To Design a Mechanism for Improvement of Productivity of Hot Rolling Process

[1]Anugya Patil Giri, [2]Prof. S.M Awtade

[1]Student, [2]Professor
RTM Nagpur University: Mechanical engineering,
Priyadarshini College of engineering, Nagpur, India

***Abstract*: Field data-based modelling concepts were found very useful and can be applied to any complex construction activity because the observations for the variables are obtained directly from the work place. Relevant variables and data include worker anthropometrics, environmental conditions, tools used and their geometry, layout of work stations and material properties. Modelling and proper analysis can suggest a correct method for performing such activities and making changes to tool geometry, tool materials, work station layouts and so on will improve Productivity and construction ergonomics and reduce losses of materials and losses due to errors in construction work.**

It is suggested that, for countries where the construction work involves intensive manual labour, each component of construction activity should be analysed by creating fdbm models. A new method of performing work can be developed for all types of infrastructure construction; it has been observed that the non-availability of construction workers leads to delays of major projects; therefore, ergonomic construction is in need for the present scenario.

I. Introduction

Rolling is a bulk deformation process in which the thickness of the work is reduced by compressive forces exerted by two opposing rolls. The rolls rotate to pull and simultaneously squeeze the work between them.
The process of shaping metals into semi-finished or finished forms by passing between rollers is called rolling. Rolling is the most widely used metal forming process. It is employed to convert metal ingots to simple stock members like blooms, billets, slabs, sheets, plates, strips etc.
In rolling, the metal is plastically deformed by passing it between rollers rotating in opposite direction. The main objective of rolling is to decrease the thickness of the metal. Ordinarily, there is negligible increase in width, so that the decrease in thickness results in an increase in length.
The products of hot rolling mills are either semi-finished, i.e. Hot rolled sheet, billets, rods, or finished (i.e. Sections, round and flat bar, plates). Due to the complex product geometries, there are many different types of rolling process. The following are some of them:- (1) . Flat rolling (strips, sheets and plates) (ii). Profile rolling (shapes) (iii). Ring rolling (iv). Powder rolling (v) . Electric resistance rolling

Reason for the selection of present work:

Rolling mill is considered to be the corner stone for the industrial development .there are two basic classification of rolling mills namely hot and cold rolling mill. The operation which are to be performed in cold rolling mill are less complex and less tedious as compared rolling mill.it is spectuated the hot rolling mill are further classified as: 1.automatic 2.semi-automatic 3.partial automatic.
Most of rolling mill are running partial automation where human interaction is at its culmination level .on the flip-side ,the industries are facing with its production rate issue and profitability with optimum resources.

Rolling mills are generally classified according to their product or their layout or temperature And are specified by the number of rolls in each stand. According to the basis of number of Rolls, stand may be termed as two-high, three-high, four-high, twelve-high or twenty-high mills Having six or more rolls are generally termed as cluster mills. The purpose of rolling is to convert Material of large cross-sections into smaller sections of various shapes. This deformation is Accomplished by applying compressive force through a set of rolls.

Literature review:

There are three zones in rolling process. These are backward or lagging zone, neutral zone, forward or leading zone. Deformation is the change in dimensions or form under the action of applied forces. Deformation is caused either by mechanical action of external forces or by various physical and physiochemical process. The process of deformation comprises the elastic deformation, plastic deformation, and fracture. The plastic deformation of metal may occur by slip. Plastic deformation of metal is the basic concept used for rolling process commonly used for manufacturing of materials where smallest part are called crystal grain that has uniform properties. However, the research out puts on this area is limited. Some of the researches' outputs in relation to the objective of this thesis are:
v. Yadav1, a.k. Singh2 and u.s. Dixit3[31] in this work, the material parameters for power law and coefficient of friction are obtained using inverse analysis by measuring exit strip temperature and slip. The procedure makes use of finite element model for

deformation and an analytical method for the estimation of temperature. A heuristic optimization algorithm is used for this purpose that minimizes the error between the measured and estimated flow stresses. The method is verified by conducting some numerical experiments. Less than 1% error is observed. A methodology of yadav et al. (2013) has been employed to obtain the average temperature of both roll and strip at the interface. In this work, two sub-modules are used for obtaining the temperature distribution. One sub-module finds the temperature distribution in the strip when the heat generation due to plastic deformation and due to friction is known. The other sub-module estimates the temperature distribution in rolls, when the heat transfer through the roll-strip interface is known.
Rudolf pernis, j. Kasala [32] the main aim of the present paper is the distribution of relative deformation in rolling zone; due to the fact that relative deformation along the length of contact arc is changed. Mathematical analysis of the distribution of relative deformation covers elliptic distribution. Average value of relative deformation in rolling zone was obtained as integral value which more accurately describes total quantity of deformation.

