STUDIES ON INFLUENCE OF ROLLER DIAMETER AND ROLLER SPEEDON PROCESS PARAMETERS IN HOT ROLLING PROCESS USING MANUFACTURING SIMULATION

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ABSTRACT
This paper deals with the studies on influence of roller diameter and roller speed in hot rolling. This analysis is carried out using new software AFDEX and data is interpreted. The roller diameter is varied from 100 mm to 300 mm over a speed reduction of 480rpm to 30 rpm. The main aim of this analysis is to study the effect of roller diameter and speed on Pressure, Von Mises stress, Effective Stress, Effective strain and Shear stress of the workpiece. The simulation is done for steel material AISI_1055 at 1000˚C. The results show the decrease in Pressure, Von Mises stress, Shear stress, Effective stress, Effective strain etc.

Key words: - Roller diameter, Roller speed, AFDEX.

1. INTRODUCTION

Rolling process is one of the most popular Metal forming processes, in their lifetime 80% of materials are exposed to rolling process. And 40-60% of rolling takes place by flat rolling. Many scientists optimised parameters such as rolling speed and rolling diameter to improve quality and quantity of the rolling process [1]. To stay in market condition manufacturer develop new low cost products and new technologies in mills to improve quality [3]. FEM method and numerical simulations have been proved to be a very powerful tool for prediction of rolling force and energy parameters in rolling process.

Rolling speed controls properties such as flow stress, strain rate, roll force, heat of deformation and interface heat transfer coefficient [2]. A. K. Tieu simulated hot rolling process considering lubricated and dry condition to find effect on roll separating force and torque [4]. Cold rolling was carried to find effect on residual stress, contact pressure [5]. Heat is retained in material while higher rolling speed since there is less time contact between roll and material also leads to lower temperature gradient between surface and centre of work piece [2]. Rolling speed increases rolling force and it has effect on strain rate [1]. The increase in roller diameter increases rolling force [11]. Santosh Kumar carried out study on reducing or minimising defects of hot rolling process. Larger roll diameter leads to decrease in Von Mises stress, plastic strain [6]. Most of rolling simulations are done using ABAQUS, and few using new emerging manufacturing simulation package AFDEX [9]. 2D model does not show occurrence of damage hence 3D model is required for accurate prediction of data [12].

Simulation techniques are applied using the AFDEX (Advisor as friend for Forging Design Experts) software. It is a Lagrangian approach based FEM (Finite Element Analysis) package. It can predict different parameters of Rolling/ forming process such as Hydrostatic pressure, Von Mises stress shear stress, effective stress, effective strain rate etc [7]. Many have carried out their work using AFDEX software for simulating various components [7, 8, 9]. In this work a rolling process is carried out in six different cases with different roller diameter and roller speed to analyse the effect over rolling parameters using manufacturing simulation.

2. PROBLEM DEFINITION

Primary objective of this study is to reduce rigid steel plate of squire cross section of 40mm by 40mm with length of 100mm to 30mm in thickness in one roll pass [3] and to study the influence of roller speed and roller diameter on rolling parameter in hot rolling process using manufacturing simulation. The secondary objective is to simulate the rolling process using manufacturing simulation AFDEX

Simulation is carried out in six cases, as the data shown in the Table 1. A 3D FEM study carried with roller diameter varied from 100mm to 300mm and also the roller speed varied from 480rpm to 30rpm. And all over the cases the friction is kept same.

Case No	Roll Diameter in mm	Rolls rpm	Friction
1	100	480	0.3
2	150	320	0.3
3	200	240	0.3
4	250	120	0.3
5	275	60	0.3
6	300	30	0.3

Table 1 roller diameter and roller speed

In each case friction is kept constant as 0.3. The simulation is carried out for steel material AISI_1055 (1000℃). The figure 1 shows true stress v/s plastic strain of AISI_1055 at 1000℃.

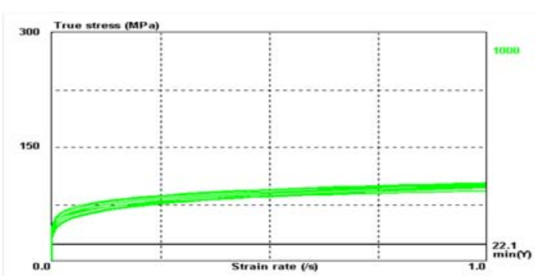

Fig 1 true stress v/s plastic strain of AISI_1055 at 1000˚C

3. METHEDOLOGY

The methodology is shown in figure 2. The billet and roll modelling is done using UG NX 9. The six different models are prepared with different diameters [4]. This step holds maximum important as it holds geometrical information about the model. The positioning of rolls and billet is done in CAD software itself as it is difficult in AFDEX. The model is then fed into AFDEX using STL format and once it is fed the material properties and rolling conditions are given. Position of rolls and billet is ensured and also the input data. The process is simulated and then the flow analysis results are interpreted.

