THE EFFECTIVENESS OF ROLLING PROCESS-A CASE STUDY

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ABSTRACT

Hot rolling is the process that converts cast ingots or semi finished steel into finished product. Since the rolling operation is very costly and many preceding processes also involve considerable cost, the rejection of hot rolled products involves significant loss and hence strict quality control of rolling process is essential to avoid rejects. One of the quality control concepts is the “internal customer concept” within the industry wherein each step of processing (department) is the customer of its previous processing unit. The voice of customer receives due importance in production flow and in turn, maintaining the quality of intermediate semi-finished ‘products’. The regular interaction between different units of a factory helps to resolve the quality problems encountered in different operations as at each operational unit, the quality of input material is checked vis a vis specifications. This practice leads to a minimum reject at final stage and thus improves economy. As a proof of concept, a case study of Magnum steels , Banmore in Madhya Pradesh is presented in this paper.

Keyword: Internal customer, external customer, cause and effect diagram, Pareto’s analysis.

1. INTRODUCTION:

Due to economic globalization, Indian industries are facing severe competition from foreign competitors on account of quality of the product and its cost. To succeed in this environment the industry must improve the quality of finished product and productivity. The economy in the process of production strongly depends on reducing the generation of scrap and waste in addition to optimizing energy consumption and restricting environmental costs within limits. The quality of the final product, in turn, depends on the quality of intermediate (semi finished) products. Hence there Is an urgent need from steel industry for effective process control in the flow of production [1].

In the preset paper, a case study is presented on the effect of "voice of internal customer" for improving the quality of finished product in steel industry, dealing with hot rolling process [2,3].

The internal customer ship in the hot rolling steel industry is divided among the different steps of the whole process viz., the rolling mill is the customer of reheat furnace shop, the reheat shop is the customer of foundry. Any shortcoming observed by the customer in its input product is immediately conveyed to internal supplier, the cause of defect is identified and necessary action is taken by the "internal supplier" so that the further rejections do not occur. This saves lots of money and avoiding processing of defective raw material leads to production of higher quantity of high quality product which in turn will also satisfy the outside customer [4].

1.1. Hot Rolling

Rolling is a process where the metal is compressed between two rotating rolls for reducing its cross sectional area. Because of higher productivity and comparatively lower cost, the hot rolling process is most widely used (accounts for about 90% of all metal produced) in steel industry [5, 6]. The process was first developed in the late 1500's for producing flat products like plates or sheets. It produces products which have a constant cross section throughout its length. At present the process is used to manufacture product shapes such as plate, girder, T, L and channel sections are easily produced by hot rolling.

At elevated temperatures of hot rolling, the coarse grained brittle and porous structure of the metal in the ingot, or the continuously cast metal is converted into a wrought structure having finer grain size and improved properties.

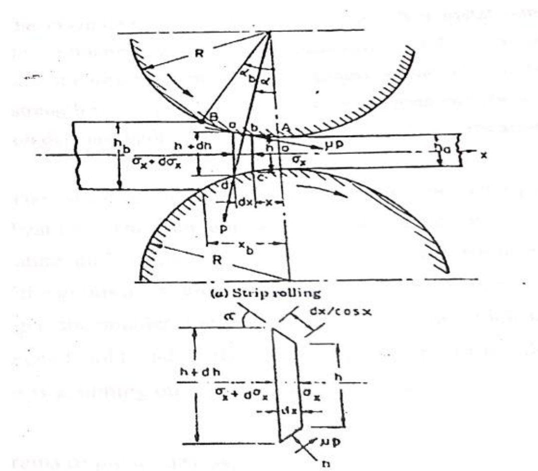


Fig. Strip Rolling

1.2. Zones In The Rolling Process :

There are three zones in rolling process. These are:

Backward or Lagging zone: In this zone the velocity (Vb) of the strip at entry point is lower than the linear velocity of the roll (Vr) and the backward slip is given by -

$$\frac{Vr-Vb}{Vr} \times 100 \quad \text{............ (i)}$$

Neutral zone: In this zone the velocity of the roll is equal to the velocity of the strip and consequently the slip is zero.

