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Design Analysis and Fabrication of Hydraulic Bar Bending Machine

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***Abstract** – Now a day's bar bending is done either manually or by bending machines but these are having many drawback, less productivity, This project describes the bending of bar by using hydraulic system. It is the new and simplest method of bar bending by using hydraulic system. It can be make automated with the additional components like sensor, integrated circuit which may lead to increase in cost. . Hydraulic rod bending machine consist of hydraulic cylinder, Hoses, Pulley, Cutting blades, Fixture, etc .The rod is bent by the hydraulic cylinder piston with holding the rod in the fixture. The main advantage of our project is the square shape of the Stirrups is bent continuously rod in the machine.*

Key words: **Frame (MS)1, Fixture2, Double acting cylinder3, Motor4, Pump5, CAE software(ANSYS)6, EN47**

1. INTRODUCTION

The project is designed on the basis of principle of hydraulic system. Here the use of principle of hydraulic system is to increase the productivity. Now a days it is very essential to use this system in order have a higher reliability. As rod bending is extensively in the construction of buildings and fabrication. There we need variety of bends of bar like V-shape, U-shape and many more. This can be achieved by using this hydraulic system based bar bending machine. Same bending machine can be manufactured by using a pneumatic system. The reason behind using hydraulic system instead of pneumatic system is that hydraulic system has many more advantages over pneumatic system. But the most important advantages more power transmission capacity. Different types of bends like U-bending, Offset-bending, Edgewise-bending, Torsion- bending , etc. can be achieved easily with use of this bar bending machine. We used different components like hydraulic pump, double acting cylinder, motor & frame.

1.1 OBJECTIVES

1. To make a bending machine to bend a metal bar up to 20mm.
2. Analytical design of "hydraulic bar bending machine"
3. Modelling and simulation of "hydraulic bar bending machine"
4. Preparation of prototype sample of "hydraulic bar bending machine"
5. Experimental workout of "hydraulic bar bending machine"
6. Study of comparative result of "hydraulic bar bending machine"

2. MATERIAL SELECTION

The material selected as MS for Hydraulic Bar Bending is EN47. The material properties for design listed are Plain carbon steel, chromium vanadium steel, chromium-Nickel- Molybdenum steel, Silicon manganese steel, are the typical materials that are used in the design of Automatic Bar Bending.

Table 2.1 Mechanical Properties of material

Parameters	**Values**
Material selected as MS	En47
Tensile strength	210GPA
Yield strength	1158MPA
Young's modulus(E)	1034MPA
Poisson ratio	0266
Density	7700kg/mm ^{3}

3. ANALYTICAL DESIGN

The formula we used for calculating stress in rod is following:

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

Where,

1) σ is the bending stress.

2) M is the moment about the neutral axis.

3) y is the perpendicular distance to the neutral axis .

4) Ix is the moment of inertia about the neutral axis x

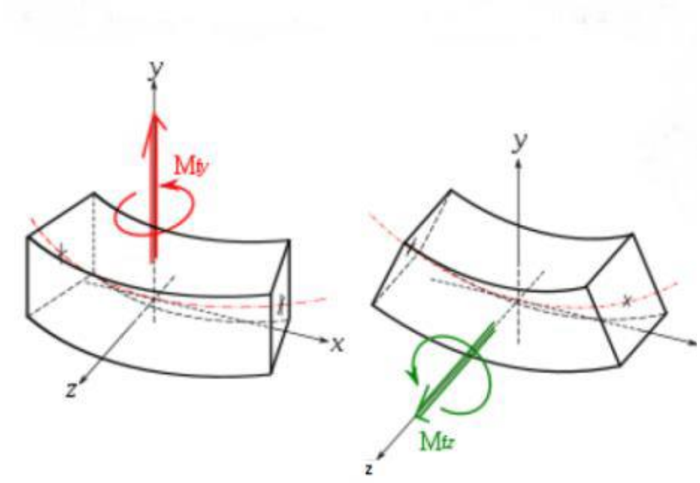

Fig- 3.1: Bending stresses in rod.