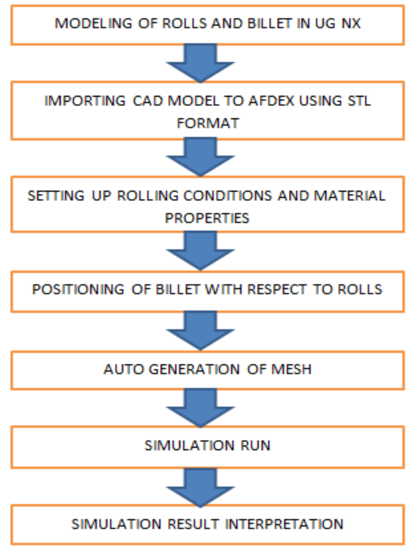

Fig 2 AFDEX rolling methodology

3.1.SIMULATION

The rotation of rolls cause billet to go through roll gap and obtain desired thickness. To happen this various inputs are given before starting the simulation. The table 2 shows simulation process input parameters. Once the simulation starts the material is auto meshed into tetrahedral meshing as shown in figure 3.

Type of rolling	Hot rolling
Type of simulation	3d without flash
Type of analysis	Flow analysis
Deformation	Rigid plastic
Billet material	AISI_1055
Lubrication used	Graphite + water hot (steel)
Friction	0.3
Material temperature	1000℃

Table 2 rolling parameters used for simulation upset rolling.

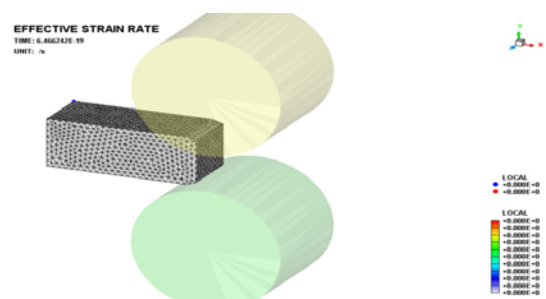

Fig 3 tetrahedral meshed workpiece in AFDEX

4. RESULTS AND DISCUSSION

The main interest of this work is to analyse rolling parameters for different roller diameter and roller speed in hot rolling process. The roller speed is easily controllable parameter.

4.1.EFFECT OF ROLLER DIAMETER ON PRESSURE

Figure 4 shows the effect of rolling diameter and speed on hydrostatic pressure. The pressure is as high as 480.5MPa when diameter is low, it gradually decreased as the speed decreased and diameter increased ie in sixth case. When speed is low at higher diameter, hydrostatic pressure is 240 MPa. Hydrostatic pressure has effect of true stress and hence the flow stress is decreases with reducing pressure.

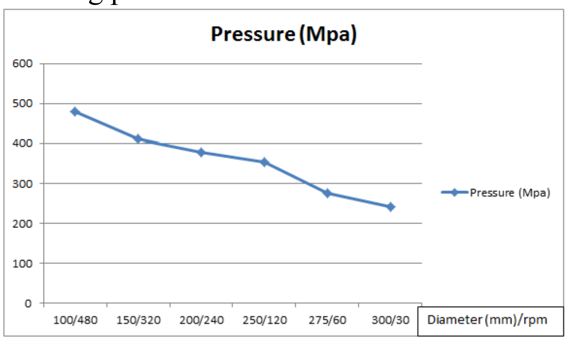

Fig 4 graph between hydrostatic pressure and diameter/speed at constant friction 0.3

4.2. EFFECT OF ROLLER DIAMETER ON VON MISES STRESS

Figure 5 shows the effect on Von Mises stress. Von Mises stress is decreased as the rolling diameter increases and rolling speed decreases. This helps roller capacity to take more loads [12]. In first case Von Mises stress is 200 MPa and in case 6 it is 139.5 MPa.

