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Study and Minimization of Surface Defects on Bars and Wire Rod Originated in Continuous Cast Billets

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Abstract: *In order to minimize surface defects in long products, their origin needs to be assessed .To this purpose a methodology was developed, that includes metallographic studies on bars and wire rod using several reagents. A description is made of the different steps involved in this method, including the use of etchants to determine the former position of the defect in the billet, it is also discussed the interpretation given to internal oxidation, scale inside the defect, decarburization, and other metallographic features. A discussion of pin holes and transverse cracks on billet is made, taking into accounts its aspect and metallographic features on billet, the evolution during reheating and rolling and the final aspect and metallographic features on bar/wire rod. Root causes of these defects and solutions recommended are analyzed for each case.*

Keywords: *Continuous Casting, Billet Casting, Cast Defects, Rolling, Surface Defects.*

I. INTRODUCTION

Casting of carbon steel billets for commercial products usually implies silicon and manganese oxidation, and is mostly carried out with metering nozzle and powder lubrication. Under these conditions, surface defects are often detected in rolled products.

So, finding of the defect in the rolled products is helpful in keeping control of casting conditions. A methodology is used to reached this aim was developed at Mahalaxmi TMT steel plant along the time, as troubleshooting work for several plants was carried out. The paper is based on experience made by own while troubleshooting defect problems in carbon steel long products at several rolling mills.

II. METHODOLOGY TO DETERMINE THE ORIGIN OF DEFECTS

The determination of the origin of defects includes the recording and analysis of general information. It is important to know the frequency of defect, position in same corner or face of the billet, position in bar or wire rod. It is also relevant an exhaustive study of the general appearance of the defect by naked eye or with magnifying glass. After that, the observation of polished samples, generally transverse cuts of the rolled products or of the billet and microscopic study at higher magnification, etching with reagents give insight defects features. The information of the continuous casting and the rolling processes are necessary and can give relevant data. Sometimes it could be important to design the follow up of heats in the metal shop and rolling mill processes. The general criteria are summarized in Table 1.

TABLE I

Tasks	Information
General information	Frequency, position, in one of the strands or in one of the faces of the billet, position in wire rod, influence of some steel grade, etc.
Microscopic study	With the necked eye or helped with magnifying glass, polished sample observation, transverse cuts in rolled products & billets, etching with reagents.
Process information	Routine data from Rolling Mill & Steel Melting Shop(CCM)
Own Background	Search for similar defects in own reports and from other plants like Nilesh steel Jalana.
Physical simulation	Generally it has only academic interest or for preventing the problem from repetition in the future.

III. METALLOGRAPHIC OBSERVATIONS

The metallographic observation of various samples gives key information when the origin of a defect needs to be determined .often; it is not possible to find out the origin of defect with just observation of transverse cuts under microscope, without an idea of the general aspect of the defect. In Table 2 different techniques for the study of the defects and the information that can be taken from them, regarding to the origin of defects are monitored.

TABLE II: Study of defect and information regarding origin

Observation type	Information obtained
With naked eye or with magnifying glass	Oxygen Penetration (pin holes) due to internal oxidation after cutting billet samples, location on billet corner and mid way cracks.
As polished	Micro inclusions, Irregular solidification structure
Etching by HCL	Decarburization, segregation

IV. DEFECT ANALYZED

4.1. PIN HOLES:

Pin holes are observed often for semi-killed steels cast with casting powder. It can give a place to defects in the final product if there is an important number in a small area or if they penetrate deep in the billet.

4.1.1 APPEARANCE IN BILLET:

Figure 1 and 2 shows pin holes in billet surface after continuous casting forming a deep penetration of 50 mm repeating on each strand.

Fig I: Aspect of pin holes on the surface of a billet cast with casting powder observed by magnifying glass

Fig II: Aspect of pin holes on the surface of a billet cast with casting powder observed by naked eye.

The pin hole have a characteristic look showing in Figure I and Figure II which is due to development of scale and certain degree of decarburization.

4.1.2 ASPECT DURING ROLLING:

Figure III shows the defect on rolled bar of the billet having deep pin hole

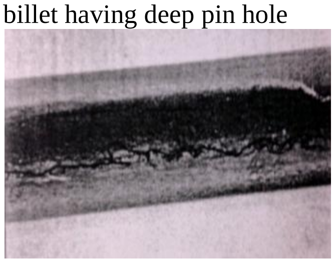

Fig III: Defect on rolled bar the billet having deep pin hole.

Most pin holes on surface of billet disappears during reheating due to scale formation, but the deeper pin holes are yet observed necked eye on the billet after reheating, they are difficult to rolled.

4.1.3 CAUSES AND SOLUTIONS.

Formation of pinholes is mostly related to evolution of gases resulting from casting powder decomposition during casting and can be enhanced by high oxygen activity in the liquid steel. Normal figures for lubrication rate are 20 to 30 gm/min, depending on powder properties, billet size and casting speed .To minimize pinhole formation it is important not only to check if lubrication rate is within the usual range, but also verify if the powder distribution in the transverse section is homogeneous. Good distribution of casting powder is very important and to avoid excessive use of lubrication in corners.

4.2 TRANSVERSE CRACKS:

Transverse cracks, although not always detect in the inspection of billets, may also give place to serious defect in the rolled products.

4.2.1 APPEARANCE IN BILLET

Figure IV and Figure V shows the aspect of transverse cracks in continuous casted billets observed by magnifying glass and by HCL etching closed to a surface, the cracks are looks as if it has been formed at high temperature, probably in the mould.

Fig IV: Transverse cracks on observed by magnifying glass

Fig V: Transverse cracks on observed after etching with HCL

4.2.2 ASPECT DURING ROLLING:

Transverse cracks during rolling gave place to V defects which is shown in Figure VI.

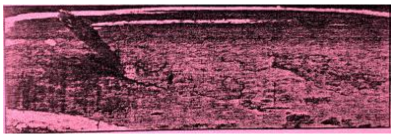

Fig VI: Evolution of transverse cracks during rolling, forming V defect

In transverse cut, they display a change in the direction for high reduction ratios.

4.2.3 CAUSES AND SOLUTIONS

Transverse cracks can form in the mould or during strengthening. When they are located in any corner, they are likely to be formed due to tensile effort related to sticking, this can be worsen by deep oscillation marks When the cracks are present only in the corner belonging to inner radius, they could be formed by tensile efforts during strengthening. This is common when corner temperature is within low ductility range. A sound approach to solve the problem is to set proper secondary cooling to avoid the dangerous temperature range in the corners during strengthening.

V. CONCLUSION

A methodology to study effects in carbon steel long products was developed at Sidhabali Ispat Chandrapur and Vinas Rolling Mill Hingna, Nagpur (India) while troubleshooting defect problems for iron and steel industry- Mahalaxmi TMT, Wardha, India.

For the study of defects many lab technique were developed that allow having different tools when the step where the defect was originated is to be determined. This way, it is much easier to take action in the plant in order to minimize a given defect.

This is exemplified with two defects commonly encountered when billets are cast with casting powder as lubricant: Pinholes and transverse cracks.

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