3.1 Torque on the gear by the motor:-

$$T = \frac{P \times 60}{2 \times \pi \times N}$$

Where,

P- Power (700w)

T- Torque

N- Speed in rpm (90 rpm)

T= 74.27 × 10^3 N-mm

3.2 Force required to bend the bar:-

Bending equation,

$$\frac{M}{I} = \frac{\sigma_b}{y}$$

For solid circular shaft,

$$I = \frac{\pi}{64} \times d^4$$

$$y = \frac{d}{2}$$

$$\sigma_b = \frac{syt}{FOS} = 93.33\ N/mm^2, \text{SI grade } 20;$$

Syt= 271 N/mm², FOS=3

$$M = \frac{W \times L}{4}$$

Torque supplied by the rotating disc to this shaft,

Where,

L Centre distance between centers of the shaft

L=105mm

W= 510 N

Put the value in eq. (b) we get

M= 13.38 KN-mm

a) Diameter of bending bar

Substituting the values in eq. (a) we get

d = 12 mm

3.3 Torque required to bend the bar

$$T = \frac{\pi}{16} \times d^2 \times \tau$$

$$d = 11.34\ mm$$

$$T = 74.27 \times 10^3\ N - mm$$

$$74.27 \times 10^3 = \frac{\pi}{16} \times 11.34^2 \times \tau$$

$$\tau = 2.94\ N/m^2$$

3.4 For, D = 12 mm

- **Force required to bend the bar:-**

Bending equation,

$$\frac{M}{I} = \frac{\sigma_b}{y}$$

For solid circular shaft,

$$I = \frac{\pi}{64} \times d^4$$

$$y = \frac{d}{2}$$

$$\sigma_b = \frac{syt}{FOS} = 78.87\ N/mm^2, \text{SI grade } 20;$$

Syt= 271 N/mm², FOS = 3.43

$$M = \frac{W \times L}{4}$$

Torque supplied by the rotating disc to this shaft,

Where,

L Centre distance between centers of the shaft

L=105mm

W= 510 N

Put the value in eq. (b) we get

M= 13.38 KN-mm

a) Diameter of bending bar

Substituting the values in eq. (a) we get

- **Torque required to bend the bar**

$$T = \frac{\pi}{16} \times d^2 \times \tau$$

$$d = 12 \text{ mm}$$

$$T = 74.27 \times 10^3 \text{ N} - \text{mm}$$

$$74.27 \times 10^3 = \frac{\pi}{16} \times 12^2 \times \tau$$

$$\tau = 2.62 \times 10^3 \text{ N/mm}^2$$

3.5 For, D = 14 mm

- **Force required to bend the bar:-**

Bending equation,

$$\frac{M}{I} = \frac{\sigma_b}{y}$$

For solid circular shaft,

$$I = \frac{\pi}{64} \times d^4$$

$$y = \frac{d}{2}$$

$$\sigma_b = \frac{syt}{FOS} = 49.66 \text{ N/mm}^2, \text{SI grade } 20;$$

Syt= 271 N/mm², FOS = 5.45

$$M = \frac{W \times L}{4}$$

Torque supplied by the rotating disc to this shaft,

Where,

L Centre distance between centers of the shaft

L=105mm

W= 510 N

Put the value in eq. (b) we get

M= 13.38 KN-mm

a) Diameter of bending bar

Substituting the values in eq. (a) we get

- **Torque required to bend the bar**

$$T = \frac{\pi}{16} \times d^2 \times \tau$$

$$d = 14 \text{ mm}$$

$$T = 74.27 \times 10^3 \text{ N} - \text{mm}$$

$$74.27 \times 10^3 = \frac{\pi}{16} \times 12^2 \times \tau$$

$$\tau = 1.92 \times 10^3 \text{ N/mm}^2$$

3.6 For, D = 16 mm

- **Force required to bend the bar:-**

Bending equation,

$$\frac{M}{I} = \frac{\sigma_b}{y}$$

For solid circular shaft,

$$I = \frac{\pi}{64} \times d^4$$

$$y = \frac{d}{2}$$

