STUDIES ON THE INFLUENCE OF DIFFERENT GRADES ROLLS ON MICROSTRUCTURE PROPERTIES CORRELATION AND PROCESS ECONOMICS IN HOT ROLLING

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ABSTRACT

Cast iron containing free graphite has been used as hot rolls in mills since almost fifty years. Nodular iron then was recognized as a better material for rolls as it met most of the demands of rolling mills due to the unique combination of high wear and fire crack resistance coupled with good strength and ductilility. The first generation high chromium iron came up in the finising stands of mini mills in the mid 50s. The second generation with 18% chromium was introduced particularly for flat rolling in 70s whilst the third generation with improved heat treatment came up later which is mainly used in the early finishing stands. This paper takes into account all these developments and reports the influence of different roll material on structure –property correlation in rolled products.

INTRODUCTION

Right selection of roll material is vital for good rolling practice . Thus, roll preparation, maintenance through periodic dressing and roll management have significant influence on the productivity of rolling mills, quality of the rolled products and economics of the mills. To remain competitive in the rolling business it is necessary to reduce the production by technological upgradation. The options available are:

- Increasing rollling speed.
- Increasing mill flexibility.
- Reducing the amount of down graded products.
- Reducing roll consumption.

To achieve the above and to withstand longer campaigns at increased load the efforts have been focused on:

- Improved roll quality.
- Optimization of the different roll manufacturing technologies for specific mill requirements.

A good quality roll should possess the following properties :

a) High wear resistance for longer life and economy.

b) Resistance to fracture to withstand increasing rolling load.

c) Resistance to fire cracking to overcome the susceptibility of rolls to fire cracking due to the steep temperature gradient between rolling (1100 and1200°C) and the roll (around 800°C).

d) Spalling resistance to resist the premature failure of rolls due to very high thermal and pressure gradients between the stock and rolls

e) Good surface finish to produce high quality surface in the products.

STRUCTURE- PROPERTY CORRELATION IN ROLLS

Early high chromium cast iron rolls had pearlitic structure with a barrel hardness of 60-70° Sh'C. Around 1980 such rolls were replaced by martensitic grade having higher alloying elements and barrel hardness of 65-85° Sh'C. The usual range of the shell thickness was between 40 and 80 mm. This most widely used type of roll covers a large hardness range which can be regulated by minor alteration in the chemical composition and heat treatment. The microstructure of shell in high chromium iron rolls comprises of martensitic, carbide and bainite with some amount of austenite. Free graphite is not present practically. The chromium content of 15-20% guarantees white carbides on solidification. Eutectic carbides formed on solidification in these materials can not be altered by heat treatment and hence all precautions will have to be exercised to get the correct microstructure . It is well known that microstructure plays an important role . Some important mechanical properties of the shell of high chromium steel are given below:

Compressive Strength:

The compressive strength of the shell material increases approximately linearly with the barrel hardness. Soft high chromium rolls show a compressive strength of around 2000 N/mm^2 while the hard ones exhibit more then 2500 N/mm^2. In comparison the compressive strength of Graphite containing indefinite chill rolls is 15-25% lower.

Impact Strength

Impact bending strength of high chromium iron rolls measures between 5.5 and 7.5 J/cm^2 while indefinite shell material reaches only 3 J/cm^2 due to its content of free graphites. The modulus of elasticity of chromium roll shell is equal to the one of steel. The bending strength lies at around 1000 N/mm^2 and is nearly twice as high the one of indefinite chill material.

A general comparison of the mechanical (Table 1) properties of high chromium rolls and VI- rolls shows that high chromium rolls have better properties than VI-rolls. Regarding the physical properties the high chromium rolls are more sensitive than VI-rolls. Comparing the density and specific heat capacity shows that there is only slight and minor difference.It is essential that high chromium iron has a lower thermal diffusivity and conductivity but has a higher thermal expansion coefficient than a VI-shell.

Roll Type

The rolls can be classified in three major head:

i) Forge rolls.

ii) Cast Steel rolls.

iii) Alloy iron rolls.

Forged Rolls

Forged rolls are vacuum treated Ni, Cr, Mo, V alloyed hypo-eutectoid steel ingots forged blanks are machined volume hardened and then induction hardened to achieve desired hardness. These rolls are used where toughness rather then roll wear is the prime consideration to withstand high rolling load. These rolls have very high impact strength and are suitable to withstand heavy reduction.