s m byon , s i kim and y lee [35] this documents basically concerning about, a laboratory-scale hot-plate rolling experiment, together with three-dimensional finite element analysis coupled with the proposed model. It has been performed to investigate the accuracy of the proposed constitutive model. A large-deformation constitutive model applicable to the calculation of roll force and torque in heavy-reduction rolling has been presented. The finite element predictions of roll force based on the proposed model and the experimental results was shown to be in fair agreement whereas those based on the misaka–yoshimoto model, in which dynamic recrystallization was not considered, failed to predict the roll force precisely at heavy reduction.

Valentin nikolayevich danchenko [36] this paper presented, the fundamentals of plastic deformation of ferrous metals, non-ferrous metals and alloys. The deformation is conducted in heated state for decreasing the strain resistance and increasing the plasticity of the worked metal. The rise in temperature no higher than (0.3-0.4)тf (тf – the metal fusion temperature in absolute scale, ºk) doesn't bring the structure changes to the metal, but the acceleration of diffusion processes contributes to the healing of structure defects and drop of inner stresses in metal. At temperatures of heating higher than 0.4тf the process of grain recovery takes place in the metal.

Kristina nordén [12]the main aim of the present paper is the evolution and reduction of cracks during shape rolling is studied in this thesis. To accomplish this, artificial longitudinal cracks are machined along bars of high speed steel. The cracks are positioned at different sites evenly distributed along the periphery in intervals of 45°. Some of the cracks are left open and some are filled with carbon or stainless steel welds. Fe simulations are performed using the commercial and the results from the simulations are compared with experimental ones. Generally, simulations predict less reduction

Theoretical framework

Table i. List of process variables

Sr.no.	Name of variable	Symbol	Dimensions
1	Anthropometric dimensions Ratio of worker	A	$M^0 l^0 t^0$
2	Height of worker	H	$M^0 l^1 t^0$
3	Age of worker	Ag	$M^0 l^0 t^1$
4	Weight of worker	W	$M^1 l^0 t^0$
5	Shoulder height o worker	Sh	$M^0 l^1 t^0$
6	Elbow height of worker	Eh	$M^0 l^1 t^0$
7	Forward reach of worker	Fr	$M^0 l^1 t^0$
8	Upper reach of worker	Ur	$M^0 l^1 t^0$
9	Hip height of worker	Hh	$M^0 l^1 t^0$
10	Height of worksurface	Hw	$M^0 l^1 t^0$
11	Width of work surface	Ww	$M^0 l^1 t^0$
12	Depth of worksurface	Dw	$M^0 l^1 t^0$
13	Height of stack	Hs	$M^0 l^1 t^0$
14	Width of stack	Ws	$M^0 l^1 t^0$
15	Depth of stack	Ds	$M^0 l^1 t^0$
16	Length of raw workpiece	Lr	$M^0 l^1 t^0$
17	Width of raw workpiece	Wr	$M^0 l^1 t^0$

18	Thickness of raw workpiece	Tr	$M^0 l^1 t^0$
19	Hardness of workpiece	Bhn	$M^0 l^0 t^0$
20	Compressive strength of the Workpiece material	Sc	$M^1 l^{-1} t^{-2}$
21	Weight of raw workpiece	Wr	$M^1 l^0 t^0$
22	Weight of tool	Wt	$M^0 l^0 t^0$
23	Force applied by tool	Ft	$M^1 l^1 t^{-2}$
24	Length of tool	Lt	$M^0 l^1 t^0$
25	Width of tool	Wt	$M^0 l^1 t^0$
26	Thickness of tool	Tt	$M^0 l^1 t^0$
27	Atmospheric temperature	Tatm	$M^0 l^0 t^0$
28	Humidity	Ø	$M^0 l^0 t^0$
29	Wind speed	Vf	$M^0 l^1 t^{-1}$
30	Light intensity	Lux	$M^0 l^0 t^0$
31	Sound intensity	Db	$M^0 l^0 t^0$
32	Initial pulse rate of worker	Pi	$M^0 l^0 t^0$
33	Final pulse rate of worker	Pf	$M^0 l^0 t^0$
34	Human energy input	Y	$M^1 l^2 t^{-2}$
35	Duration	T	$M^0 l^0 t^1$

for determining the indices of the relation between output and inputs multiple regressions and matlab software can be used

Model is represented by equation (1)

$$\Pi_6 = k \times \pi_1^a \times \pi_2^b \times \pi_3^c \times \pi_4^d \times \pi_5^e \qquad (1)$$

There are six unknown terms in the equation (1) curve fitting constant k and indices a, b, c, d, e. To get the values of these unknowns we need minimum a set of five set of all unknown dimensionless pi terms.