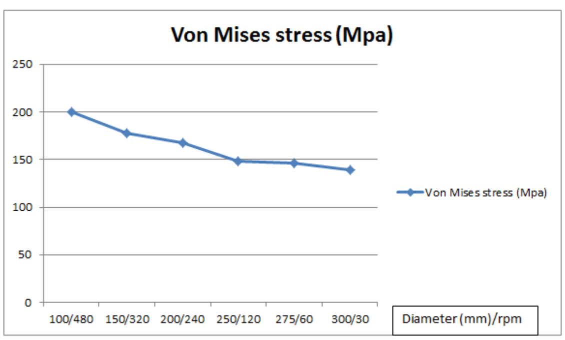

Fig 5 graph between von Mises stress and diameter/speed at constant friction 0.3

4.3.EFFECT OF ROLLER DIAMETER ON EFFECTIVE STRESS

Figure 6 represents effective stress graphically. Stress 211.2 MPa is maximum in the first case and in further cases it goes on decreasing. In sixth case effective stress is 136 MPa.

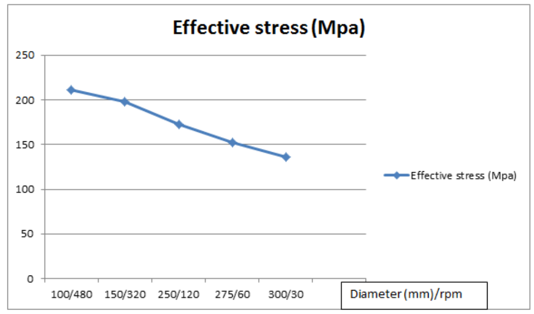

Fig 6 graph between Effective stress and diameter/speed at constant friction 0.3

4.4.EFFECT OF ROLLER DIAMETER ON EFFECTIVE STRAIN

Figure 7 shows decreasing trend in effective strain. In first case it is high and at case six it is low as shown in figure.

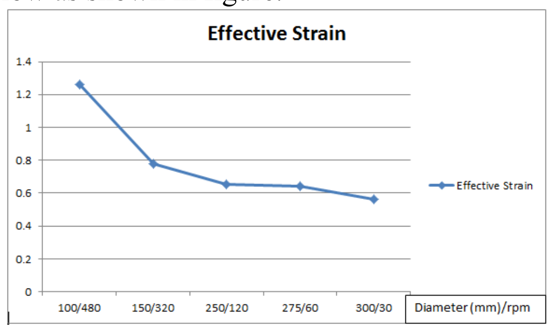

Fig 7 graph between Effective strain and diameter/speed at constant friction 0.3

4.5.EFFECT OF ROLLER DIAMETER ON SHEAR STRESS

Shear stress effects on deformation. Figure 8 shows shear stress. The shear stress is maximum in first case and decreased in sixth case.

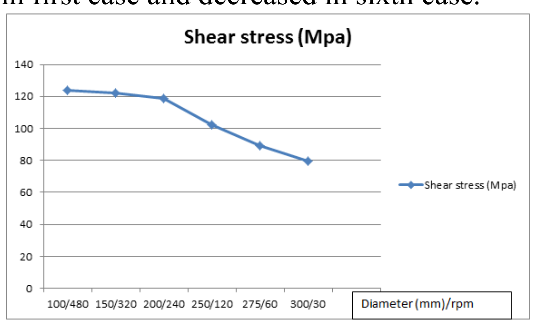

Fig 8 graph between Shear stress and diameter/speed at constant friction 0.3

4.6.EFFECT OF ROLLER DIAMETER ON HARDNESS

As the speed has effect on rolling force the decrease in speed reduces the rolling force [1] and meanwhile the stresses. As the six cases are studied the hardness of material is decreased to some extent from case one to case four and then is remained 192 ±0.4 kgf/mm² for the next cases. Figure 9 graphically represents the hardness variation.

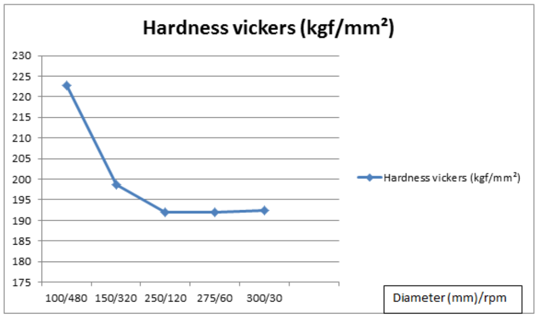

Fig 9 graph between hardness and diameter/speed at constant friction 0.3

As the roller diameter increases there is larger arc of contact between roll and material and hence roller diameter also has effect on rolling force and hence hardness remained constant after fourth case. As per the AZO materials [10] the hardness of AISI_1055 is 207kgf/mm². In first case the hardness is high as 222.8kgf/mm²and in fourth case it is 192kgf/mm² and in fifth and sixth cases the hardness is 191.9kgf/mm² and 192.4kgf/mm² respectively.