$$\sigma_b = \frac{syt}{FOS} = 33.27 \text{ N/mm}^2, \text{SI grade } 20;$$

Syt= 271 N/mm², FOS = 8.14

$$M = \frac{W \times L}{4}$$

Torque supplied by the rotating disc to this shaft,

Where,

L Centre distance between centers of the shaft

L=105mm

W= 510 N

Put the value in eq. (b) we get

M= 13.38 KN-mm

a) Diameter of bending bar

Substituting the values in eq. (a) we get

- **Torque required to bend the bar**

$$T = \frac{\pi}{16} \times d^2 \times \tau$$

$$d = 16 \text{ mm}$$

$$T = 74.27 \times 10^3 \text{ N} - \text{mm}$$

$$74.27 \times 10^3 = \frac{\pi}{16} \times 12^2 \times \tau$$

$$\tau = 1.47 \times 10^3 \text{ N/mm}^2$$

3.7 For, D = 18 mm

- **Force required to bend the bar**

Bending equation,

$$\frac{M}{I} = \frac{\sigma_b}{y}$$

For solid circular shaft,

$$I = \frac{\pi}{64} \times d^4$$

$$y = \frac{d}{2}$$

$$\sigma_b = \frac{syt}{FOS} = 23.36 \text{ N/mm}^2, \text{SI grade } 20;$$

Syt= 271 N/mm², FOS = 11.60

$$M = \frac{W \times L}{4}$$

Torque supplied by the rotating disc to this shaft,

Where,

L Centre distance between centers of the shaft

L=105mm

W= 510 N

Put the value in eq. (b) we get

M= 13.38 KN-mm

a) Diameter of bending bar

Substituting the values in eq. (a) we get

- **Torque required to bend the bar**

$$T = \frac{\pi}{16} \times d^2 \times \tau$$

$$d = 18 \text{ mm}$$

$$T = 74.27 \times 10^3 \text{ N} - \text{mm}$$

$$74.27 \times 10^3 = \frac{\pi}{16} \times 12^2 \times \tau$$

$$\tau = 1.16 \times 10^3 \text{ N/mm}^2$$

3.8 For, D = 20 mm

- **Force required to bend the bar:-**

Bending equation,

$$\frac{M}{I} = \frac{\sigma_b}{y}$$

For solid circular shaft,

$$I = \frac{\pi}{64} \times d^4$$

$$y = \frac{d}{2}$$

$$\sigma_b = \frac{syt}{FOS} = 17.03 \text{ N/mm}^2, \text{SI grade } 20;$$

Syt= 271 N/mm², FOS = 15.91

$$M = \frac{W \times L}{4}$$

Torque supplied by the rotating disc to this shaft,

Where,

L Centre distance between centers of the shaft

L=105mm

W= 510 N

Put the value in eq. (b) we get

M= 13.38 KN-mm

a) Diameter of bending bar

Substituting the values in eq. (a) we get

- **Torque required to bend the bar**

$$T = \frac{\pi}{16} \times d^2 \times \tau$$

$$d = 18 \text{ mm}$$

$$T = 74.27 \times 10^3 \text{ N} - \text{mm}$$

$$74.27 \times 10^3 = \frac{\pi}{16} \times 12^2 \times \tau$$

$$\tau = 945.63 \text{ N/mm}^2$$

Summary:

11.34 mm	$\sigma_b = 93.33$, T = 74.27×10^3, FOS = 3, $\tau = 2.94 \times 10^3$, M = 13.78×10^3
12 mm	$\sigma_b = 78.87$, T = 74.27×10^3, FOS = 3.43, $\tau = 2.62 \times 10^3$, M = 13.78×10^3
14 mm	$\sigma_b = 49.66$, T = 74.27×10^3, FOS = 5.45, $\tau = 1.92 \times 10^3$, M = 13.78×10^3
16 mm	$\sigma_b = 33.27$, T = 74.27×10^3, FOS = 8.14, $\tau = 1.47 \times 10^3$, M = 13.78×10^3
18 mm	$\sigma_b = 23.36$, T = 74.27×10^3, FOS = 11.60, $\tau = 1.16 \times 10^3$, M = 13.78×10^3
20 mm	$\sigma_b = 17.03$, T = 74.27×10^3, FOS = 15.91, $\tau = 945.63$, M = 13.78×10^3

