To Compare Rolling Force, Torque and Power of Pure Aluminium and Stainless Steel in Cold Rolling Process

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Abstract:-
On the basis of cold rolling process, a rolling force, torque and power of pure aluminum and stainless steel was investigated. Our aim is to compare these factors for stainless steel and pure aluminum by using experimental method for pure aluminum & ANSYS for stainless steel. Factors which influenced rolling force including radius of roll, stress coefficient & deformation resistance.

Keywords: Cold Rolling process; SOLIDWORKS; ANSYS; Pure Aluminum; Stainless steel.

1 INTRODUCTION

The Rolling process is a metal shaping operation in which material thickness reduced by passing the metal stock through one or more pairs of roll. For the manufacture of thin sheet Cold rolling is a financial & effective process. The design of the aluminum plate starts with the die casting and after that passing it through the rollers to reduce the thickness of aluminum plate. For the stainless steel the design of the roller and the plate starts with the making of the roller geometry by using SOLIDWORKS & 3D model of the roller and plate is shifted to ANSYS and analyze. The ANSYS software generates the result for stainless steel.

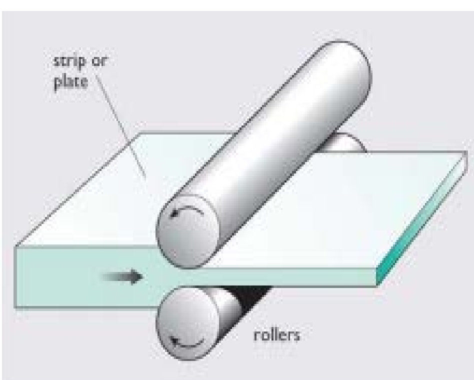

Fig. 1 Principle of Rolling

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Nomenclature

F	Rolling force KN
P	Power
T	Torque

J.B.HAWKYARD et al[1] developed an analysis to estimate the torque and rolling force in ring rolling between the cylinder-shaped rolls, with some supporting experiments. He concluded that the roll force provide within 10% and torque generally 15% of experimental measurement, but there have been doubts because of possible slip. I.J.FRESHWATER [2] simplified that the theory of flat rolling and calculate roll force, torque & pressure. He used classical theories in experiment (FEM) and give a detailed deformation analysis into rolling. He used annealed copper (Cu) and estimate parameters for calculation of rolling force, torque & pressure. He concluded that the solutions of these numerical are unfalteringly affected by hypothesis inherent in surface friction & lubrication modelling. M.KAZEMINEZHAD & A.KARIMI TAHERI [3] developed a analysis to find the rolling force and pressure distribution in wire flat roll process of low carbon steel, in analysis they varies the width of area contact between wire & rolls during the process. By reduction in height & increasing the friction coefficient the neutral angle is increased and yield strength has effective less. J.G.LENARD & S.ZHANG [4] study the forward slip, roll torque & separating force of aluminum alloys with lubricants(SAE 5 & SAE 30 oils) present during process of cold rolling, they observed that the negative forward slip with higher viscosity oil. They found that coefficient of friction increase with decreasing rolling speed and increasing reduction and discussed result in term of adhesion theory of friction. J.C.LIN[5] predict the force in rolling process and maximum error in surface in a 3D rolling process by using finite element method(FEM). He used 27 different tools geometry for this process, with the different variation of rolling ratio & radius of die. Based on results he proved that this approach is a feasible and new which can be used for controlling of rolling process for different materials. MARIA CRISTINA & VALIGI MORICA MALVEZZI, [6] developed an analysis for the full-film regime in cold rolling process that uses lubricant emulsion sprayed on at the entrance of the strip. The strip thickness versus the flow rate of lubricant given the other rolling operation parameters. OWAIS KHAN et al.[7] studied the deformation in material. He observed that friction between the material & rolls contact produce a large quantity of heat. The heat that conduct in from of energy between roll and work piece. Large plastic strain occurs in friction process between the work piece and the roll. The heat is carried out from roll and strip in free air convection or forced convection. J.V. OPLAWSKI & D. A. SECCOMBE [8]Analyzed the temperature varieties in the workpiece and the roll are inspected at different move revolution and in addition to the free and constrained convection circumstances. Exhibited both the roll & the work-piece divert a noteworthy sum of miss-happening heat and grinding heat produced, especially for the circumstance of free mode convection. A. A. TSENG et al. [9] developed the model to find out the strip and roll temperature profile. He used basic heat transfer theory and gives the analysis for studying the effect of parameters on temperature of roll work and work piece. The hot and cold rolling of alloys of aluminum are given to determine the possibility and capability of the developed mode. I. HOSHINO et al. [10] studied the cold rolling mill of aluminum that has immersed from an application of (MCT). The mutual interaction between thickness of strip and understand the tension. They developed a multi-variable systems of controlling type for aluminum cold mills is performed based on the output theory.

2. Experimental data, procedure & materials:

The experiment was conceded out on a rolling machine having two rolls of each diameter 457mm & length of 609mm. The mill is powered through DC motor with continuously variable speed.

