Design and Fabrication of Rolling Mill

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Abstract - *Rolling is the process of reducing the thickness or changing the cross section of a long work piece by compressive force applied through set of rolls. Generally rolling mills are used to roll large ingots and the size of rolling mill is also huge. Small scale Industries and educational institutions are often facing an issue in rolling smaller ingots to get thin strips. Hence there is a need for compact rolling mills with a low cost which can roll very small thickness plates. In this work a rolling mill is designed to roll a maximum width of 100mm and the maximum draft value is 0.25mm per pass.*

***Key Words*: Roll force, Draft, Flow stress, Belt drive, Adjustment screw, Sleeve.**

1. INTRODUCTION

Rolling is one of the most important industrial metal forming operations. It is the plastic deformation of materials caused by compressive force applied through a set of rolls. In sheet metal industries rolling is used to reduce the thickness in order to change the cross section of a long work piece by compressive forces applied through a set of rollers. Here the material gets squeezed between a pair of rolls, as a result of which the thickness gets reduced and the length gets increased. In this paper, we have illustrated rolling mill to roll sheet metals in cold rolling process.

1.1 Hot Rolling

Hot rolling uses large pieces of metal, such as slabs or steel billets, and heats them above their recrystallization temperature. The metal pieces are then deformed between rollers creating thin cross sections. These cross sections are thinner than those formed by cold rolling processes with the same number of stages. Hot rolling also reduces the average grain size of metal but maintains an equal microstructure

1.2 Cold Rolling

Cold rolling is a process which passes metal through rollers at temperatures below its recrystallization temperatures. This increases the yield strength and hardness of the metal. This can be done by introducing defects into the crystal structure of the metal creating a hardened microstructure which prevents further slip. Because the metal is at room temperature, it is less malleable than metal above its recrystallization temperature.

2. DESIGN CALCULATIONS

In our project work, we are fabricating a rolling mill to reduce the sheet metal of thickness of 10mm and maximum Width of 100mm with a thickness reduction of 0.25mm per Pass.The material which has a hardness value less than that of EN 24 steel can be rolled on that machine. The maximum load produced by the set of rollers is about 13 tonnes including the factor of safety of 1.75. A two stage belt drive is used to run the mill with a 1 HP motor.

2.1 Conceptual Design

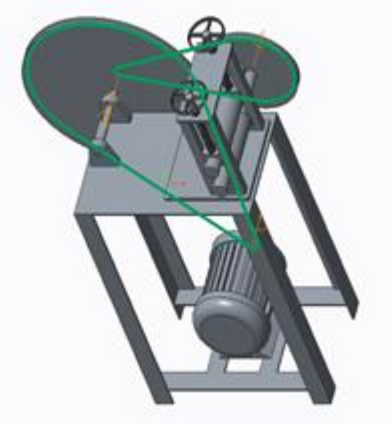

Fig – 1: Rolling Mill

$$\text{Roll force, } F = y_f\sqrt{R\Delta H}\times W$$
$$= 353.6\sqrt{32.5\times 0.25}\times 75$$
$$= 754\text{KN}$$
$$= 7.5\text{ tonnes}$$

Considering factor of safety as 1.75,

$$F = 7.5\times 1.75 = 13\text{tonnes}$$

$$y_f = \frac{2}{\sqrt{3}}y = \frac{2}{\sqrt{3}}\times 250 = 353.6\text{N}/\text{mm}^2$$

y_f - Flow stress (N/mm^2)

y - yield strenght (N/mm^2)

R - Radius of roller (mm)

ΔH - Draft = (intial thickness - final thickness) mm
= maximum 0.25mm

W - maximum rollable width of ingot (mm)

$$\text{Torque required, } T = F \times (\sqrt{R\Delta H})/2$$
$$= (127530 \times 2.85)/2$$
$$= 181.73\,\text{Nm}$$

$$\text{Power required, } P = T\omega$$
$$= \frac{181.73 \times 2\pi \times 30}{60}$$
$$= 570.92\,\text{Watts}$$
$$= 0.77\,\text{HP}$$
$$= \text{HP (standard motor specification)}$$

Standard motor specification :

$$\text{Power} = 1\text{HP}$$
$$\text{Speed} = 1440\text{rpm}$$
$$\text{Torque, } T = \frac{P}{\omega}$$
$$= \frac{60P}{2\pi N}$$
$$= \frac{60 \times 746}{2\pi \times 1440}$$
$$= 4.95\,\text{Nm}$$

Belt drive calculations :

Stage 1 :

$$\frac{N_1}{N_2} = \frac{D_2}{D_1}$$
$$\frac{1440}{144} = \frac{D_2}{40} \left(D_1 = 40\text{mm from PSG Design data book}\right)$$
$$D_2 = 400\text{mm.}$$

Torque,

$$\frac{N_1}{N_2} = \frac{T_2}{T_1}$$
$$\frac{1440}{144} = \frac{T_2}{4.95}$$
$$T_2 = 49.5\,\text{Nm}$$

Stage 2 :

$$\frac{N_3}{N_4} = \frac{D_4}{D_3}$$
$$\frac{144}{30} = \frac{D_4}{40} \left(D_3 = 40\text{mm from PSG Design data book}\right)$$
$$D_4 = 192\text{mm.}$$
$$D_4 = 200\text{mm (standard diameter from PSG design data book).}$$

Torque,

$$\frac{N_3}{N_4} = \frac{T_4}{T_3}$$
$$\frac{144}{30} = \frac{T_4}{49.5}$$
$$T_4 = 237.5\,\text{Nm}$$

Design of bolt :

Compressive strenght on bolt body,

$$\sigma = \frac{W}{\pi d^2/4}$$

$\sigma = 500\text{MPa}$ (for high tensile steel).

d - core diameter of bolt (mm).

W - load on one bolt (N).

$$500 = \frac{63765}{\pi d^2/4}$$
$$d = 12.75\text{mm}$$

Bolt = M16 (standard bolt size from PSG design data book)

Table – 1: Bill of Materials and Cost Estimation

Component	Materials	Numbers	Cost
Housing	M. S. Plate	4	Rs.70/kg
Roller	EN24	2	Rs.80/kg
Sleeve	Gun metal	4	Rs.575/kg
Bolt	High Tensile steel	2	Rs.180/kg
Motor	1 HP	1	Rs.3000
Pulley	Cast iron	4	Rs.42/kg

3. CONCLUSIONS

A compact two high rolling mill to roll sheets within the width of 100 mm and maximum draft of 0.25 mm is designed. The rollers are selected made up of EN24 steel with a diameter of 63.5 mm which can roll materials with hardness less than the roller material with the maximum load of 13 tonnes including a factor of safety of 1.75. The rollers are supported in a mild steel housing and the distance between the rollers are adjusted using high tensile steel bolts with a pitch value of 2 mm. The rollers are driven by 1 HP motor through two stage belt drives. The speed of the rollers is reduced to 30 rpm which is a reduction of about 48 times and simultaneously the torque is increased by these drives. Through this a design of the low cost rolling mill is proposed and then the mill has been fabricated as per the design and the estimated cost.

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