Alloy Cast Steel/Alloy Steel Base Rolls

These rolls are mostly substituted for forged steel rolls mainly due to cost consideration. From mechanical strength point of view, cast steel rolls could be substituted for forged rolls where toughness as well as wear are considered. These rolls possess adequate strength, sufficient and optimum wear resistance properties.

Alloy Iron Rolls

These are very widely used class of rolls employed in variety of composition in intermediate and finishing stands. These rolls may be sub divided in the following categories :

a) Clear chill rolls

b) Nichilites rolls

c) Indefinite chill rolls

d) Spheroidal Graphite grey cast iron rolls

e) Double pour rolls

f) Non metallurgical rolls

S. G. Iron Rolls

Spheroidal graphite cast iron rolls or in short S.G. rolls are most important class of alloy iron rolls. There the graphite structure is in nodular form which improves the strength remarkably along with impact properties and elongation. They possess in strength-range 35 kg/mm^2 to 65 kg/mm^2 and hardness range 45° Sh'C - 75° Sh'C. These rolls in proper composition can be made to replace major proportion of intermediate and finishing rolls. The constraint with the use of these rolls is that their thermal conductivity being better than IC rolls, require maximum cooling to avoid occurrence of cracks. However these rolls cannot be used if surface finish of the product is of prime consideration.

Alloy Iron Double Pour Rolls

As the name suggests such rolls have very hard shell of high modulus of elasticity and core soft and tough. Initially double pour rolls were made by displacement method with shell of extra hard ($80-85^0$ Sh'C) Ni, Cr, Mo alloyed cast iron (Table 1) with tensile strength upto 45 kg/mm^2 and core of grey iron with strength 20-25 kg. mm^2 (Table 2). With the advent of centrifugal casting methods, the roll making was revolutionised in the sense that roll makers had a wide combination of shell and core meterials.

CONCLUSION

Rolls are one of the costliest inputs for rolling mills, failure of rolls leads not only to loss of very expenssive item but also disrupts the entire production schedule thereby losing the stake / opportunity in the market.

For optimum performance and reliability of rolls the following few factors, besides others are utmost important.

- Selection of roll materials.
- Metallurgy of rolls
- Adequate care and economic utilization of rolls.
- Roll cooling facility.

Table1 : Mechanical and Physical Properties of Shell Materials (at room temperature)

Property	Unit	High chromium CI (VX)	Indefinite Chill Roll (VI)
Tensile strength	N/mm^2	550-650	400 approx.
Compressive strength	N/mm^2	2000-2800	1800-2200
Bending strength	N/mm^2	1000	400-600
Impact Bending Strength	J/cm^2	5.5	2.5-3.0
Shear Modulus	N/mm^2	225000	170000
Density	Kg/m^3	7500	7200
Specific Heat Capacity	J/kg.K	500	500
Thermal Diffusivity	m^2/s	$4x10^{-6}$	$10x10^{-6}$
Thermal Conductivity	W/mK	15-17	20-30
Linear Thermal Expansion Coeff.	K-1	$13.6x\ 10^{-6}$	$11x10^{-6}$

Table 2 : Microstructure and Properties of Core Materials of Hot Strip Mill Workrolls

		High Chromium CI Rolls		Indefinite Chill Rolls	
At room temp	Units	Grey Iron core high strength	Nodular iron core	Grey iron core	Nodular iron core
Graphite		lamellar	nodular	lamellar	nodular
%ferrite		0	0-10	0	0-10
%pearlite		95-100	90-95	95-100	90-95
%carbides		0-5	0-5	0-5	0-5
Brinnell hardness		230-275	200-260	220-270	200-270
Tensile strength	N/mm²	200-350	300-600	150-250	300-600
Compressive strength	N/mm²	600-1000	800-1100	500-800	800-1100
Bending strength	N/mm²	350-550	550-1100	340-500	550-1000
Bending fatigue Strength	N/mm²	100-130	100-180	80-110	100-180
Youngs modulus	kN/mm²	120-165	160-190	110-150	160-190
Shear modulus	kN/mm²	55-70	65-75	50-65	65-75
Thermal conductivity	W/mK	35-40	25-30	40-45	25-30
Neck hard.	ShC	36-44	36-44	35-42	35-42