Forward or leading zone: In this zone the velocity of the roll is lower than the velocity of the strip at the exit (Vs). The forward slip, is given by

$$\frac{Va - Vr}{Vr} \times 100 \quad \text{............... (ii)}$$

1.3. Plastic Deformation of Metal

Plastic deformation of metal is the basic concept used in the rolling process. The smallest part which has uniform properties in a metal is called crystal grain. The dimensions of the grain are usually between 0.1 to 0.01 mm and distance between the atoms in the lattice is of the order of 10^{-8} cm. A metal with very fine grains has in general a higher strength than the same metal with a coarse granular structure. In engineering construction, high purity metallic elements are seldom used and by addition of very little amount of additives, the strength of the metal increases due to grain refining. The cooling rate also has an effect on grain size and in turn the strength of the metal [7,8,9]. The magnitude of the forces under which a metal will yield plastically or fracture, depends on its composition and crystal structure. The absolute size of the grains can be changed by re-crystallization. The amount of existing cold deformation and the temperature & duration of reheating during re crystallization process determine the absolute size of the grains. As a rule re-crystallized grains are larger. The different types of structures observed in grain boundaries are :

(I) Lamellar i.e. needle type (II) Spherodized i.e. globules type and (iii) Dendrites i.e., branches of a tree type

The crystal structure of steel may be either (a) Body centered cubic (BCC) or

Face centered cubic (FCC)

Stresses higher than the elastic limit cause plastic deformation. Plastic deformation is associated with displacements of the atoms within the grains and causes permanent changes in shape of the specimen. The plastic deformation may occur due to slip, formation of twin, deviation of atoms from regular position.

1.4. Re-Crystallization, And Grain Growth

In re-crystallization process, new equi axed and strain free grains are developed, replacing the older grains at re-crystallization temperature which results in a decrease in the density of dislocations, lowering of strength and increased ductility. The changes occurring in crystal structure during hot rolling followed by re-crystallization are shown in the Figure-1 below.

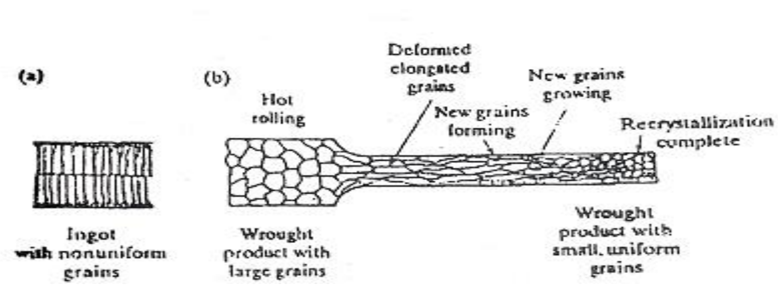


Fig. 1 re-crystallization

2. LITERATURE SURVEY

Nong Jin and hiyu Zhon [5] used multi level regression to study the effect of process variables during hot rolling on number of surface defects. Chakraborti, Siva Kumar, Satush Babu, Moitra and Mukhopadhyay [6], using variants of Genetic Algorithms studied surface profile of hot rolled slabs in terms of 'crown' a major parameter related to their geometric tolerance. Two different models are presented and simulations in a multi objective mode are carried out to generate the relevant Pareto fronts, which in turn are tested against the operational data of a steel plant [10].

Tarno Polskaya, Gates and Hoog [12] proposed a model and numerical algorithm for the analysis of lateral movement of a metal strip during cold rolling process. The model includes a simplified description of physical process responsible for strip lateral movement and plastic deformation of the strip and dynamics of strips outside the plastic reduction region. The paper by Saroj Biswas, Shih Chen and Satyanarayana [9] describes the development of a control system for tackling temperature time profile in cooling processes in hot rolling of steel. The control of temperature during cooling is essential for achieving desired mechanical, and metallurgical properties in steel. The cooling process is represented by the heat equation, in Lagrangian coordinate, which is approximated by a set of ordinary differential equations. The control variable is the velocity of coolant water flow through a jet. Gamkerlidze minimum principal is used to determine the optimal jet velocity for the desired temperature tracking.

