DESIGN AND FABRICATION OF MANUAL ROLLER BENDING MACHINE

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Abstract: *The aim of this paper is to develop a roller bending machine which is useful to bend a metal strips in workshop. This project is to design and construct a portable roller bending machine. This machine is used to bend metal strips into curve and the other curvature shapes. The size of machine is very convenient for portable work. It is fully made by steel. Moreover, it is easy to be carry and use at any time and any place. It reduces human effort and also required less skill to operate this machine. We are designing manually operated roller bending machine with use of rollers, chain sprockets and support (frame). The roller bending machine is manually operated. Therefore, our objective is to increase accuracy at low prize without affecting the bending productivity. This machine works on simple kinematic system instead of complicated design. Due to its portability it can be used by small workshop or fabrication shop. Bending machine is a common tool in machine shop that is used to bend a metal.*

Key words: constructing machine, bend metal strips, manually operated, three point roller bending, load applied by screw.

1. INTRODUCTION

The main problem that people who are occupied with doing various metallic projects and generally constructions, faces the bending of metallic strips. The reason that this problem is arisen during these projects is because the metallic pieces need a lot of pressure, strength as well as accuracy to be bent. There are many machines to be used to achieve this but the cost is high. This construction is more user-friendly to everyone, relatively affordable, extremely useful and it will fill with feelings of joy and satisfaction the people who want to spend their time productively.

1.1 Objectives of the work:

The main objectives of the work are

a. To design and fabricate a bending machine for metal strips.

b. To utilize unskilled worker with simple working principle.

c. To reduce the time and cost of the operation.

1.2 Design Process:

The process of design is essentially an exercise in applied creativity. Various design process have been defined to help organize to attack upon un-constructed problem definition is vague for which many solution exist .some of this design process as shown below.

1. Recognition of need: It involves identification by someone that a problem exists for which some corrective action should be taken. The problem may be identification some defect in the existing machinery or a need of new product in the market.
2. Definition of problem: It involves through specification of the item to be designed. This specification includes physical or functional characteristics, cost, quality, and operating performances.
3. Synthesis: In this phase we developing preliminary (basic) ideas regarding the topology and geometry of the problem, i.e., regarding the shape and size and connectivity of various parts in the product. In this phase a prototype model is created.
4. Analysis: In this phase a prototype model is analyzed by giving different boundary conditions and constraints, subjecting the model to different temperatures and loads to perform feasibility study. If the product fails at this stage, once again the design is reverted back to the synthesis phase.
5. Evolution: The end products of the analysis phase is compared with destination phase. If they require any changes, then the design is once again reverted back to the synthesis phase.
6. Presentation: This includes documentation of the design by means of drawings, material specifications, bill of materials, views, tolerances etc.

2 OVERVIEW OF MANUAL ROLLER BENDING MACHINE

The design and fabrication of portable manual roller bending machine uses chain sprocket based roller mechanism to bend pipes/rods. The mechanism is widely used in industry to for bending purposes. The machine is made with a supporting frame that supports the roller mechanism between it. The work to be bent can then be rolled across it to achieve desired bending. The rollers are fitted with bearings so as to achieve the desired smooth motion. One of the rollers is integrated with a hand driven spindle wheel to drive it manually. This wheel is also connected to the other roller using a chain sprocket mechanism to drive it along with spindle at the same rate. The frame is made with a mechanism to fit a movable roller in the center through a screw mechanism. This is used to adjust the bending angle. The mechanism is fitted through a slot made in the frame center. This screw based mechanism along with the spindle powered rollers allows the user to achieve desired bending

3. ADVANTAGES

- Very Useful in Fabrication
- Easy To Make Curved Parts
- Supports a Variety of Soft Metals
- Portable
- Low initial cost
- Low maintenance cost
- Simple Design

4. DISADVANTAGES

- As it is a prototype model, here bending is limited up to the thickness of 4mm. For higher thickness of specimen this machine size should be increased.
- Chances of accident due to improper concentration on work.