Consider the following relation

$$Z = a + bx + cy \qquad (2)$$

equation (2) represents equation of a curve fitting technique.

Equation (1) can be brought in the form of equation (2) as follows.

Taking log on both side of equation (1)

$$\text{Log}\pi_6 = \log k \times a\log\pi_1 \times b\log \pi_2 \times c\log\pi_3 \times d\log \pi_4 \times e\log \pi_5 \qquad (3)$$

Let, z = log π_6, k = log k, a = log π_1, b = log π_2, c =log Π_3, d = log π_4, e = log π_5,

Equation (3) become

$$Z=k+a\times a+b\times b+c\times c+d\times d+e\times e \qquad (4)$$

Equation (4) is a regression equation of z on a, b, c, d and e in a dimensional co-ordinate system

Again equation (4) is written as

$$Z = n\times k + a\times\sigma a+b\times\sigma b+c\times\sigma c+d\times\sigma d+e\times\sigma e \qquad (5)$$

$$\Sigma za = k\,\sigma\, a+a\times\sigma a\times a+b\times\sigma b\times a+c\times\sigma c\times a+ D\times\sigma d\times a+e\times\sigma e\times a \qquad (6)$$

$$\Sigma zb = k\,\sigma\, b+a\times\sigma a\times b+b\times\sigma b\times b+c\times\sigma c\times b+ D\times\sigma d\times b+e\times\sigma e\times b \qquad (7)$$

$\Sigma zc = k\ \sigma\ c + a \times \sigma a \times c + b \times \sigma b \times c + c \times \sigma c \times c + D\ \times \sigma d \times c + e \times \sigma e \times c$ (8)

$\Sigma zd = k\ \sigma\ d + a \times \sigma a \times d + b \times \sigma b \times d + c \times \sigma c \times d + D\ \times \sigma d \times d + e \times \sigma e \times d$ (9)

$\Sigma ze = k\ \sigma\ e + a \times \sigma a \times e + b \times \sigma b \times e\ c \times \sigma c \times e + D\ \times \sigma d \times e + e \times \sigma e \times e$ (10)

In the above set of equations the values of the multipliers k,a,b,c,d,e are substituted to compute the values of a, b, c, d and e. After substituting these values in the equations one will get a set of five equations, which are mutinously to get the values of k , a, b, c, d and e .the above equations can be verified in the matrix form and further values of k , a, b, c, d and e can be obtained by using matrix analysis .

Pi terms related to anthropometric data	Π1	((a1×w1×ag1)/(a2×w2×ag2)) × ((a1×w1×ag1)/(a3×w3×ag3)) × ((a2×w2×ag2)/(a3×w3×ag3))
Pi terms of workstation	Π2	(hw×ww×dw)/(hs×ws×ds)
Pi terms of workpiece material	Π3	(hn×lr×wr×tr×sy)/(ft×wt)
Pi terms of tool used	Π4	(lt×wt)/(tt×wr)
Pi terms of environmental Factors	Π5	(ø×tatm×vf×db)/(lux×g×t)

Research methodology

The canvas of the total work is detailed as under:

1.the work will start with –a literature review and further field visit .in the present case the field are prominent because it would be an eye opener segment for the candidate to enhance his canvas of his research.

2.study of operation which are prominent in rolling mill as the aim to improve the existing process.

3.ascertain the variables of causes and effects for prominent operations and preparations of probable plan for gathering of data.

4.collection of field data considering the causes and effects of the operations which is to be considered as a phenomena .

5.establishment of empirical relationship between the causes and effects of operation applying the concept of multiple regression analysis.

6.the established empirical models will be proceed for quantitive and qualitative analyses.

Research objective

1.to know the failure phenomenon of hot rolling rollers .

2.to minimize time duration.

3.to increase productivity.

Research gap identification

In survey, the scrupulous observation are explored that are detailed out as below:
1.some rolling mill operations are more hectic and tedious.
2.there is a continuous interaction between man and machine system .

3.the value of environment parameters are at its extreme levels.
4.the postures acquired by worker during the operation are not appropriate .
5.the handling mechanisms provided to the workers are not ergonomically designed .
6.continous interaction with hot environment revels the skin problem to worker.

