© JUN 2019 | IRE Journals | Volume 2 Issue 12 | ISSN: 2456-8880

Design and Fabrication of Hydraulic Metal Bender

NWE NI TUN
Mechanical Engineering Department, Mandalay Technological University, Myanmar

***Abstract-* Bending machine is used to bend a metal sheet, plate and pipe. The aim of this project is to design and construct a portable metal bending machine. This machine is used to bend sheets into curve and the other curvature shapes. And it is convenient for portable work. This machine is the easy way to be carried and can be used at any time and any place. It eases human effort and no required skill workers to operate the machine. It is manually operated metal bending machine with use of metal shaft, hydraulic bottle jack, pedestal bearing and support (frame). This machine works on simple kinematic system instead of complicated design. Due to its light weight and portable system, it can be used by small workshop, fabrication shop and small scale industry. There is no proper small scale bending machine for bending a pipe. A Metal Bending machine uses 3 rollers to bend metal. The common product of metal bending machine are pipe (square and circular) bending if separate attachment of die is provided, sheet bending. During the roll bending process the sheet or plate or pipe is passed through consecutive rollers that gradually apply pressure on the pipe.**

***Indexed Terms-* 3 roll bending; sheet and pipe bending; shaft diameter; bending stresses; strain**

I. INTRODUCTION

Hydraulic jack metal bender is a machine used for bending the rods or work pieces manually. By using hydraulic energy, the rod bending process can be carried out. This research is designed with hydraulic bottle jack and roller. Bending is a process by which metal can be deformed by plastically deforming the material and changing its shape. The material is stressed beyond the yield strength but below the ultimate tensile strength. The surface area of the material does not change 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. Bending is done using press brakes. In this study, the hydraulic power is used to bend the metal pipe because the hydraulic system has good load capacity and good efficiency. This machine consumes no electrical power, so it costs less compared to electrical powered hydraulic systems.

II. MAIN COMPONENTS AND FUNCTIONS FOR FABRICATION

A. Hydraulic Jack

Figure1. The design of a hydraulic jack

A jack is a mechanical device used as a lifting device to lift heavy loads or to apply great forces. Hydraulic bottle jack can be operated with everything in the packaging. It does not need any additional fluid, or an electrical source. The six-pound jack can lift vehicles weighing up to 3 tons simply by moving a handle up and down.

B. I-BEAM

Figure 2. The design of I-beam for metal bender

An I-beam is a beam with an I or H shaped cross-section. The horizontal element of "I" is known as flange, while the vertical element is termed the "web". I-beams are usually made of structural steel and are used in construction and civil engineering. I-beams are widely used in the construction industry and are available in a variety of standard sizes. I-beam can be used both as beams and as columns.

C. Bearing

Figure 3. The desired bearing for bender

A bearing is a machine element that constrains relative motion to only the desired motion, and reduces friction between moving parts. A wide variety of bearing designs exists to allow the demands of the application to be correctly met for maximum efficiency, reliability, durability and performance.

D. Shaft

Figure 4. The shaft design

A shaft is a rotating machine element, usually circular in cross section, which is used to transmit power from one part to another, or from a machine which produces power to a machine which absorbs power. The various members such as pulleys and gears are mounted on it. The material used for ordinary shafts is mild steel.

III. METHODOLOGY

A. Estimation of Shaft

For a solid shaft having little or no axial loading, the ASME code equation is given as follows,

$$d = \left[\frac{16}{\pi\tau} \sqrt{(K_b M_b)^2 + (K_t M_t)^2} \right]^{\frac{1}{3}} \qquad (1)$$

Where:
d - Diameter of shaft (m)
M_b - bending moment (N-m)
M_t - torsional moment (N-m)
K_b - combined shock and fatigue factor applied to bending moment
K_t - combined shock and fatigue factor applied to torsional moment
τ - Allowable stress (N/m^2)

The bending moment will be considered positive when the moment on the left portion is clockwise, and on the right portion anticlockwise. A bending moment diagram is one which shows the variation of bending moment along the length of the beam or shaft as shown in figure 5.