5. EFFECT OF ROLLER DIAMETER AND SPEED ON VARIOUS PARAMETERS

Several cases are analysed as listed below in the table 3. The table shows the derived Von Mises stress, Effective stress, Effective strain, Rolling pressure and Shear stress. Data shows the gradual decrement from case 1 to case 6.

case	Diameter (mm)	Speed (rpm)	Von mises stress (MPa)	Effective strain	Effective stress (MPa)	Pressure (MPa)	Shear stress (MPa)	Hardness Vickers (kgf/mm²)
1	**100**	**480**	200	1.26	211.2	480.5	124	222.8
2	**150**	**320**	177.4	0..78	198.3	410	122	198.6
3	**200**	**240**	167.4	1.212	204	378	119.8	220
4	**250**	**120**	148.5	0.6509	172.6	354	102.2	192.4
5	**275**	**60**	145.8	0.64	152.7	275.2	89	191.9
6	**300**	**30**	139.5	0.5642	136	240.1	79.7	192.4

Table 3 analysed data at each case

6. CONCLUSIONS

1. The pressure affects the properties such as ductility, yield stress of metal and hence the formability.
2. There is decreasing trend in Von Mises stresses as the roll diameter is increased and this helps roll capacity to take more loads.
3. As the speed decreases hardness also decreases and hence roll diameter is increased the hardness remains constant after some decrement.
4. Using larger diameter rolls over lower speed properties such as Shear stress, Effective stress and Effective strain can be reduced.

7. REFERENCES

[1]. A.R. Shahania,S. Setayeshib, S.A. Nodamaiea, M.A. Asadic, S. Rezaiec “Prediction of influence parameters on the hot rolling process using finite element method and neural network”. Journal of materials processing technology 2 0 9 (2 0 0 9) 1920–1935.

[2].Mahdi Bagheripoor*, HoseinBisadi “Effects of rolling parameters on temperature distribution in the hot rolling of Aluminum strips”. Applied Thermal Engineering 31 (2011) 1556e1565.

[3]. K. Devarajan, K. PrakashMarimuthu and Dr.Ajith Ramesh “FEM Analysis of Effect of Rolling Parameters on Cold Rolling Process”. Bonfring International Journal of Industrial Engineering and Management Science, Vol. 2, No. 1, March 2012.

[4]. A K Tieu, Z Y Jiang, C Lu "A 3D finite element analysis of the hot rolling of strip with lubrication" Journal of Material Processing Technology 125-126 (2002) 638-644.

[5]. Akira Azushima, Yoshifumi Nakata, Takahiro Toriumi "Prediction of effect of rolling speed on coefficient of friction in hot sheet rolling of steel using sliding rolling tribo-simulator". Journal of Materials Processing Technology 210 (2010) 110–115.

[6]. Santosh Kumar, Prof.Bharat S Kodli "A Study on Thermo-Mechanical Analysis of Hot Rolling & Estimation of Residual Stresses by using FEM". IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 9, Issue 3 (Sep. - Oct. 2013), PP 26-34.

[7] www.afdex.com

[8] Dr. P.L Srinivasa Murthy, Hemant Patil, B.N.Sarada "ANALYSIS OF ROLLER SPEED AND ROLLER DIAMETER- A REVIEW" (IJAER) 2016, Vol.No.11,Issue No. II, February e-ISSN: 2231-5152/ p-ISSN: 2454-1796.

[9] Hemanth S Thulasi, Y. Arunkumar, M.S.Srinat "Design and Manufacturing Simulation of Preform for Thread Rolling Operation". International Of Modern Engineering Research (IJMER) Vol. 5 | Iss. 10 | October 2015 | 60|

[10] www.azom.com

[11] Licheng Yang, Jinchen Ji, Jingxiang Hu, A. Romagos. "Effect of process parameters on mechanical behavior in hot-slab rolling" ISSN 1392 - 1207. MECHANIKA 2011. 17(5): 474-479.

[12] S. Ghosh, M Li, D. Gardiner. "A computational and experimental study of cold rolling and Aluminium alloys with edge cracking". Vol. 126, FEBRUARY 2004.