4. ANALYSIS

4.1 Geometry Of Hydraulic Bar Bending

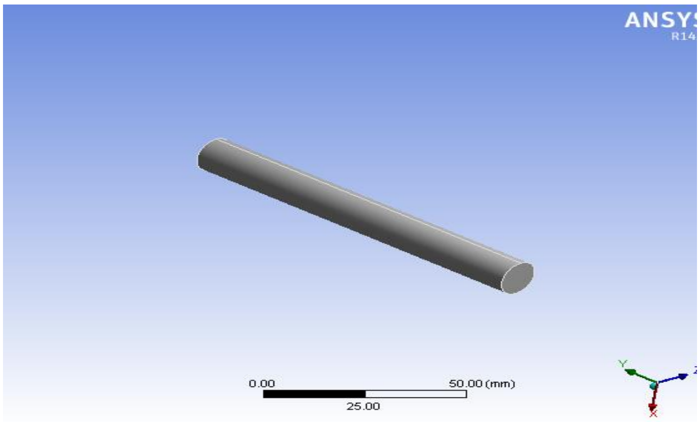

Fig.-4.1: shows the imported geometry of Hydraulic Bar Bending

4.2 Meshed Model Of Hydraulic Bar Bending

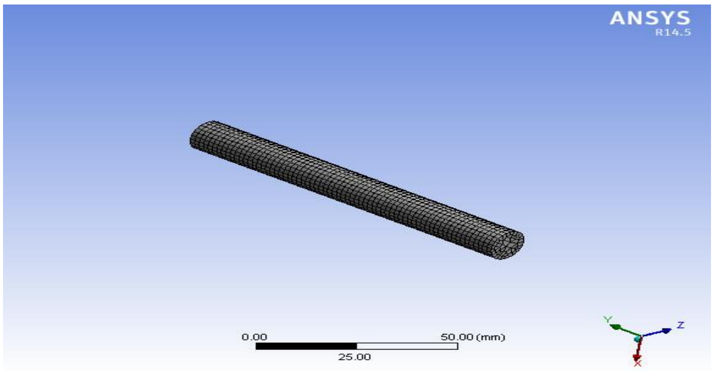

Fig.-4.2: Meshed Model of Hydraulic Bar Bending

4.3 Diametering & Boundary Conditions

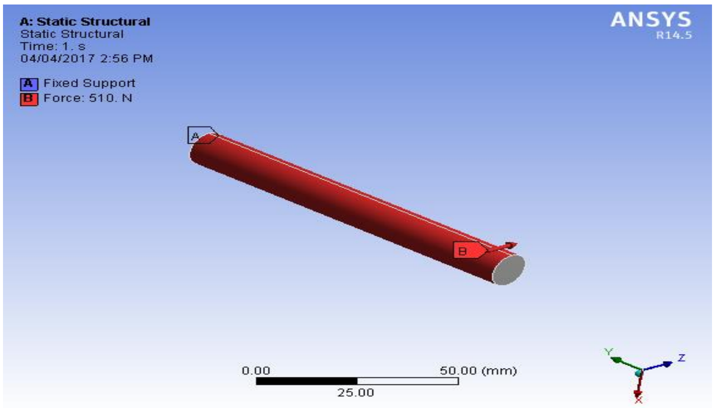

Fig.-4.3: Force Model of Hydraulic Bar Bending

4.4 Results and Discussion

4.4.1Total Deflection Of Hydraulic Bar Bending 11.34 mm

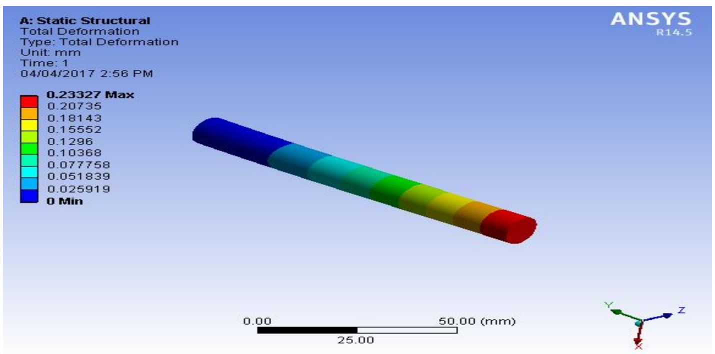

Fig.-4.4.1: Total Deflection of Hydraulic Bar Bending

4.4.2 Total Stress Of Hydraulic Bar Bending 11.34 mm

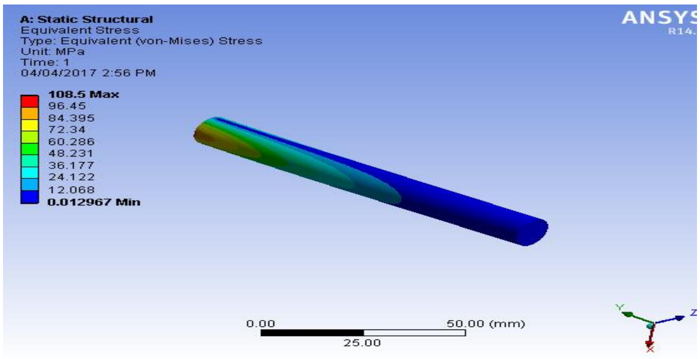

Fig.-4.4.2: Total Stress of Hydraulic Bar Bending

4.4.3 Total Strain Of Hydraulic Bar Bending 11.34 mm