3. METHODOLOGY

The company under case study possessed ISO 9000 certificate, which mentioned the specified control parameters during production and testing along with the details training of employees and record keeping of defects etc. under ISO 9000 certification , we can decide internal and external customer who uses semi finished product and finished product of the company. At every step of the process flow, the producer has to put its best efforts to minimize defect and improve the quality of the product. This is possible only when each of the internal customers of the flow remains satisfied with the unfinished product, which in turn they receive from previous process. . The internal customer is decided by process flow chart. If all the internal customers are satisfied, final product will be as per defined specifications and of good quality, which is the requirement of the external customer.

3.1. Basic Problem Solving Techniques

The different basic problem solving techniques are equipped with quality tools used for data analysis. Every technique has its own merits and demerits, the members of quality control team are trained in the application of these techniques. The following are more commonly used techniques [4]:

(i) Brain storming, (ii) Pareto diagram (iii) Cause and effect diagram and (iv) Data collection analysis . The tools used for data analysis are [4], the representation of the data in Tables, Bar charts, Histogram, Pie chart, Line graph/Scatter graph etc.

3.2. Raw Materials:

The raw materials used in this industry during hot rolling are ingots, billets etc. The annual requirement at full capacity utilization was approximately 36000MT. The main suppliers of the raw materials were M/s Deluxe alloy Ltd, M/s Vibha steel Ltd. Located in near proximity of the plant although some raw material was also procured from SAIL, TISCO and some scrap was obtained from local market [11].

For energy needs, furnace oil and LPG was used. Oxygen Cylinders were procured from local market and electricity was received through a 132/133 KV substation.

Table1: Specifications and Chemical Composition of Raw Materials

S No.	Grade	Reference Standard No.	C %	Mn %	S %	P %	Si %	Cr %	V %
1	55Si17	IS3431 -1992	0.5-0.6	0.8-1	0.045	0.045	1.5-2	-	-
2	60Si65S177	-do-	0.55-0.65	-do-	-do-	-do-	-do-	-	-
3	65Si17	-do-	0.6-0.7	-do-	-do-	-do-	-do-	-	-
4	50Cr4V2	-do-	0.45-0.55	-do-	-do-	-do-	-do-	0.9-1.2	0.15-0.3
5	60Cr4V2	-do-	0.6-0.68	-do-	-do-	-do-	-do-	-	0.15
6	65Si17	SS9020A	0.55-0.65	-do-	-do-	-do-	1.5-1.8	-	-
7	EN45A	BS970	0.32-0.4	1.3-1.7	0.05	0.5	1.7-2	-	-
8	EN15	-do-	0.40-0.45	0.7-0.9	0.04	0.04	0.15-0.35	-	-
9	EN8	-do-	0.95-1.1	0.25-0.45	0.06	0.06	-do-	-	-
10	SAE52100	SAE	0.55-0.65	0.7-1	0.035	0.035	0.25	1.3-1.6	-

Table 2: Description of Rolling Mill, Furnace Crane etc.

1 . Size of rolling mill	A . 400 mm (16") Roughing Mill. B . 250 mm (10") Finishing Mill
2. No. of Stands	One roughing and six finishing stands
3. Speed of rolling	180 RPM finishing
4. Reheating Furnace	Double zone Pusher Type
	Dimension : 17000 X 1600 X1700 mm
	Capacity : 5 MT/hr
	Temperature of Furnace : Soaking zone : 1150 C Heating zone : 900 C
	Length of soaking zone : 5 meters
	Number of Burners/blowers 4 of 125 KW
Cooling Bed Size	2200 cm x 30 cm
Crane	One EOT of 2 MT capacity.

