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Design & Development of Roller Machine

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Abstract: *The global drive toward intermediate technology and sustainable development motivated the development of sheet metal rolling machines for small scale artisanal manufacturers. The entire system is mounted on a metal frame made from angled-iron bars which were secured in place with 19 mm bolt and nuts. The clamping and folding bearing blocks are 120 mm thick, the throat width is 1,200 mm, and maximum length capacity of the machine is 1,050 mm. The best roller aperture for material tested is 5.5 mm and maximum bend radius of 2.5 mm. The roller diameter is 22 mm, bottom roller center distance is 45 mm and yield strength and thickness of sheet is 205 Mpa, 1.5 mm. This paper presents the design, fabrication and evaluation of a sheet metal rolling machine for small-scale enterprises. This is used for performing the multiple operations like drilling bending threading and rolling. It was reduce the floor surface area and reduce material handling time and increase production efficiency. Fifteen percent of the welders and 40% of tinsmiths are well acquainted with the functions of the machine. A total of 73.53% (n=26) of the respondents are not acquainted (technology awareness) with the shape rolling technology while 26.47% (n=9) have a fair knowledge of the use of such machines in metal rolling. The whole machine has a very small footprint, making it ideal for the home workshop and small factory alike.*
Key Word: *metal rolling, bushing, bearing block, economical, multi operational.*

I.INTRODUCTION

Several mechanical and hand-operated machineries are employed in the sheet metal working sector. Due to the size and expansion of the sheet metal sector, several machine types are employed for various tasks. Sheet metal rolling uses a roller and motor to operate in a relatively straightforward manner. Various diameters of cylindrical objectives are produced by this machine. There are several applications for this equipment [1]. This machine has three rollers connected to a motor, which is connected to the motor shaft via a worm shaft. This machine is easy to build and use. One big and growing company is sheet metal [2]. These days, this industry uses a lot of special-purpose machinery. The kind of work that the specific industry does determines which equipment is best for it. There are numerous instances of sheet metalwork that we see on a daily basis. Brass, copper, tin, aluminum, stainless, and black iron sheets are among the metals that are frequently used for sheet metal fabrication [3]. The main aim of this paper is to "Design & Development of Roller Machine" finds huge application in the sheet metal industry. Rolling is the process of bending sheets to a curved form. The article in the shape of cylinders is made by rolling rollers. Rolling operation can be done on hand- or power-operated rolling machines. In forming cylindrical shapes, a gradual curve is to be put in the metal rather than sharp bends. The gap between the rollers can be regulated by hand-operated screws.

Study theory and practice of creating modern roller machines [4] Design and development of a roll-to-roll machine for continuous high-speed micro contact printing [5] Design And Fabrication Of Manual Roller Bending Machine [6]. Instrumented roll technology for the design space development of roller compaction process [7]. Design, development and evaluation of a divergent roller sizer for almond kernels [8]. study on the pressure mechanism improvement of a roller type machine working bodies.[9] Design, construction and instrumentation of a machine to measure tension and impact forces in roller chain drives.[10] Development of a roll-in oriented machine for maize shelling[11] The development of a roller rig for experimental evaluation of contact mechanics for railway vehicles[12] Development of an optimally designed real-time automatic citrus fruit grading–sorting machine leveraging computer vision-based adaptive deep learning model[13] Design and develop spiral conveyor for flexible manufacturing system[14] A calibration-based hybrid transfer learning framework for RUL prediction of rolling bearing across different machines[15] Machine learning-assisted development of organic photovoltaics via high throughput in situ formulation[17] Development of production technology of rolling stock cast parts[18] Sustainable Process Design for Special Welded Profiles via Roll Forming Compression [19] Advances in machine learning- and artificial intelligence assisted material design of steels[20] Influence of The Design of The Rolling Roller on The Quality of The Surface Layer During Plastic Deformation on the Workpiece [21] For defining the goal of research, in this section, a brief overview of the sheet metal rolling machine, the system design approach, numerical simulations, and experimental test results of previous work carried out are reported and discussed.

II.MATERIAL AND METHODS

TThe first definition of the project in a clear and concise manner is a sheet metal rolling machine, which means bending long rectangular plates into cylinders. The machine should be semi-automatic, which means the load is applied manually and driven by an electrical power unit. Bending of the sheet should be based on the three-roller bending concept. The flow chart and experimental setup are shown in Fig 1 and 2.

