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BENCHMARKING OF IMPORTED AND INDIGENOUS ICDP-EC WORK ROLLS USED IN HOT STRIP MILLS

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ABSTRACT

In recent years the Steel Rolling Mills have undergone a significant change regarding quality requirements, productivity and the thickness of the products being rolled. The Hot Strip Mills have emerged with higher productivity, excellent surface finish of coils with thinner gauge rolling. Stringent dimensional tolerance, strip finish and profile flatness requirements and higher mill productivity have called for improved wear resistance and fatigue crack resistance of the rolls used in the finishing stands.

For the finishing stands of hot strip mills Duplex ICDP and ICDP-EC rolls are nowadays produced through either Vertical Centrifugal Casting (VCC) or Horizontal Centrifugal Casting (HCC) process. These duplex rolls generally consist of a Shell made of alloy cast iron and the Core made of spheroidal graphitic Iron. It has been observed that the Performance of the imported ICDP-EC Rolls manufactured by the Market leaders far superseded the Performance of the indigenous rolls due to higher wear and fatigue crack resistance of the imported rolls. Use of the imported rolls also improved the surface quality of products rolled and improved the campaign life of the rolls.

A study of few Imported and Indigenous rolls was carried out to find out the deficiencies of the Indigenous Rolls in comparison to the Imported Rolls manufactured by the market leaders. In this paper the chemical compositions and microstructure of the imported rolls have been benchmarked with those of the indigenous rolls. The morphology and content of *shell graphite, carbide & matrix of the imported and indigenous ICDP-EC rolls, which play significant roles in the performance of the rolls, were compared. The study helped to optimize these parameters for improving the Performance of the Indigenous rolls and reduce occurrences of failures at the Mills.*

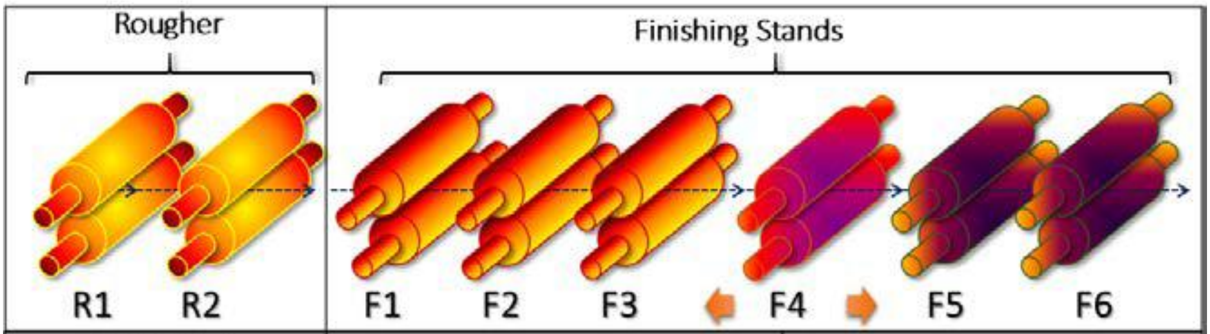
KEYWORDS: Hot Strip Mill, Vertical Centrifugal Casting, EC-ICDP Rolls, Wear resistance, Fatigue crack resistance, Chemical composition, Microstructure, Graphite morphology, Carbide.

INTRODUCTION

Centrifugally cast ICDP rolls with a working layer of ICDP (Indefinite Chilled Double Poured) alloy cast iron are used in the finishing stands of hot rolling mills. The term "indefinite" is associated with the fact that part of the total carbon content creates eutectic carbides and a small amount is present in the form of graphite (1-5%). ICDP rolls provide high mechanical and thermal stability of working layer, good surface quality and simultaneously eliminate sticking of rolled material. The core of the composite ICDP rolls consists of softer Spheroidal Graphitic Cast Iron or Gray Iron with flaky graphite. Further to improve performance, a roll grade ICDP-EC has been developed in which Microalloying elements like Nb & V are added (0.2- 2.0 %) in the working layer (shell). The microalloy added ICDP-EC rolls have Martensitic /Bainitic matrix and finer globular higher hardness MC carbides which give a higher campaign life in comparison to the conventional ICDP. The Microalloying addition imparts necessary wear resistance without making the shell material brittle.

TYPICAL MILL CONFIGURATION OF HOT STRIP MILL

A typical configuration of roll stands used in a hot strip mill (HSM) is schematically shown in Fig.1. The roughing and finishing rolling stands consist of particular roll types with different chemical compositions in order to withstand specific mechanical, environmental and thermal loading.