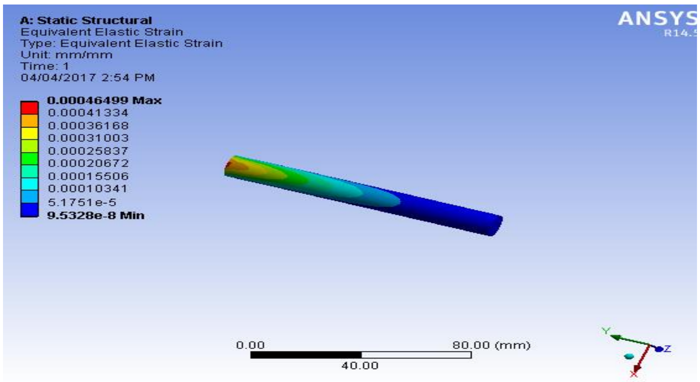

Fig.-4.4.3: Total Strain of Hydraulic Bar Bending

4.4.4 Total Deflection Of Hydraulic Bar Bending 12mm

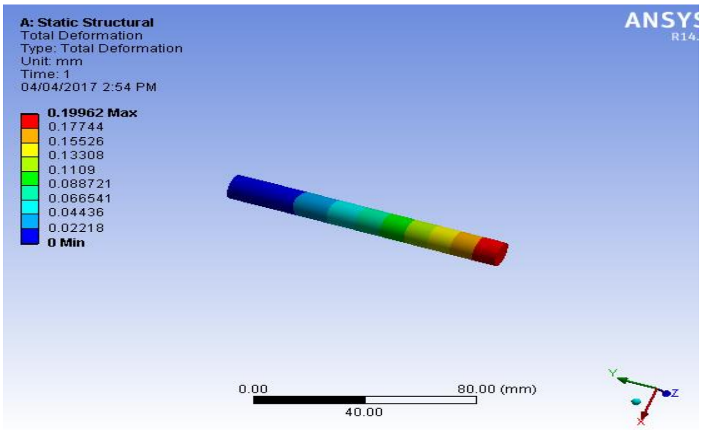

Fig.-4.4.4: Total Deflection of Hydraulic Bar Bending

4.4.5 Total Stress Of Hydraulic Bar Bending 12 mm

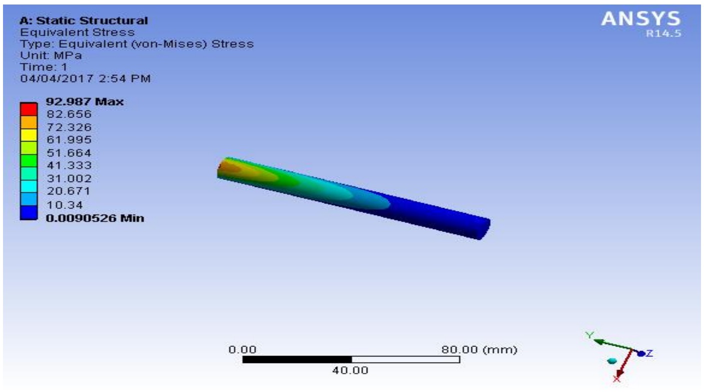

Fig.-4.4.5: Total Stress of Hydraulic Bar Bending

4.4.6 Total Strain Of Hydraulic Bar Bending 12 mm

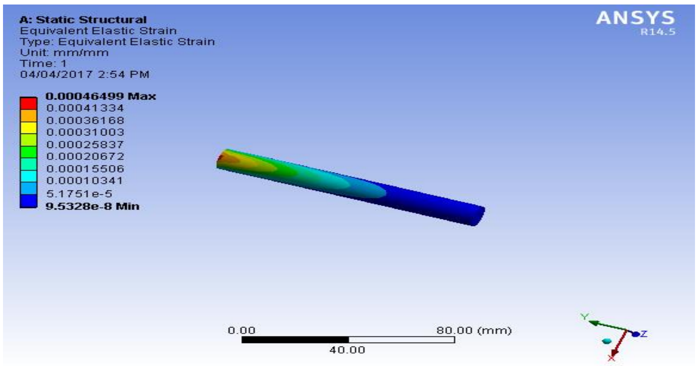

Fig.-4.4.6: Total Strain of Hydraulic Bar Bending

4.4.7 Total Deflection Of Hydraulic Bar Bending 14 mm

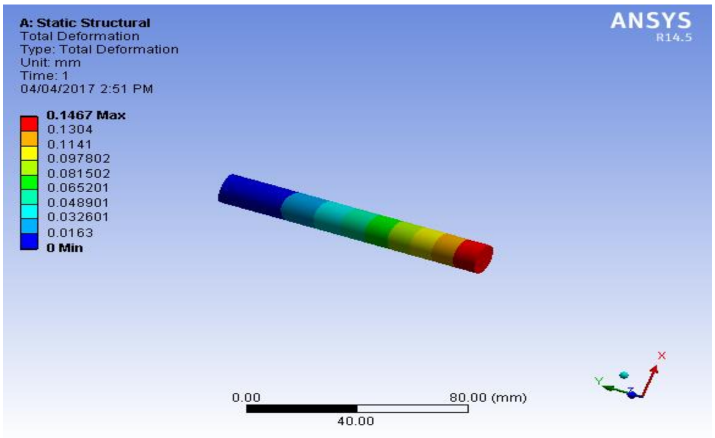

Fig.-4.4.7: Total Deflection of Hydraulic Bar Bending

4.4.8 Total Stress Of Hydraulic Bar Bending 14 mm