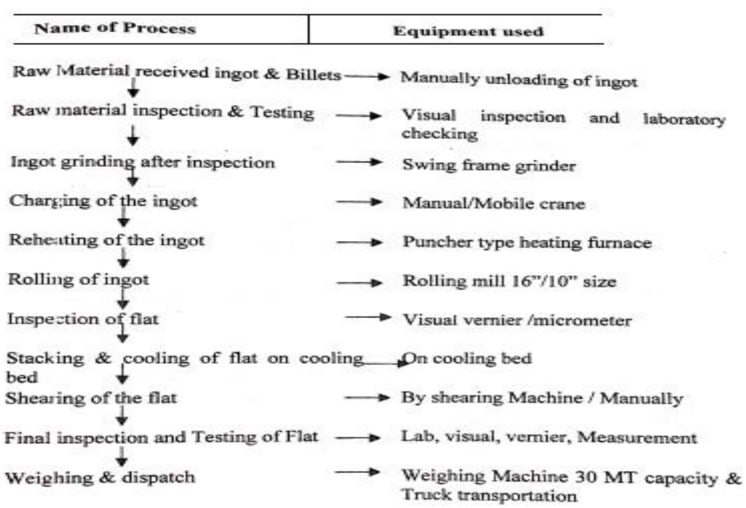


Fig 2: Process Flow Chart

Table 3 Melting Report for Month (Rolling mill section 20"*16"

Name of the Unit	Production	Quantity	Ingot Size	Defect %
Vibha	Sup 11 A	707x140 Kg	4.5"x5.5"	Melting scrap 7.9 MT- 7.35% Defect short length 6.0 MT- 6.1% OK short length5.5MT - 5.6%
	65Si7	2553x140 Kg 357.420 MT 1428x100 Kg 142.800 MT **500.220MT**	4.5"x5.5" 3.5"x4.5"	Melting scrap 38.8MT – 6.18% Defected short length 25MT - 6.1% OK short length 25 MT – 5%

Table 4 : Defects in the Section (sup 11A)

Sl. No.	Location	Defect %
1.	Seam	20%
2.	Piping	14%
3.	Refractory	6%
4.	Lapping	NIL
5.	Rolling Dent	2%
6	Roll Mark	5%
7.	End Cutting	8%

4. DATA ANALYSIS.

4.1. Pareto Analysis

Pareto analysis reveals that seam, piping, and refractory, end cutting defects are more , they should have to be taken care for improvement in the quality and ultimately,process effectiveness can be established.

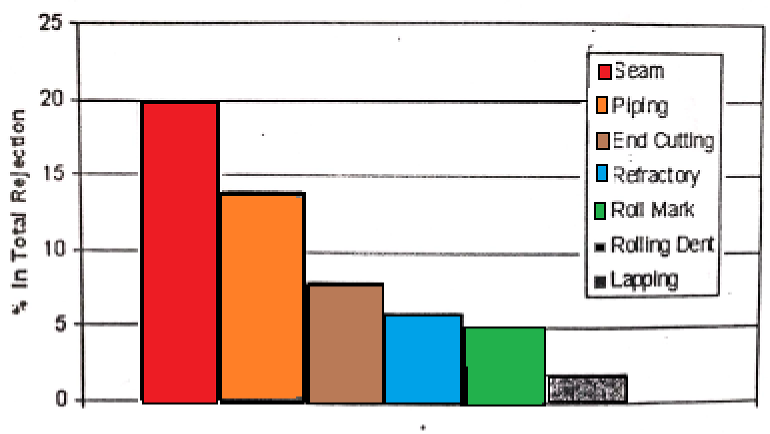


Fig 3 Pareto Analysis

4.2. Cause and effect diagram.

The cause effect diagrams are presented in figure 4 (a) , (b) & (c) for the piping defect, seam defect, and refectory defect respectively.