High Cr-Steel 1-1.3 %C, 10-12% Cr HSS Rougher 1-1.4 %C, Cr, Mo, V Semi-HSS Rougher 0.6-1.1 %C, Cr, Mo, V	High Cr-Iron 2.5-3.0 %C, 16-18% Cr, Mo HSS 1.5-2.0 %C, Cr, Mo, V	ICDP 3.2-3.5 %C, 1.6-1.9 %Cr, Ni, Mo High-Cr graphite 3.2-3.5 %C, 7.0-8.0 %Cr, Ni, Mo
Thermal fatigue, thermo-mechanical impact	Thermal fatigue, wear	Abrasive wear, mechanical fatigue
Reduced carbide network; improved oxidation; tough, stable matrix	Fine uniformly distributed alloyed carbides; improved oxidation; thermally stable, tough matrix	Increase of carbides

Fig. 1

After the casting operation, the slab is first passed through the furnace and then to the roughing stand. This is where maximum reduction in thickness is achieved. Following this, the material is passed through the finishing stand where the thickness is reduced further but the reduction after each single pass is much less in comparison to a single pass in roughing stand. The finishing stand consists of 6 sets of rolls (F1 to F6), In finishing stand, surface finish rather than thickness reduction is the objective. Here the contact time and material temperature is lower than that in case of roughing stand. The rolls in the finishing stand must have the following properties for the efficient rolling:

(a) Good wear resistance
(b) Resistance to oxidation
(c) Resistance to fire cracking
(d) Excellent surface finish which is vital for the finished product quality.

In the initial finishing stands (F1- F4) Hi-Cr cast iron roll is used, whereas, the ICDP cast iron rolls are used in the final finishing stands – F5 and F6. It is manufactured by both static casting method and centrifugal casting method. The shell matrix having proper distribution of carbides along with graphite particles dispersed in it imparts high wear resistance, stability in shape and good surface finish. The softer core ensures good mechanical properties and resistance to cyclic thermal and mechanical loads.

In recent years Hot Strip mills have undergone significant changes especially with regards to strip quality requirement and thin gauge rolling for improving the overall efficiency of the mill. The performance of the ICDP-EC Rolls which are being used in the last two finishing stands therefore needs to be improved. Moreover, the yield strength of the roll material also needs to be enhanced to reduce the propagation of crack through the interdendritic carbides.

The development of superior grade of ICDP-EC Roll has been aimed with optimized chemical composition and micro alloying additions (Nb & V) to produce:

1) Rolls having higher wear resistance with suitable primary carbides and secondary alloy carbides and highe matrix hardness than the existing grade of ICDP-EC roll.
2) Transforming Graphite morphology (shape, size and distribution) to replace flaky grapite.

The shape and distribution of graphite particles and carbides in the metal matrix are function of chemical composition, melting technology, innoculation practice and solidification rate. The morphology and content of shell graphite, carbide & matrix of ICDP-EC rolls play significant roles in the performance of the rolls in the rolling mills. Optimization of these parameters helps to improve performance and reduce occurrences of failures at the Mills.

COMPARATIVE STUDY OF IMPORTED AND INDIGENOUS IICDP-EC ROLLS

It has been observed that the Performance of the imported ICDP-EC Rolls manufactured by the Market leaders far superseded the Performance of the indigenous rolls due to higher wear and fatigue crack resistance of the imported rolls. Use of the imported rolls also improved the surface quality of products rolled and improved the campaign life of the rolls.

A comparative study of ICDP-EC rolls of Imported and Indigenous manufacturers was carried out to find out the deficiencies of the indigenous rolls in comparison to the Imported rolls manufactured by the market leaders.

PROCEDURE FOLLOWED

For the study samples of 3 Nos. of Imported rolls and 3 Nos. of Indigenous Rolls were collected. Shell chemical composition of all the rolls was analyzed. The microstructure of the shell was examined in both 'as polished' and 'as etched' condition. The microstructure of the Core was examined in 'as etched' condition.