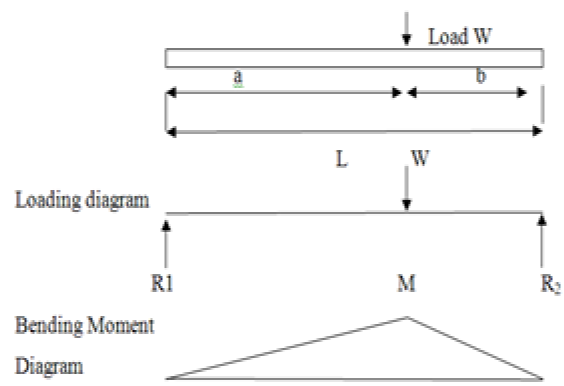

Figure 5. The bending moment and loading diagram

The fluctuating stresses due to bending and torsion are given as follows;

Bending stress; $$\sigma_x = \sigma_b = \frac{32M}{\pi D^3} \qquad (2)$$

Centrifugal stress; $$\sigma_y = \sigma_c = \left(\frac{3+v}{8}\right)\rho\omega^2 r^2 \qquad (3)$$

Shear stress; $\tau_{xy} = \frac{16M_t}{\pi D^3}$ (4)

Where,
M = bending moment
D = diameter of shaft
μ = poison ratio
ρ = density of shaft
ω = angular velocity
M_t = torsional moment

The Principal stresses can be found as follows;

$$\sigma_{1,2}=\frac{1}{2}(\sigma_x+\sigma_y)\pm\frac{1}{2}\sqrt{(\sigma_x+\sigma_y)^2+4\tau_{xy}{}^2} \quad (5)$$

The effective stresses are also found that in equation 6;

$$\bar{\sigma}=\frac{1}{\sqrt{2}}[(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2]^{\frac{1}{2}} \quad (6)$$

The three principle strains are simultaneously applied to the shaft. The three-dimensional form of Hooke's law would show that as follows;

$$\varepsilon_1=\frac{1}{E}[\sigma_1-v(\sigma_2+\sigma_3)] \quad (7)$$

$$\varepsilon_2=\frac{1}{E}[\sigma_1-v(\sigma_1+\sigma_3)] \quad (8)$$

$$\varepsilon_3=\frac{1}{E}[\sigma_3-v(\sigma_1+\sigma_2)] \quad (9)$$

Effective strain is defined such that:

$$\bar{\varepsilon}=[\frac{2}{3}(\varepsilon_1{}^2+\varepsilon_2{}^2+\varepsilon_3{}^2)]^{\frac{1}{2}} \quad (10)$$

Where,

ε_1 - First principal strain

ε_2 - Second principal strain

ε_3 - Third principal strain

B. Bearing Selection

The equivalent bearing load is as follows;

$$P = XVF_r + YF_a \quad (11)$$

Where,
P = equivalent bearing load
F_r = actual radial bearing load
F_a = actual axial bearing load
X = radial factor
Y = thrust factor
V = rotating factor

For pure radial load,

F_a = 0, X = 1

So, P = V F_r

For the single row bearing;

Thrust force does not influence the equivalent load;

If, $\frac{F_a}{VF_r} \le e$ X = 1, Y = 0 (12)

If, $\frac{F_a}{VF_r} > e$ X = 0.56, (13)

Y = appropriate value

For the double row bearing;

Small thrust force influence the equivalent load is as follows;

$\frac{F_r}{VF_a} \le e$ Y > 0 (14)

$$L=\frac{60nL_h}{1000000} \quad (15)$$

Where,
L_h = nominal life in working hr

n = speed in rev/min

Relationship between load and life is;

$$L=\left(\frac{C_r}{P}\right)^p \quad (16)$$

Where,

L = nominal life in millions of revolution

C_r = basic dynamic capacity

P = equivalent bearing load

C. Design Specifications

The required data for design estimation of shaft are included in table 1.