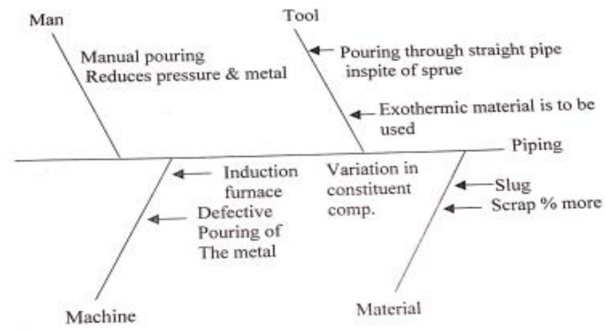


Fig. Cause – effect diagram for (Piping Defect)

(a)

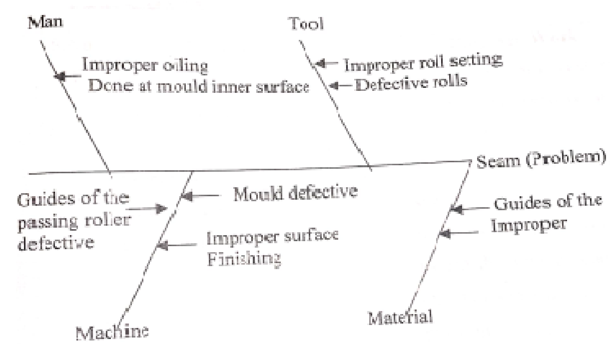
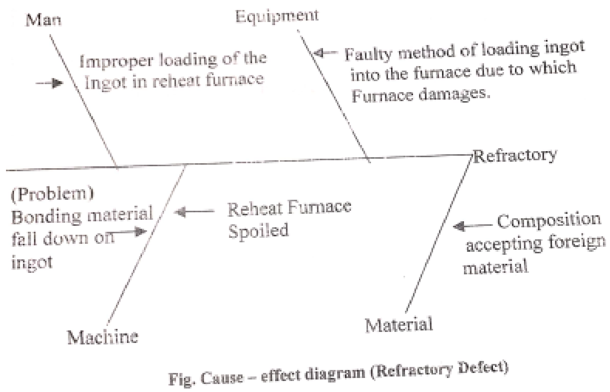


Fig. Cause – effect diagram (Seam Defect)

(b)



(c)

Fig. 4 Cause and effect diagram.

4.3. Evaluation

Present Work	Proposed Work
Processes are carried out without much attention paid on them.	Internal customer ship scenario is to be imposed process-wise.
Defects analysis was not done very rigorously. Hence heavy rejection is observed.	Applying recommended statistical quality control tools like brain storming, Pareto's diagram & cause and effect diagram to correct the problem and minimize defect level.
Unskilled contractor labors are at many places employed.	Skilled labors are needed at main processes.
Manual labors are employed more at various places.	Atomization is possible. To be considered

4.4. Suggested Remedial Actions:

1. Workers take time out for 5 minutes after one hour work. In a shift, each worker thus takes 40 minutes break, which in production equivalence is loss of 3.5 T/shift Provision of drinking water at work site may minimize this loss.

2. Training is to be provided to supervisors as well as workers for their skilling and betterment

3. Roll surfaces can be better maintained by polishing roll mill with oil stone in the running condition of mill. Also roll reconditioning is to be done only one or two times and afterwards roll to be discarded.

4. Roll of the mill to be checked regularly.

5. Furnace capacity is low and needs to be increased.

6. Molten metal poured through plain pipe. It should be replaced by spruce so that momentum of the molten metal can be maintained and entrapped gases may be minimized.

7. Manual pouring is to be replaced by automatic arrangement, so that uniform pouring pressure can be maintained.

8. Exothermic material is to be use at mould face so that end defect on ingot can be minimized.

9. Stainless steel grate may be used to avoid slug inclusion in the metal, this way slug can be trapped on grate and can be separate out

10. Automation, energy audit and labor time management may go a long way in improving productivity.

5. CONCLUSION:.

The concept of internal customer ship was found to work well for improving the quality of semi-finished products at different steps of processing. It helped to reduce rejection of final product and enhanced acceptance in the market.

During the process different defects occur due to failure in methods/man/material/machine/etc. The analysis by cause and effect diagram helps to identify the defect as well as their root cause.

There is still some scope for improvement in productivity by incorporating automation and carrying out energy and manpower audit.

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