DESIGN AND DEVLOPMENT OF THREE ROLLER SHEET METAL BENDING MACHINE

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Abstract: The metal forming can be described as a process in which the sizes and shapes desired are obtained through plastic deformation of a substance without any loss of meaning of things. Bending is a method of metal shaping in which the straight length is turned into a curved shape. The shape of rollers is a continual bending Operation where a long metal strip is passed through consecutive roller sets, until the desired cross-sectional profile is obtained. The roller bending process usually results in large quantities of larger parts of cylindrical or conical cross sections. Standard roller bending practice still relies heavily on the operator 's skill and performance. Trial and error are an industry method common to all. Rolling cycle often began with critical pre-bending operation of both ends of the piece of work. This operation eliminates flat spot when a full cylindrical shape is rolling, and ensures better closure.

Keyword: **bending, design, calculation, analysis, bending machine, cost estimation.**

I. INTRODUCTION

II. In three roller sheet, the bending machine sheet is bent by means of a load acting on the upper roller, which is movable. 3 roller blade bending system consists mainly of the following parts: 3 rollers (top roller and 2 bottom rollers); Engines, gears, power screws, and frames. Using the upper roller, which is movable, the bending process is performed by applying load (force). It can be shifted by manually changing the control screw. There are two bottom rollers fixed which act as a support to hold the sheet of metal. If the upper roller moves in the direction of the clockwise, the bottom rollers move immediately in the direction of the anticlockwise direction. Square threaded power screw is used to change the position of the top roller. This operation is completely manual. Frame is a fixed rigid support used to support the assembly and also to prevent vibration from the machine.

II. Literature Review

Jong Gye Shin: The Center Roller Displacement in Three Roll Bending for Smoothly Curved Rectangular Plates was experimented with Mechanics-based Determination. The purpose of this paper is to establish a logical procedure in the three-roll bending process to determine the center roller displacement needed in the manufacture of curved rectangular plates with the curvature desired.

Nitin P. Padghan: The paper shows the six steps of the sheet roll bending process. The setting of the sheet, the position of an upper roller, pre-bending of edges, continuous rolling. various parameters like sheet thickness, sheet width, sheet material property, diameter to be rolled, centre to centre distance between two bottom rollers, etc. are required for top roller load calculation. they calculate various design parameters like stress acting on a sheet, bending moment, bending stress, etc. by formulas. From their results, they concluded that, load increases as modulus of elasticity increases. load changes according to the radius of curvature changes, sheet thickness changes. The objective of the paper is to modelling and simulation of machine and force analysis of sheet. they show the isometric, exploded, orthographic views of a design model of sheet metal bending machine.

III. PROBLEM IDENTIFICATION

Manufacturing is an area for the conversion of raw materials to finished products. There are many manufacturing firms that can be found, such as automobile factories, electrical factories, etc. Some of the manufacturers manufacture their products in mass production. As a result, these manufacturers or businesses compete with each other to get their goods to the market. They must therefore have good manufacturing facilities to increase their profitability. In this project, we design and produce the 3-Roller Sheet Metal Bending Machine so that small pipes of the necessary diameters can be bent in the industry itself using their sheet metal scrap.

IV. STUDY OBJECTIVE OF RESEARCH

This literature review work indicates that the operator 's knowledge of trial and error is still a popular occurrence in the industry. Sequential bending on a roller bending machine is commonly used in practice but requires a very high amount of work to mark, locate, push and inspect the sheet after each sequential bending. The operator must have knowledge of various system parameters in order to obtain cylinders with the desired diameter. The ultimate purpose of the research work shall be:

- Calculation, modelling and Simulation of sheet Bending Machine.
- Force analysis of machine

V. CALCULATION

4.1 Maximum torque required for a cylinder rolling

Roller Diameter =22 mm
Bottom roller center distance= 45 mm
Yield strength of sheet =205 Mpa
Sheet thickness= 1.5 mm
Bending Moment(M),

$$M = \frac{K\sigma s * B\delta^2}{4}$$

K =Reinforcement coefficient, the value can be K = 1.10~1.25, when the result for δ/R is big, then take the biggest value.

R =Neutral layer’s radius of a rolling plate (m)

B, δ =The maximum width and thickness of rolled steel sheet (m)

$$M = \frac{K\sigma s * B\delta^2}{4}$$

$$= \frac{1(.1*205*1000*0.05*1.5*1.5}{4*1000^2}$$

=0.00634 KN.m

4.2 Force Condition

When rolling steel plate, the force condition is shown as below figure. According to the force balance, the supporting force F2 on the roll plate can be obtained via the formula:

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

In the above formula,

θ = The angle between defiled line OO1 and OO2,

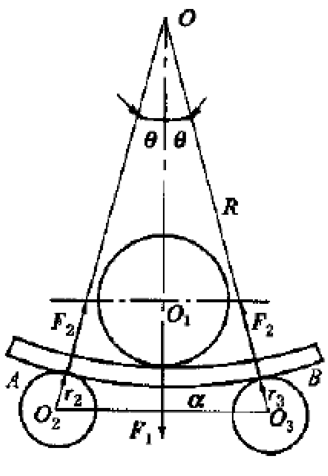
R=Neutral layer's radius of the rolling plate

$$\theta = arc\sin\frac{\alpha}{\text{dmin} + \text{d2}}$$

α =Lower roller center distance (m)

d_{min} =Min diameter of plate rolling (m)

d_2 =Lower roller diameter (m)



Force analysis of roll bending

$$\theta = \sin^{-1}\frac{0.045}{0.027+0.022}$$

$$\theta = 66.68°$$

$$\sin\theta = 0.9183$$

Considering that the thickness of the plate δ is far less than the minimum diameter of the rolling tube, the radius R of the neutral layer is around 0.5 d_{min},

To simplify the calculation, the above equation can be changed to:

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

$$F_2 = \frac{0.00634}{\frac{13.5}{1000}*0.9183}$$

$$F_2 = 0.5114 \text{ KN}$$

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

$$F_1 = 2F2 * \cos\theta$$

$$= 2 * 0.5114 * \cos 66.68$$

$$= 0.40489 \text{ KN}$$

<u>4.3 Driving Power</u>

4.3.1 Lower roller drive movement

The lower roller of the 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 the friction torque T_{n2}. In the process of steel plate rolling, the deformation capabilities stored in the AB section of steel plate (see Fig 2) is 2Mθ, the costed time is 2θR/V (V is rolling speed).

The ratio is equal to the power of deformation torque T_{n1}, namely:

Therefore,

$$T_{n1} = \frac{\text{Md2}}{2\text{R}} = \frac{Md2}{\text{dmin}}$$

$$T_{n1} = \frac{0.00634*22}{2*13.5}$$

$$T_{n1} = 0.0051 \text{ KNm}$$

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

$$T_{n2} = f(\text{F1} + 2F2) + \mu(F1\frac{D1}{2}\frac{d1}{d2} + F2\text{D2})$$

In above formula:

f =Coefficient of rolling friction, take f = 0.008m

μ =Coefficient of sliding friction, take μ = 0.05-0.1d1, d2 =Upper roller & lower roller diameter (m)

D1, D2 =Upper roller & lower roller neck diameter (m)

Sizes are still not precise in designing step, the value may equal $D_i=0.5d_i(i=1.2)$.

$$T_{n2}= 0.008(0.40489 + 1.0228) + 0.05(\frac{0.40489*11}{2*1000} + \frac{0.5114*11}{1000})$$

=0.01181 KNm

The bottom roll driving torque is equal to the deformity torque T_{n1} and frictional torque T_{n2} amount.

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

T=0.0051+ 0.01181

T=0.01691 KNm

4.3.2 Lower roller driven power

$$P = \frac{2\pi Tn2}{60n}$$

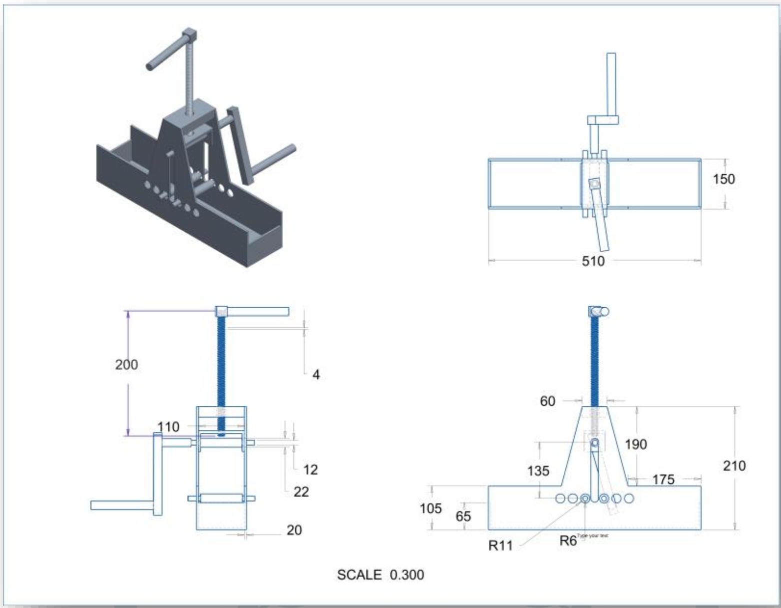
P =drive power(m.KW)
T =drive strength point (KN.m)
n_2 =bottom roll rotating rate (rpm)
=$2V/d_2$, where V indicates roll speed
η =transmitting efficiency
=0.65-0.8

$$P = \frac{2\pi * 0.01691 * 15}{60 * 0.65}$$

P=0.0435 KW

VI. Modelling

Modelling a bending machine with a 3-roller bar consists of any number of components and involves good coordination between the neighboring components. A minute error in assembly causes major damage to the machine when it is running. As a result, this machine builds up high tension on its part (shaft & roller) during bending and billet rolling. Modelling of this machine must be carefully selected; I think the best-suited modelling system for the machine above is Creo parametric. It includes a range of special features such as error correction, transitional mating, rotational mating, mating restriction selection, transverse to rotational mating, backup definition, division, presentation, etc.