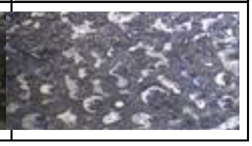
CHEMICAL COMPOSITION

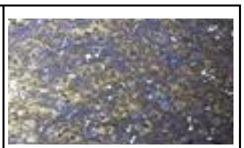
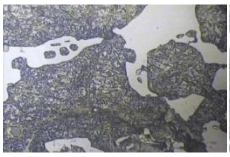
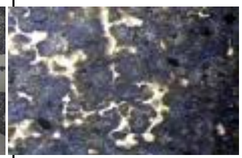
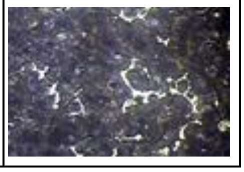
The chemical compositions of the Shell of all the rolls are given below:

S. No.	Manufacturer	C	Si	Mn	P	S	Cr	Ni	Mo	Nb+V
IMPORTED ROLLS										
1	IMPORTED - A	3.40-3.45	0.90-1.00	0.80-0.90	0.05-0.06	0.02-0.03	1.7-1.8	4.40-4.50	0.30-0.40	0.80-0.90
2	IMPORTED - B	3.35-3.40	0.90-1.00	0.80-0.90	0.05-0.06	0.02-0.03	1.7-1.8	4.30-4.40	0.30-0.40	0.70-0.80
3	IMPORTED - C	3.35-3.40	0.80-0.90	0.70-0.80	0.05-0.06	0.02-0.03	1.7-1.8	4.30-4.40	0.40-0.50	0.50-0.60
INDIGENOUS ROLLS										
4	INDIGENOUS - A	3.40-3.45	0.80-0.90	0.70-0.80	0.06-0.07	0.02-0.03	1.6-1.7	4.40-4.50	0.30-0.40	0.05-0.10
5	INDIGENOUS - B	3.40-3.45	1.00-1.10	0.70-0.80	0.06-0.07	0.02-0.03	1.6-1.7	4.40-4.50	0.40-0.50	0.70-0.80
6	INDIGENOUS - C	3.35-3.40	1.00-1.10	0.80-0.90	0.03-0.04	0.02-0.03	1.6-1.7	4.30-4.40	0.30-0.40	0.80-0.90

MICROSTRUCTURE

The photomicrographs of the Shell and Core of the rolls are given below:

Microstructure (Shell & Core)				
Manufacturer	Shell Graphite x50	Shell Carbide x100	Shell Matrix x500	Core x50
IMPORTED - A				

IMPORTED - B				
IMPORTED - C				
INDIGENOUS - A				
INDIGENOUS - B				
INDIGENOUS - C				

OBSERVATION

SHELL

1. Cr contents of the Imported Rolls were found to be higher than those of the Indigenous Rolls.

2. Si contents of the Imported Rolls & Indigenous A Roll were found to be lower than those of Indigenous B & C Rolls.

3. Microalloying contents (Nb+V) of the Imported Rolls & Indigenous C Roll were higher than those of the Indigenous A & B Rolls.

4. The graphite content of the Imported Rolls was less and finer and carbide content of the Imported Rolls was more in comparison to those of the Indigenous Rolls.

CORE

1. The Ferrite contents of the Imported Rolls and Indigenous Rolls were 10-20 % and 5-10 % respectively.

2. The Carbide contents of the Imported Rolls were <5 %, whereas those of the Indigenous Rolls were 10-15 %.

DISCUSSION

The wear behaviour at elevated temperature and the initiation and propagation of the surface crack are strongly influenced by the chemical composition and microstructure of the shell material of the ICDP-EC rolls. Apart from chemical composition the various factors which affect the microstructure include type of charge mix, procedure followed during melting and casting and cooling conditions during solidification of the rolls after casting.

The comparative study between the Imported and Indigenous rolls revealed the difference in chemical composition as well as in the microstructural characteristics of the rolls. The effect of differences in the chemical composition and microstructure of the Imported and Indigenous rolls are elaborated below.

Shell

The higher Cr content of the Shell of the Imported rolls resulted in higher percentage of carbides and better wear resistance of these rolls. As Silicon is a graphitizer higher Silicon content had increased the Graphite content of the Indigenous rolls resulting in higher rate of wear during rolling.

Both Nb and V form MC carbides, which have very high hardness levels and precipitate as fine globular carbides. Thus increasing the microalloying addition (Nb+V) played a major role in increasing the wear and crack resistance, while at the same time improving the toughness of the all the Imported rolls.

The finer graphite of the imported rolls enhanced the resistance to thermal stresses by increasing the thermal conductivity, thus reducing fire cracks.

Core

The higher Ferrite content and lower Carbide content of the Imported rolls have rendered them more tough and less prone to breakage under loading conditions during rolling.

CONCLUSION

It has been observed that chemical composition, contents, morphology and uniformity of distribution of graphite and carbide played major roles in enhancing the Performance of the Imported rolls in comparison to that of the Indigenous rolls.

To match the Performance of the Imported ICDP-EC Rolls trials are to be carried out by modifying the chemical composition by the Indigenous roll manufacturers. Fine tuning of the Process is also needed for modifying the morphology and contents of graphite and carbide to improve Performance of the Indigenous Rolls.

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