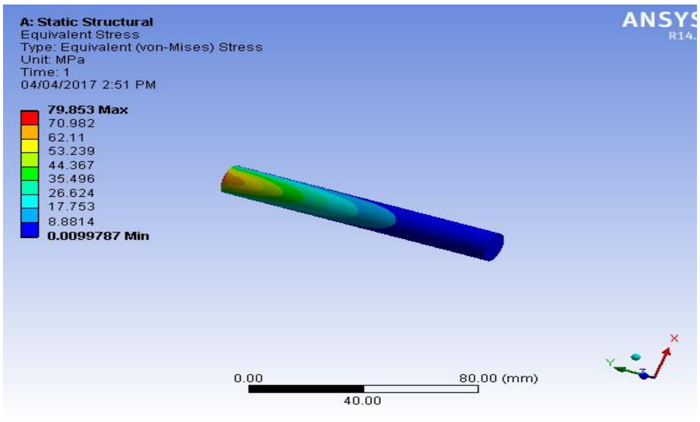

Fig.-4.4.8: Total Stress of Hydraulic Bar Bending

4.4.9 Total Strain Of Hydraulic Bar Bending 14 mm

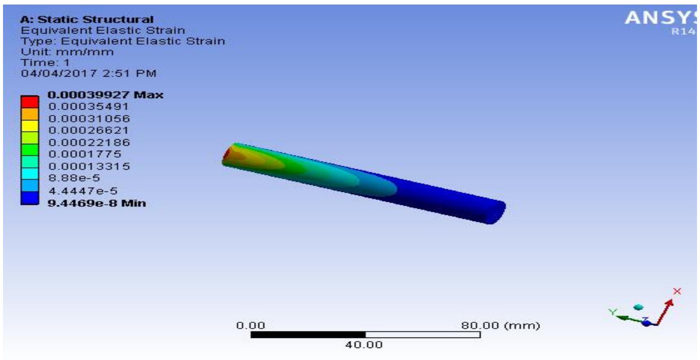

Fig.-4.4.9: Total Strain of Hydraulic Bar Bending

4.4.10 Total Deflection Of Hydraulic Bar Bending 16 mm

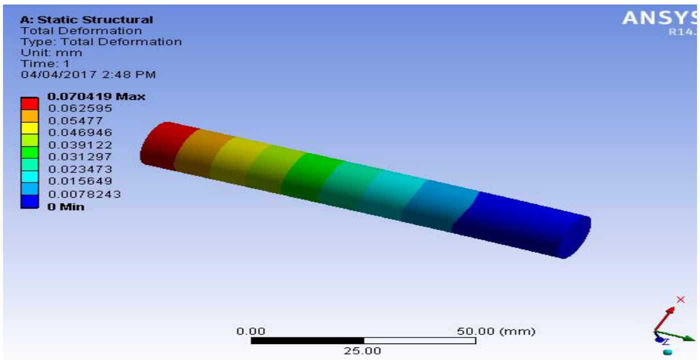

Fig.-4.4.10: Total Deflection of Hydraulic Bar Bending

4.4.11 Total Stress Of Hydraulic Bar Bending 16 mm

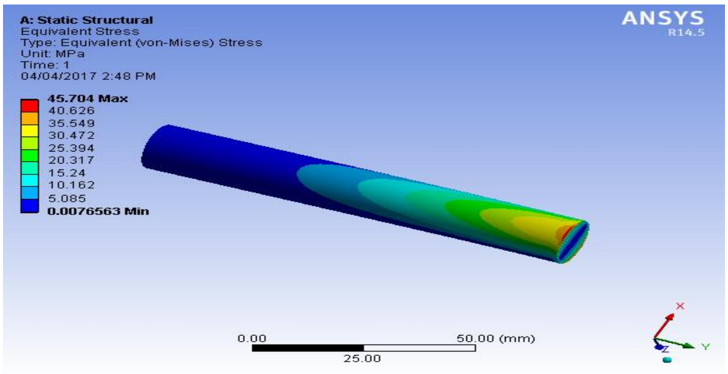

Fig.-4.4.11: Total Stress of Hydraulic Bar Bending

4.4.12 Total Strain Of Hydraulic Bar Bending 16 mm

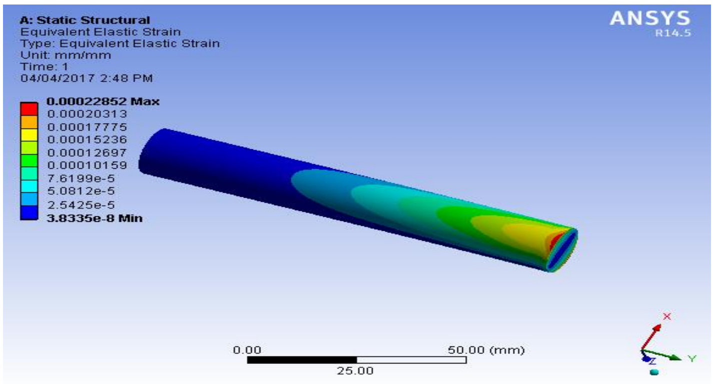

Fig.-4.4.12: Total Strain of Hydraulic Bar Bending

4.4.13 Total Deflection Of Hydraulic Bar Bending 18 mm

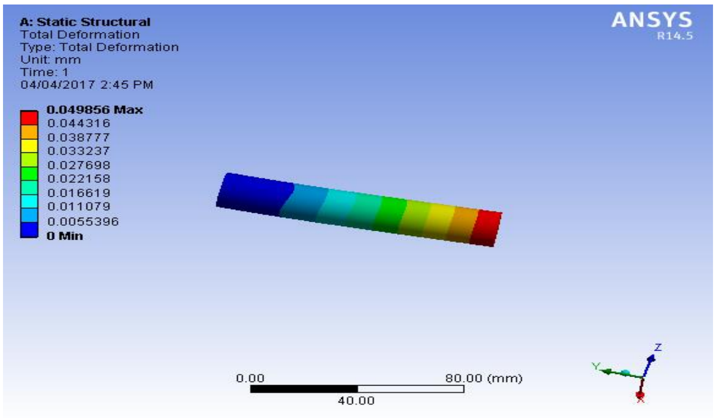