VII. Analysis

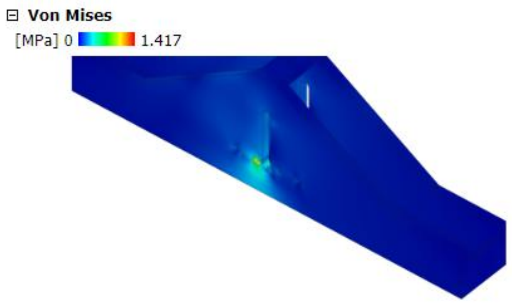
Components are evaluated after design and modelling. The model analysis is performed under computer-aided software to ensure that the design is safe. Mainframe and roller are elements of a bending device that can withstand repeated loads, but is also costly. It is very important to carry out the analysis in order to prevent practical attempts. Testing is often costly and often time-consuming; however, if parts are tested using computer-aided engineering software, this offers an opportunity to refine the design of the component before manufacturing. Therefore, the necessary material or geometric adjustments are made on the basis of the results of the analysis. Analysis of the base frame is done using Autodesk Fusion 360 software. The base frame was constrained at the bottom two-hole and 1000 N of force was applied on the two holes as it is a max force in die.

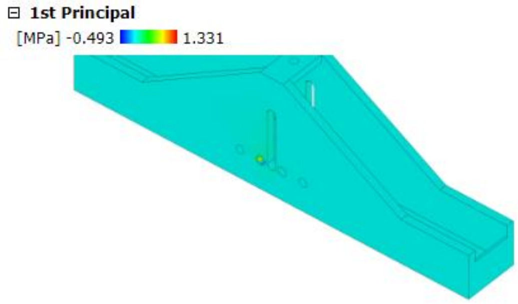
The figure below shows that the produced Equivalent (Von Mises) stresses have a maximum value of 1,417 MPa and this value is much lower than the yield stress value in the 207 MPa base frame. So, the base frame is safe.

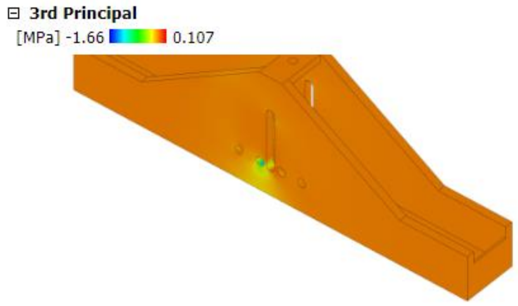
The 1st principal stress gives you the value of stress that is normal to the plane in which the shear stress is zero. The 1st principal stress helps you understand the maximum tensile stress induced in the part due to the loading conditions.

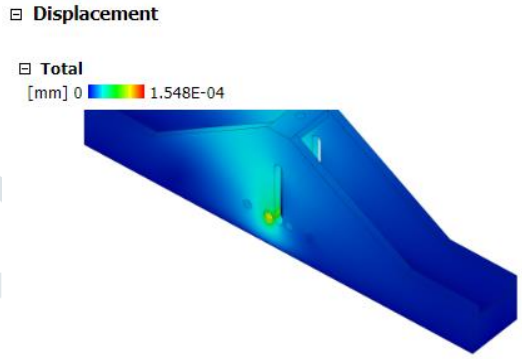
The 3rd principal stress acts normally towards the plane where the shear stress is zero. It allows you to understand the overall compressive stress caused by the loading conditions in the component.

The effects of Displacement show you the model's deformed shape after solution. The color contours show you the extent of initial shape deformation. The color contours correspond to the values the color bar determines.









VIII. COST ESTIMATION

Project cost estimation is the method of estimating the costs and other resources needed to complete a project within the framework. Cost estimation accounts for each item needed for the project and estimates the cumulative amount of the project budget.

S.R. NO	Name of materials	Quantity	Processes	Available in Ind. Premises	Material Cost	Machining Cost	Drilling cost	Milling Cost	Total cost
1	En 8 Roundbars	3	Machining	No	150 x 3 =450	30 x 3 = 90	--		540
2	Steel square Pipe	2	None	Yes	--	--			0
3	Base	1	Drilling 6 holes and Milling	Drilling:- Yes Milling :- No	--	--	6 x 20 = 120	2 x 220 = 440	560
4	Nut and bolt	6	None	Yes	--	--	--	--	0
5	Bearing	6	None	No	80 x 4 = 320	--	--	--	320
6	Welding Work			Yes	--	--	--	--	0
7	Cutting Work			Yes	--	--	--	--	0
							Total Cost		1420

IX. Conclusion

After Design of three roller bending machine finished for sheet thickness from 0.8 mm to 1.5 mm bending of sheet metal. These results are changing according to the material and according to the loading condition and finally depend upon the thickness of the sheet.

X. References

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