Iv. Results and discussion

High productivity improvement in hot rolling mill**:**

1.conventional productivity improvement method :

The bottlenecks of the efficiency of a hot mill are mainly :
1.reheating furnances heating capabilities .
2. Slow roughing mill pacing for avoiding the material collision .
3. Slow rolling speed of f-mill train .
4.down coiler handling loss time .
5. Coil conveyor transfer speed .

Each equipment capability should be decided according to the product mix of every plant .
For example,if its major strip is thin and narrow ,fisher man motor speed may be faster and rolling torque may lower .
In this case ,fisher mill rolling speed is usually still bottleneck and reheating furnance capability may be comparatively small.
In every case ,the bottleneck process will be changed to conveyor in case rolling short slab and small coil production .
Conventional rolling efficiency improvement plan is implemented as follows,
1.analyse the bottleneck process .
2.establish the hardware capacity enhancement plan
3. Estimate the benefit after hardware enhancement .

Thus the conventional productivity improvement activity has been focused on the enhancement of hardware equipment capability .
2. In 21th centuly improvement method in productivity:

2.1 present data analysis
Analysis data shows ,bottleneck process is reheating furnance when er roll over 4 feet width material and the finisher is the bottleneck process under 4 feet width material .
Conventional bottleneck ratio in each process is 22% conveyor ,39% furnance ,37% finisher and 2% other .

2.2 strattergy :improvement of reheating furnance capability
The strattergy ,heating capability enhancement ,was set and considered as the most important improvement activity .
First task was to re define the mission of reheating furnance in hot mill .
Problem institution –extraction target temperature ,
Taking a lesson from the past –unitary management by consistent temperature tracking .

2.3 rougher mill temperature tracking system
The structure of consistent temperature tracking system is simple ,it solves heat transfer equation by air and water at surface and solves internal heat conduction equation related to the direction of a section .

2.4 extract target temperature
Extract target temperature is given as sufficient condition for extraction .
Namely ,it is considered altogether that reheating furnance control is a success ,when extraction temperature exceeds extract temperature .

2.5 reheating furnance temperature tracking
The pyrometer is not used for estimation of the slab temperature in reheating furnance .
Slab temperature in reheating furnance calculates by reheating furnance temperature tracking system started from the entry table pyrometer .
There are 4 reheating furnances and every 2 furnances are different in type ,
Two of them have axial flow burners installed in noise ceiling ,and others have
Re-generative burners installed side of them and without axial flow burners .
So heating history of the slab inserted to reheating furnances have re-generative burners .

2.6 reheating furnance control
Reheating furnance control system sets furnance gas temperature to become slab temperature should be extract target temperature at a time predicted it should be extracted .

Our furnance control system receives predicted extract time from mill pacing system and extract target temperature form the consistent temperature tracking system when slab inserted to the reheating furnances .

2.7 heating assistance by bar heater

In fukuyama ,the whole rougher bar heating device (bar heater) was introduced prior to the world in 1998 .
Bar heater can raise the temperature at the entry of f-mill train about a maximum of 30 degree .when this is converted into extraction temperature ,it is equivalent to about 50 degrees .
Extraction target temperature differs every slab at a time by the method of calculating extraction target temperature on-line for every slab.
Bar heater lessens change of the extract target temperature of one slab is especially high, the phenomena in which the extract temperature of other slabs will go up unavoidable can be avoided ,and average extraction temperature can be lowered .
It is usefull to fuel cost saving of a reheating furnance to be lower average extraction temperature ,and when the reheating furnance is a bottleneck ,heating capability can be compensated with bar heater and it can contribute to the improvement in rolling efficiency .

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By doing this project we got enriched with many information which can help us in our future .

References

[1] J.p.modak, k.s. Zakiuddin, “mathematical modeling and simulation of field data based model for civil activity,” international journal of scientific & engineering research, volume 3, issue 3, march-2012.
[2] h.schenck jr., theories of engineering experimentation, mcgraw hill book co, new york.
[3] 3.manish bhadke,dr. K.s zakiuddin “formulation of field data based model for productivity improvement of an enterprise manufacturing tractor axle assembly :an ergonomic approach “proceedings of the 1st
[4] International and 16 th national conference on machines and mechanisms (incomm 2013), iit roorkee, india, dec 18202013
[5] 4. Prof.v.s.shende, prof. P. S. Borkar, prof. S.v. Sontakke , prof. N. G. Mahalle "an analysis of internal
[6] Oil cooled induction motor" international journal of innovative research in science, engineering and technology vol. 6, issue 4. April 2017.