5. APPLICATIONS

- Fabricating/Rolling
- Boilers, Pressure Vessels
- Storage Tanks, Silos
- Tubes and Pipelines
- Pumps, Burners and Filters
- Heating and Ventilation
- Wind Towers, Power Generation

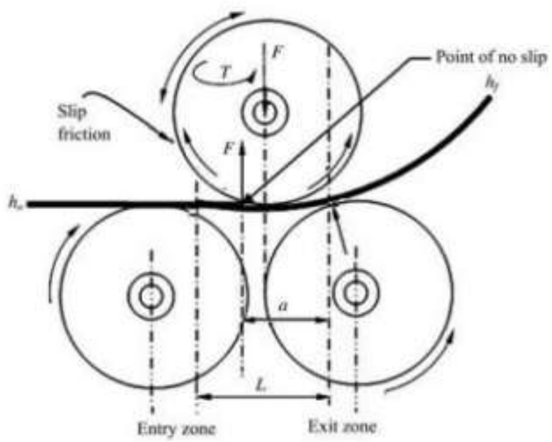
6. DESIGN

6.1 COMPONENT

Sl No.	Name of the parts	Material	Quantity
1	Bending rollers	Mild steel	1
2	Spindle wheel	Mild steel	1
3	Chain drive	Mild steel	1
4	Sprocket	Brass	2
5	Bearings	Steel	4
6	Elevating Screw	Stainless steel	1
7	Moving rollers	Mild steel	2
8	Supporting frame	Mild steel	2
9	Supporting Table	Cast iron	1
10	Others		

6.2 CALCULATIONS

Following basic shearing operation on a sheet metal, components can be rolled to give it a definite shape. Bending of parts depends upon material properties at the location of the bend. To achieve bending, the work material must be subjected to two major forces; frictional force which causes a noslip action when metal and roller came in contact and a bending force acting against the forward speed and the torque applied to move the material.



Where,

a = distance from exit zone to the no-slip point (assume a = L/2);

F = force applied to rollers;

T = torque applied to rollers;

L = roll gap;

r = radius of rollers;

μ = frictional force 0.4 Nm-1;

h_o, h_f = thickness of the sheet before and after time t.

At least two rollers are involved in flat rolling depending on the thickness and properties of material while three or multiple roller system is required in shape rolling. A work material under bending load is subjected to some form of residual stress and deformation as it bends. Materials at the outer bend radius undergo tensile plastic deformation while the material at the inner bend radius undergoes compressive plastic deformation.

1. Design of Chain drive:

Specifications:

Z_1: Number of teeth on driving sprocket=15

Z_2: Number of teeth on driven sprocket=15

a: center distance between driving sprocket and driven sprocket=201mm

D_1: diameter of driving sprocket

D_2: diameter of driven sprocket

Length of the chain

$L = L_n * P$

Where,

L_n: number of links

P: Pitch = 0.25 inch = 6.35 mm

$$L_n=2\left(\frac{a}{p}\right)+\left(\frac{Z1+Z2}{2}\right)+\left(\frac{Z2-Z1}{2\pi}\right)^2*\left(\frac{P}{a}\right)$$

$$L_n=2\left(\frac{201}{6.35}\right)+\left(\frac{15+15}{2}\right)+\left(\frac{15-15}{2\pi}\right)^2*\left(\frac{6.35}{201}\right)$$

L_n= 78.30mm

L= 78.30*6.35

L= 497.205mm

$$D=\frac{P}{\sin(\frac{\alpha}{2})}$$

$$\alpha=\frac{360}{Z}$$

$$\alpha=\frac{360}{15}=24°$$

$$D=\frac{6.35}{\sin 12}=30.54\approx 30mm$$

D= 30mm

$D=D_1=D_2=30mm$

2. Design of power screw

Specifications

μ: co-efficient of friction=0.15

W: weight of the roller=2.5Kg=24.525N

α: Helix angle

Ǿ: Friction angle

d_c: major diameter=7.4mm

d_o: minor diameter=6.04mm

P: pitch=6.35mm

Torque required lifting the load:

Lead= pitch (single trapezoidal thread)

Lead= 6.35mm

Helix angle

$\tan\alpha = \frac{lead}{\pi d}$

$d = \frac{do+dc}{2}$

$d = \frac{7.4+6.04}{2} = 6.72$mm

$\tan\alpha = \frac{6.35}{\pi * 6.72}$

$\alpha = 5.41°$

$\tan\acute{\emptyset} = \mu$

$\acute{\emptyset} = \tan^{-1}\mu$

$\acute{\emptyset} = \tan^{-1} 0.15$

$\acute{\emptyset} = 8.53°$

Torque required raising the load (for 1 revolution of one screw)

$T_1 = W * \tan(\alpha + \acute{\emptyset}) * \frac{d}{2}$

$T_1 = 24.525 * \tan(5.41 + 8.53) * \frac{6.72}{2}$

T_1= 20.45 N-mm

∴ It is the load acting on one screw.