Fig.-4.4.13: Total Deflection of Hydraulic Bar Bending

4.4.14 Total Stress Of Hydraulic Bar Bending 18 mm

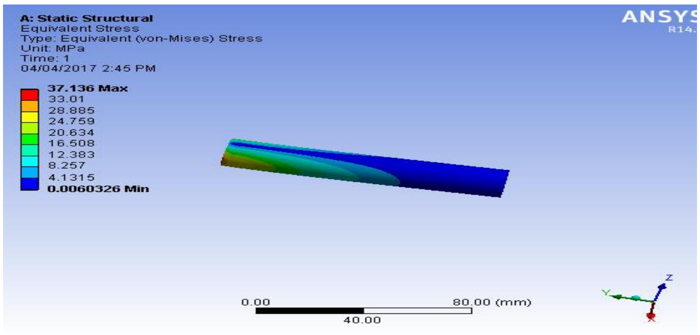

Fig.-4.4.14: Total Stress of Hydraulic Bar Bending

4.4.15 Total Strain Of Hydraulic Bar Bending 18 mm

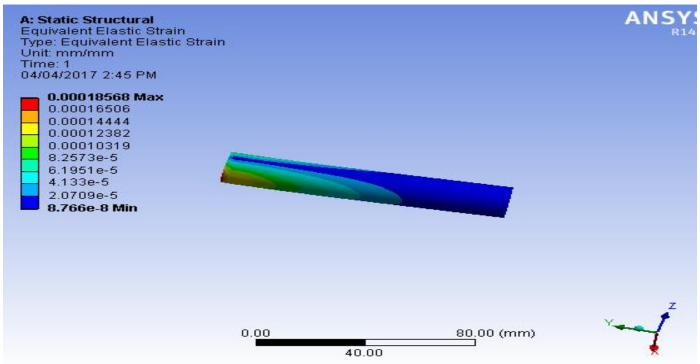

Fig.-4.4.15: Total Strain of Hydraulic Bar Bending

4.4.16 Total Deflection Of Hydraulic Bar Bending 20 mm

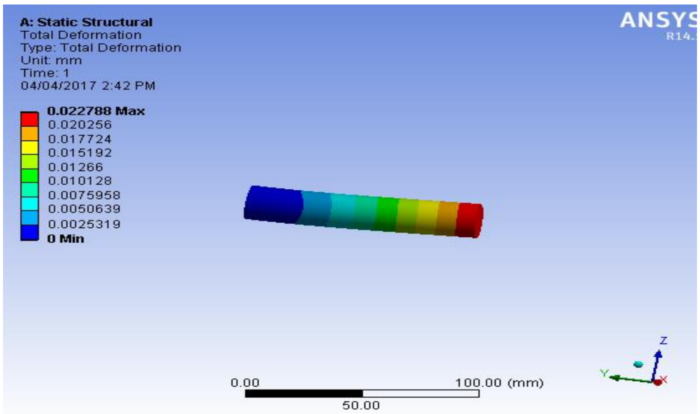

Fig.-4.4.16: Total Deflection of Hydraulic Bar Bending

4.4.17 Total Stress Of Hydraulic Bar Bending 20 mm

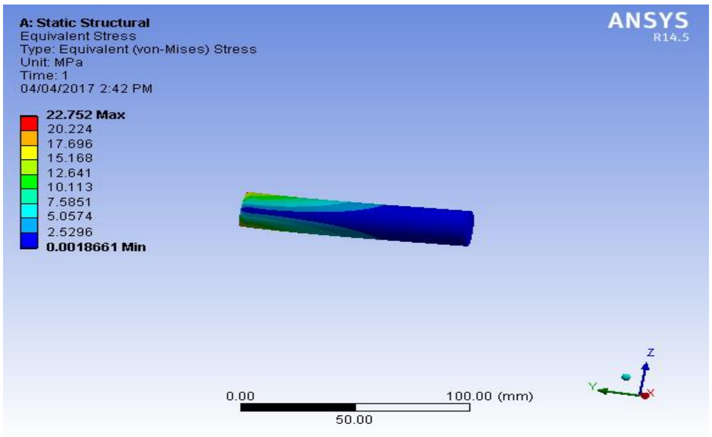

Fig.-4.4.17: Total Stress of Hydraulic Bar Bending

4.4.18 Total Strain Of Hydraulic Bar Bending 20 mm

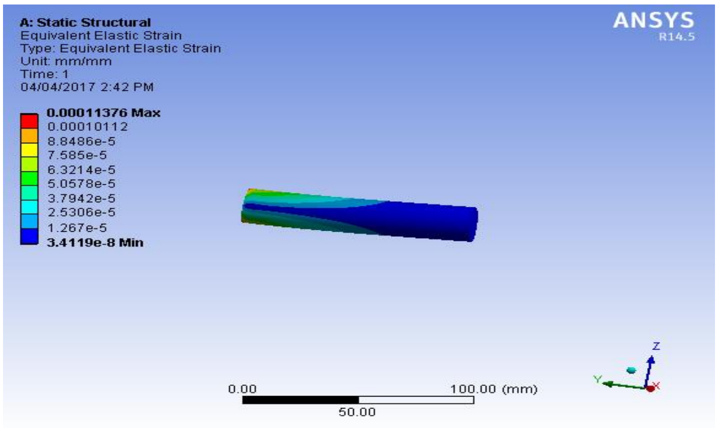

Fig.-4.4.18: Total Strain of Hydraulic Bar Bending

5. SUMMERY OF RESULT:-

The values of bending stress, strain, deflection for multiple diameters of the bar are obtained.

Diameter	Deflection	Stress	Strain
11.34	0.23327	108.5	0.00054259
12	0.19962	92.987	0.00046499
14	0.1467	79.853	0.00039927
16	0.070419	45.704	0.00022852
18	0.049856	37.136	0.00018568
20	0.022788	22.752	0.00011376

6. CONCLUSION:-

The project has carried on the detailed calculation and checking aiming at main components of bending machine. Through complicated, accurate calculation can bring great convenience to choosing components precisely so as to guarantee the machine running in good condition, avoid wear and tear caused by some certain problems, and thus increase machine's service life.

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