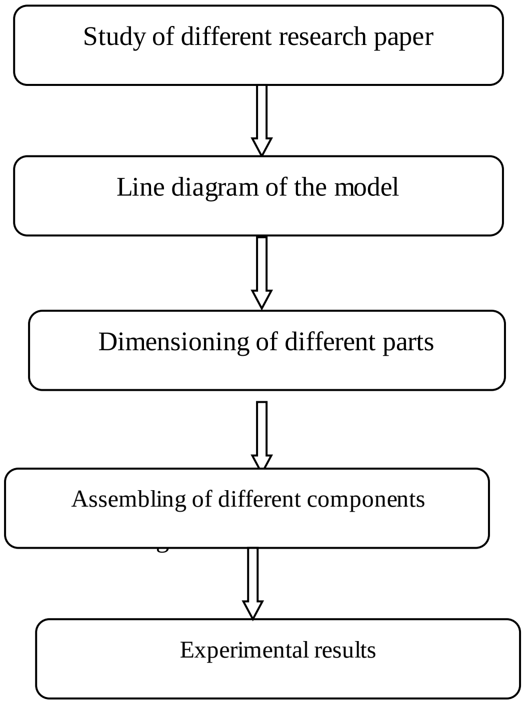

Figure 1. Shows the flow chart

Figure 2. Shows the experimental setup

III.STATISTICAL ANALYSIS

D **Maximum torque required for a cylinder rolling**
Roller Diameter = 22 mm
Bottom roller centre distance = 45 mm
Yield strength of sheet = 205 Mpa
Sheet thickness = 1.5 mm
Bending Moment (M)

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

K =Reinforcement coefficient, the value can be K = 1.10~1.25, when the result for $\frac{\delta}{R}$ 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)

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

$$= \frac{1(1.1 \times 205 \times 1000 \times 0.05 \times 1.5 \times 1.5)}{4 \times 1000^2}$$

= 0.00634 KN.m

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:

$$F_2 = \frac{\boldsymbol{M}}{\boldsymbol{R} \times \mathbf{sin} \times \boldsymbol{\theta}}$$

In the above formula,
θ = The angle between defiled line OO1 and OO2,
R=Neutral layer's radius of the rolling plate

$$\theta = arc\ sin \times \frac{a}{\mathrm{dmin}\ + \mathrm{d2}}$$

α =Lower roller centre distance (m)
d min =Min diameter of plate rolling (m)
d2 =Lower roller diameter (m)

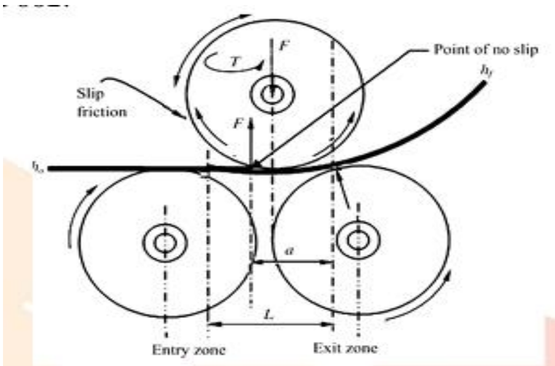

Figure 3. Force analysis of rolling Machine

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

θ =66.68°
sinθ = 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:

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

$$\boldsymbol{F_2} = \frac{\mathbf{0.00634}}{\frac{\mathbf{13.5}}{\mathbf{1000}} \times \mathbf{0.9183}}$$

F_2 =0.5114 KN

According to the force balance, the pressure force F1, which is generated by the upper roller, acting on the rolling plate is:
$F_1 = 2F_2 \times \cos\theta$
=2 × 0.5114 × cos66.68
= 0.40489 KN