Total torque= 20.45*54

= 1104.3N-mm

Total force= $\frac{\text{Torque}}{\text{Distance}}$

$= \frac{1104.3}{85} = 12.99 \approx 13$N

Force for 1 rev = $\frac{13}{1.4} = 9.28$N

Efficiency of screw (η)

$$\eta = \frac{\tan\alpha}{\tan(\alpha + \emptyset)}$$

$$\eta = \frac{\tan 5.41}{\tan(5.41 + 8.53)}$$

$\eta = 0.38 = 38\%$

Torque required to lowering the load

$T_2 = W * \tan(\acute{\emptyset} - \alpha) * \frac{d}{2}$

$T_2 = 24.525 * \tan(8.53 - 5.41) * \frac{6.72}{2}$

T_2= 4.47N-mm

∴ It is the load acting on one screw

As the lowering load is positive, the screw is self locking i.e., as $\acute{\emptyset} > \alpha$ screw is self locking.

3. Force analysis

Maximum torque required for a cylinder rolling

Specifications

σ_s: material yield limit=218 N/mm² (from data hand book)

B: maximum width of rolled shield= 40mm

δ: Thickness of rolled sheet in mm

$M_t = \int_A \sigma_y \, dA = 2\int_0^{\frac{\delta}{2}} \sigma_s B \, y \, dy = \sigma_s \frac{B\delta^2}{4}$ (N − mm)

1) For thickness $\boldsymbol{\delta = 2}$**mm**

When considering the deformation of the material, there is reinforcement and the reinforcement co-efficient K is introduced to modify the equation

$M_t = K\sigma_s \frac{B\delta^2}{4}$ N-mm

In the above formula

K: reinforcement co-efficient=1.15

δ=2mm

$M_t = 1.15 * 218 * \frac{40*2^2}{4}$

M_t = 10028 N-mm

2) For thickness $\boldsymbol{\delta}$**=3mm**

$M_t = 1.15 * 218 * \frac{40*3^2}{4}$

M_t = 22563 N-mm

3) For thickness $\boldsymbol{\delta}$**=4mm**

$M_t = 1.15 * 218 * \frac{40*4^2}{4}$

M_t = 40112 N-mm

4. Force condition

When rolling steel plate, the force condition is shown in above Figure. According to the force balance, the supporting F_2 on the roll plate can be obtained via the following formula.

$F_2 = \frac{M}{R \sin\theta}$

θ= the angle between defined line 00_1 and 00_2

$\theta = \sin^{-1}\frac{a}{\text{dmin+d2}}$

a = lower roller center distance in mm.

d_{min} = minimum diameter of the rolling plate in mm = 388mm

d_2 = lower roller diameter in mm = 62mm

$\theta = \sin^{-1}\frac{201}{388+62}$

θ = 26.53°

1) For thickness $\boldsymbol{\delta = 2}$**mm**

$F_2 = \frac{M}{R \sin\theta}$

R = neutral layer's radius of the rolling in mm

R = 0.5 d_{min}

R = 0.5*388

= 194 mm

$F_2 = \frac{10.02*10^3}{194*\sin(26.53)}$

F_2 = 115.63 N

According to the force balance, the pressure force F_1 which is generated by the upper roller, acting on the rolling plate i.e.,

$F_1 = 2F_2\cos\theta$

F_1 = 2*115.63cos 26.53

F_1 = 206.91 N

2) For thickness $\boldsymbol{\delta = 3}$**mm**

$F_2 = \frac{22.563*10^3}{194*\sin(26.53)}$

F_2 = 260.3 N

$F_1 = 2F_2\cos\theta$

F_1 = 2*260*cos 26.53

F_1 = 460.98 N

3) For thickness $\boldsymbol{\delta = 4}$**mm**

$F_2 = \frac{40.112*10^3}{194*\sin 26.53}$

F_2 = 462.90 N

$F_1 = 2*F_2\cos\theta$

= 2*462.90*cos 26.53

F_1 = 828.31 N

5. Calculation of driving Torque:

The lower roller of the plate of plate rolling machine is the driving roller and the driving torque on the lower roller is used to overcome the deformation torque T_{n1} and friction torque $T_{n2.}$

$T_{n1} = \frac{Md2}{2R}$ N-mm [for 2mm MS plate]

$= \frac{10.02*10^3*62}{2*194}$

=1601.13 N-mm

The friction torque includes the rolling friction torque between the upper and lower roller and steel plate, and sliding friction torque between the roller neck, and shaft sleeve which can be calculated as follows.