Table 1. Specification data for hydraulic jack metal bender

Item	Symbol	Value	Unit
Capacity	c	7	Kg/min
Speed of handle	N	60	rpm
Diameter of shaft	d	1	in
Diameter of handle	D	1	in
Weight of handle	W_h	7	N
Weight of shaft	W_s	13	N
Jack force	F	3	tons

IV. RESULTS AND DISCUSSIONS

The theoretical results are shown in table 2. The performance test results are also included in table 3 and testing performance is shown in figure 6. Shaft design and the value of stresses are calculated in theoretical formulas. Moreover, the bearing designs in three rows were selected and considered for this project. Based on the design data, hydraulic jack metal bender was constructed and done the performance.

Table 2. Theoretical result data for shaft design

Item	Symbol	value	Unit
Diameter of shaft	d	20	mm
Bending stress	σ_b(or)σ_x	905	MPa
Centrifugal stress	σ_c(or)σ_y	0.78	kPa
Shear stress	τ_{xy}	9.77	MPa
Principal stresses	σ_1	905	MPa
Principal stresses	σ_2	105	MPa
Principle strains	ε_1	$4.5x\ 10^{-3}$	
Principle strains	ε_2	$3.06x\ 10^{-3}$	
Principle strains	ε_3	$-1.18x\ 10^{-3}$	
Effective strain	$\bar{\varepsilon}$	$4.55x\ 10^{-3}$	

Table 3. Performance test result data

The height of hydraulic jet (cm)	The deviation of sample (cm)
1	0.8
2	1.9
3	2.3
4	3.6
5	4.5
6	7
7	8.9
8	10.3
9	13.1
10	14.5

(a)

(b)

Figure 6. (a) Complement machine (b) testing of hydraulic jet metal bender

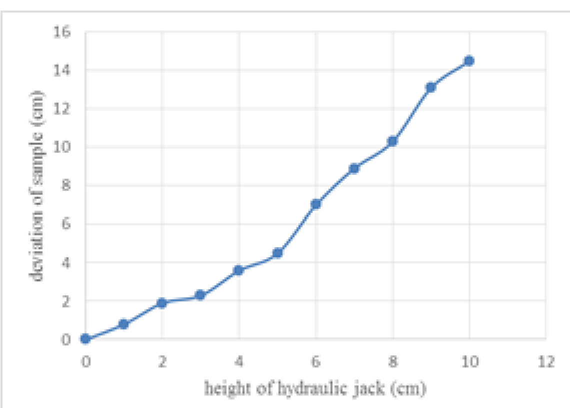

Figure 7. Deformation of material based on the height of hydraulic jack

There are some issued that cannot be addressed in this study. Therefore, the following are recommended for future research directions:

- The middle shaft should be made to move forwards the sample accordingly.
- Base wheels should be used in order to carry the heavy metal bender.
- The shaft should be designed to maintain the work against from moving horizontally.

V. CONCLUSION

The bending machine of this project is made with pre-planning, that it provides flexibility in operation. This innovation has made the more desirable and economical. The design and fabrication will be very useful for bending in small scale industries. There are many other bending machines based on hydraulic power but it has some demerits like large in size, costly, need skilled people to operate and it needs electrical input. So, this design machine will overcome these demerits by compact in size, less cost, no need for electrical input and no need for skilled people.

ACKNOWLEDGMENT

The first author wishes to acknowledge her deepest gratitude to her parents, professors, relatives and friends to carry out this paper.

REFERENCES

[1] A.D.Zope, R.R.Deshmukh, D.R.Mete, V.S.Mane, Review Paper on Design and Development of Metal Bending Machine. 2017.

[2] T.W.Stewart, Metal Bending Machine. 2017.

[3] Chanshu Tongrun, Design for Manufacturing and Assembly (DFMA). 2013.

[4] O.O.Awoluy, Working Principle of Hydraulic Jack or Hydraulic Press. 2011.

[5] J.Chattong, Design and Construction of Bending Machine. 2011.

[6] Leo, Balogun A,et al, Manufacturing Processes Reference Guide. Industrial Press Inc, 2009.

[7] Kamlesh Pradhan, Amar Dandale, and Press brake Bending: Methods and Challenges. 2003.

[8] De Vin, L.J., Streppel, A.H.,Singh, U.P. & Kals, H.J.J , A process model for air bending. 2002.

[9] Petersen, Materials Processing Technology. 2002.