Fig.2 Rolling Machine

The strip material is pure aluminum and stainless steel,

15mm thick, 156mm wide and 175mm long.
Fig.3 shows the initial condition of the workpiece.

Fig.3 before Rolling (15mm)

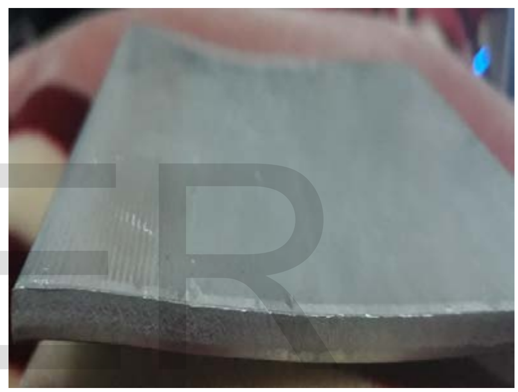

Fig. 4 after Rolling (4mm)

The design of the aluminum plate starts with the die casting in which strips of aluminum is melt under 750^{0}C and poured into mold and give solidification time for required geometry. After that plate bring out from the mold and pass through rollers to reduce the thickness. Fig 4 shows the material thickness after rolling.

Table I
Specification of Materials

PARAMATERS	ALUMINUM	STAINLESS STEEL
Density (kg/m^3)	2700	7880
Modulus of Elasticity (10^{3}MPa)	69	200
Melting point (c^o)	660	1426
Specific heat (J/kg. c^o)	940	490
Electrical conductivity (% IACS)	62	2

Thermal conductivity (W/m. C°)	222	21
Coefficient of liner Expansion (°C^{-1})	23.6	16.2

3. *Modeling*

For stainless steel the design of rollers and plate starts with the making of rollers geometry by using SOLIDWORKS.

Table I
Design Specifications of Rollers & Plate

Sr. No.	Parameters	Dimension
1.	Length of Roller (L)	609mm
2.	Diameter of Roller (D_f)	457.2mm
3.	Inner Diameter of Roller (D_0)	300mm
4.	Length of plate	175mmm
5.	Width of plate	156mm
6.	Thickness of plate	15mm

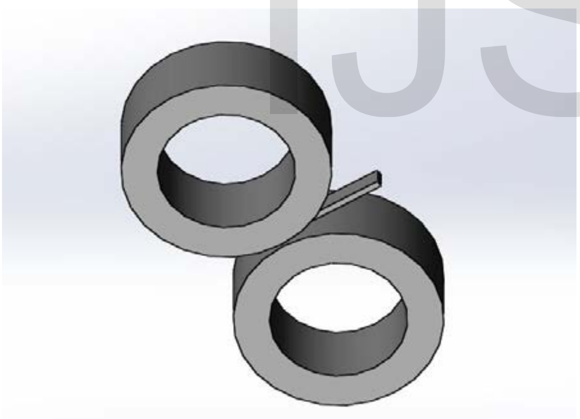

Fig. 5 3D model of roller & plate

Then the 3D model of the rollers transferred into ANSYS for further procedure. ANSYS procedure consist of selection of material properties and meshing.

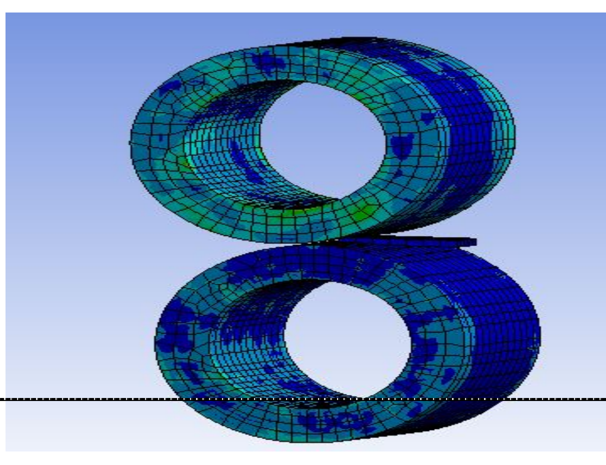

Fig. 6 ANSYS Analysis

4. Equations for Rolling Force, Torque & Power

With the help of roller radius, initial & final thickness of plate we calculate Contact length between roller & plate by using this relationship:

$$L = \sqrt{R(t_0 - t_f)}$$

Average flow stress can be calculated by using:

$$\bar{Y}_f = \frac{K\varepsilon^n}{1+n}$$

Now we calculate Rolling Force, Power & Torque by using given relationships:

$$F = \bar{Y}_f wL$$

$$P = 2\pi NFL$$

$$T = 0.5FL$$

Table 2
Results Comparison

Sr. No.	Parameters	Pure Aluminum	Stainless steel
1.	**Torque**	30243.57463 N-m	187956.0201 N-m
2.	**Force**	1206.2448 N	7496.5009 N
3.	**Power**	297.5437 KW	1849.1579 KW

5. Conclusion

It has been concluded that rolling force required for stainless steel is greater than pure aluminum because stainless steel is tough, ductile and high temperature strength properties also the strength coefficient and strain hardening exponent for stainless steel is greater than pure aluminum.

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