$T_{n2} = f(F_1+2F_2)+\mu(F_1\frac{D1}{2}\frac{d1}{d2}+F_2D_2)$ (N-mm)

In the above formula,

f=co-efficient of rolling friction = 0.008*10^3 mm

μ=co-efficient sliding friction

d_1, d_2= upper roller and lower roller diameter (mm)

D_1, D_2= upper roller and lower roller neck diameter (mm)

$D_i=0.5d_i$ (i=1,2)

$D_1=0.5d_1$

$D_1=0.5*62=31$ mm

$D_1=D_2$ (same size)

$$T_{n2}=0.008*10^3[206.91+2(115-63)] +0.04*10^3[206.91\left(\frac{31*62}{2*62}\right)+115.63*31]$$

$T_{n2}=3508.07$ N-mm

Total torque $T = T_{n1} + T_{n2}$

$T=1601.13+3508.07$

T=5109.206 N-mm

6. Shaft analysis

Specification

Shaft Material =steel (FeE580)

Tensile strength of the material (S_{ut}) = 770N/mm^2

Yield stress of material (S_{yt}) = 580 N/mm^2

f_s = factor of safety

$$\tau_{max} = \frac{0.5\ Sut}{fs}$$

$$= \frac{0.5 * 580}{2}$$

145 N/mm^2

Calculating torque

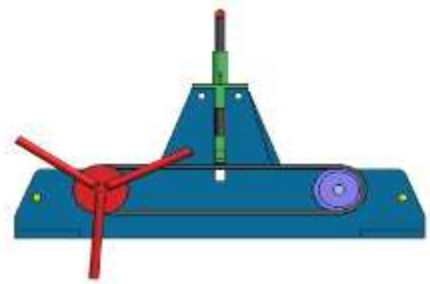
$T = 0.18\ S_{ut}$

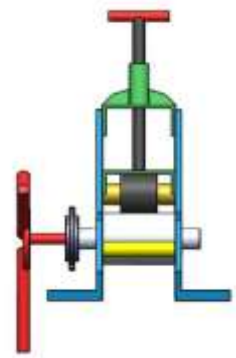
$= 0.18*770$

T = 139 N/mm^2

139<145 N/mm^2, Hence design is safe

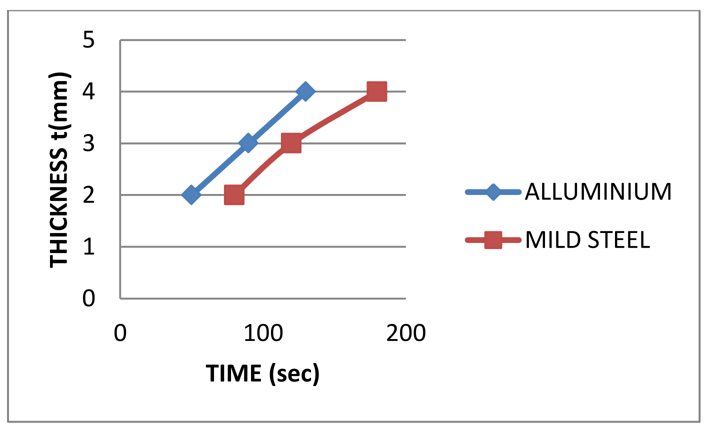
7. THREE DIMENSIONAL VIEWS





8. RESULT

Bending comparison of MS and Al sheet:



The thickness v/s time graph for length 1220mm of both Aluminium and Mild steel test specimen

According to the above graph the bending process of mild steel takes more time than alluminium in manual roller bending machine.

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10. CONCLUSION

The mechanism is widely used in industry to for bending purposes. The machine is made with a supporting frame that supports the roller mechanism between it. The work to be bent can then be rolled across it to achieve desired bending. The rollers are fitted with bearings so as to achieve the desired smooth motion.

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