Driving Power

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 Tn1 and the friction torque Tn2. 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 Tn1, namely:
Therefore,

$$\mathbf{Tn1} = \frac{\mathbf{Md2}}{\mathbf{2R}} = \frac{\mathbf{Md2}}{\mathbf{dmin}}$$

$$\mathbf{Tn1} = \frac{\mathbf{0.00634 \times 22}}{\mathbf{2 \times 13.5}}$$

Tn1=0.0051 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:

$$\mathbf{Tn2} = \mathbf{f}\,(\boldsymbol{F_1} + 2\boldsymbol{F_2}) + (\boldsymbol{F_1}\frac{\boldsymbol{D1}}{\mathbf{2}} \times \frac{\boldsymbol{d1}}{\boldsymbol{d2}} + \boldsymbol{F_2}\boldsymbol{D_2})$$

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 Di=0.5d_i (i=1.2).

$$\mathbf{Tn2} = \mathbf{0.008(0.40489 + 1.0228)} + \mathbf{0.05}(\frac{\mathbf{0.40489 \times 11}}{\mathbf{2 \times 1000}} + \frac{\mathbf{0.5114 \times 11}}{\mathbf{1000}})$$

=0.01181 KNm

The bottom roll driving torque is equal to the deformity torque Tn1 and frictional torque Tn2 amount.

T= T_{n1} + T_{n2}

T=0.0051+ 0.01181

T=0.01691 KN.m

Lower roller driven power

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

P =drive power(m.KW)

T =drive strength point (KN.m)

n2 =bottom roll rotating rate (rpm)

=$\frac{\mathbf{2V}}{\mathbf{d2}}$, where V indicates roll speed

η =transmitting efficiency

=0.65-0.8

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

P=0.0435 KW

Design chain drive

Z_1=$Numerof theteeth of sprocket = 27$

Z_2=$Numberof theteeth of sprocket = 27$

a=$distancebetweendrivingsprocket = 200\ mm$

p=$pitch$=4 mm

$$\text{eq1} \rightarrow \text{Ln} = (\frac{a}{p}) + (\frac{\text{z1} + \text{z2}}{2}) + (\frac{\text{z1} - \text{z2}}{2\pi})2\frac{p}{a}$$

$$\text{Ln} = 2 \times (\frac{200}{4}) + (\frac{27 + 27}{2}) + (\frac{27 - 27}{2\pi})2\frac{4}{200}$$

L_n =127 mm

eq_2→L=Ln P

L=127 × 4=508 mm

$$\alpha = \frac{360}{27} = 13.33°$$

$$\text{D} = \frac{p}{\frac{a}{2}} = \frac{4}{(\frac{0.33}{2})} = 34.46\ mm$$

D= D1 =D2

IV.RESULT AND DISCUSSION

Figure shows the thickness and time for steel and nickel. From this figure, it was found that the steel and nickel, it varies thickness from 2 to 1.2 mm in 10 seconds time period for a rolling operation. The steel thickness is increase when compare to nickel. According to the above figure, the nickel sheet required less time for the rolling operation, while the steel sheet required more time for the rolling operation.

