm)

b_{max} : Maximum width (mm)

F_{max} : Maximum Force (N)

M (x) : Moment about the neutral axis (N-mm)

E : Young's Modulus (Pa)

I : Moment of Inertia (mm^4)

w(x) : Deflection of the neutral axis

F(x) : Shear force of material (N)

M_b : Bending moment (N-mm)

M_t : Torsional bending moment (N-mm)

τ_{max} : Maximum shear stress (N/mm^2)

REFERENCES

[1] Final working of rolling pipe bending machine. ISSN: 2249-5762, IJRMET vol 5, issue 1, April, 2015.

[2] Milan Virani, Jagdish Vekariya, Saurin Sheth, Ketan Tamboli, Design and Development of Automatic Stirrup Bending Mechanism. Gujarata, pp.598-606, 2013.

[3] Mr.P.s.Gill, Design Data Book. 3rd Edition.

[4] Artizono, 3 Roll Bending Machine. Working principle and Rolling Process.

[5] Himanshu V. Gandhi, Anish H. Gandhi, Tanvir A Jafri, Harit K. Raval, Bendability Analysis for Bending of C-Mn Steel Plates on Heavy duty 3-roller Bending Machine.

[6] Ahmed Ktari, ZiedAntar, Nader Hadder Khaled Elleuch, Modeling and computation of three-roller bending process of steels.

[7] M. Hermes, S. Chatti, A. Weinrich, A. E. Tekkaya, Three dimensional bending of profiles with stress superposition.

[8] Mr. V. B. Bhandari, Mc-Graw Hill Publication, Design of machine element. 3rd Edtion.