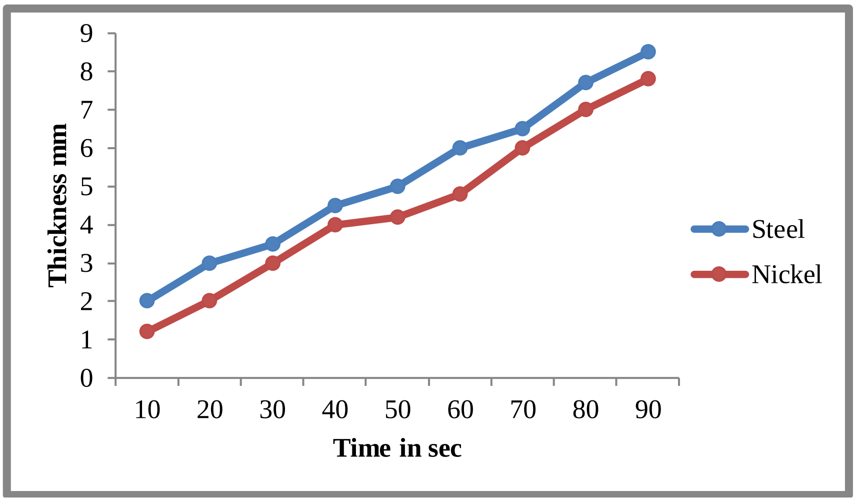

Fig.4. Thickness vs. time at steel and nickel

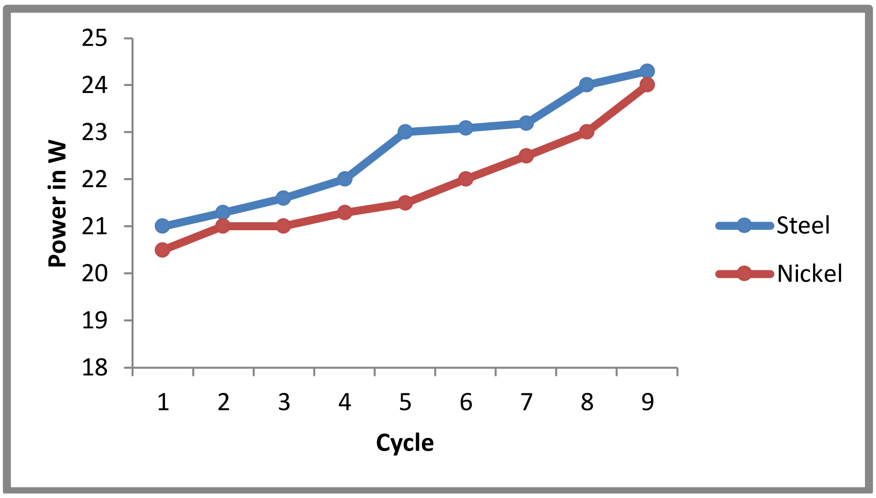

Fig.5. Power vs. cycle at steel and nickel

Figure shows the Power and Cycle for steel and nickel. From this figure it was found that the steel and nickel, it varies power from 20.5 to 24 watts for nickel and 20 to 24.3 watts for steel in 1 cycle time period for a rolling operation. The steel power is increase when compare to nickel. According to the above figure, the nickel sheet required less time for the rolling operation, while the steel sheet required more time for the rolling operation.

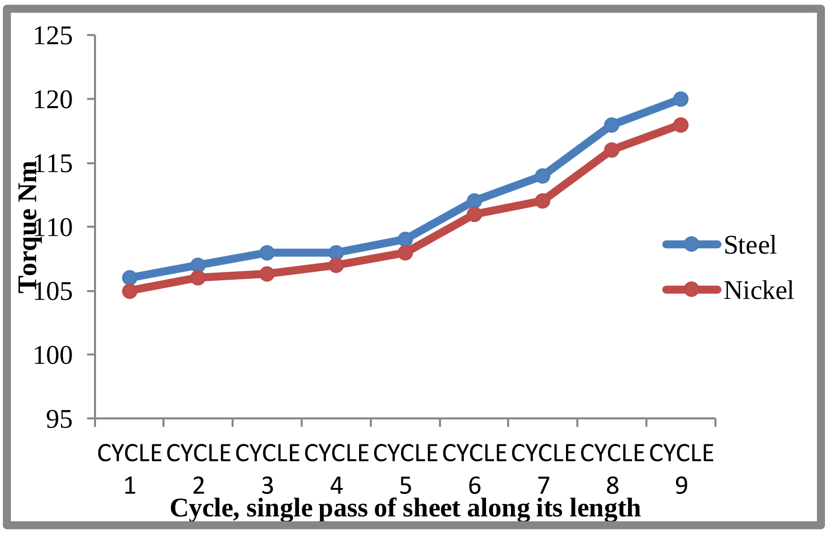

Fig.6. Torque vs. cycle at steel and nickel

Figure shows the Torque and Cycle graph for a length of 500 mm of both nickel and steel sheets. It varies torque from 105 to 118 mm for steel and 106 to 120 for nickel in 1 cycle time period for a rolling operation. From the figure 6 it was observed that the nickel sheet required less time for the rolling operation, while the steel sheet required more time for the rolling operation.

V.CONCLUSION

The major benefit of the paper is to increase the production rate. Since the top roller motion is carried out by the humans using labour manually. The existing process consumes more time. In this existing process, only 160 sheets are rolled in one shift (8 hours) per day. This causes a low production rate. This project rolls 200 sheets in one shift. Thus, the production rate is increased in the industries. Another benefit of this work is to reduce the human effort of the worker. Due the reduction in human effort, the increases in efficiency of the production.

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