ANALYZE THE MECHANICAL PROPERTY OF NEWLY DEVELOPED STEEL GRADE RAIL (1080HH) WITH THE HELP OF IMPINGEMENT COOLING SYSTEM

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ABSTRACT

The rail network that was previously used 880 Gr. Could not meet these criteria and there is need to develop new rail which has more load bearing capacity and is more wear resistance. This report talks about a newly developed steel grade rail (1080HH) which is heat treated to develop the required mechanical properties by altering the microstructure. The primary focus of this review is to bring out the changes in the microstructure and properties such as ultimate tensile strength, yield stress and hardness, due to head hardening process by induction heating and cooling. In addition to this other important aspects relating to production to rail steel starting from casting to rolling has been discussed in the report gain an insight of various process, parameters affecting properties of rails. Further a comparative study has been done to prove that new grade (1080HH) rails are not only better in mechanical properties like UTS, YS, Hardness impact but also properties such as fatigue strength and residual stress.

Keywords: -. Temperature, load, descaling pressure, online profile measurement, water jet pressure, induction heating, jet impingement.

1. INTRODUCTION

Among all the single-phase heat transfer arrangements, it has the maximum heat transfer rate. Due to growing demand of heat transfer enhancement in many industrial applications, jet impingements are widely used and studied. These techniques are used wherever high performance cooling, heating or drying of a surface is required. Rail is the defining feature and the most important element of permanent way. The main function of rail is to provide a smooth and continuous level surface for movement and to provide guidance in lateral direction for movement of the wheels. On Indian railway a large number of accident takes place on account of rail/weld failure also wear and tear of permanent way necessitates its periodical renewal is major component. The design of rail is a intricate aspect. The features like chemistry, casting, rolling, proper heat treatment process of manufacturing, handling and utilization each have bearing on its life and these aspects are to be decided depending upon the expected traffic, speed axel load etc.

Casting of blooms

Blooms are casted by continuous casting process in caster and cooled in atmospheric temperature. From pig iron to bloom making it is a continuous casting process after blooms are prepared these are rolled into the rails. For this the cut blooms which are still hot are taken for rolling into rail lengths, alternatively these are allowed to cool and stored to be the taken up for rolling later, in which case the pieces are reheated in the soaking furnace at a certain temperature for adequate time period before rolling.

Fig: Continuous casting of blooms

Process description for rail rolling

The mill is capable of producing 0.75MTPA of rails and structural from the walking beam type reheating furnace (120MT/hr.) and (225MT/hr.) / the uniformly soaked blooms are immediately passed through the high pressure primary de-scaler to achieve scale free surface with design pressure of 250 bar max. The rolling process involves three stages with brake down stand (BD) at the first stage. Intermediate stand (KV-I) at the second stage and universal tandem mill at the third stage.

The break down stand consists of nine passes, the KV-I stand five passes and the tandem mill is provided with three passes and reduction ratio is normally maintained in between 10 to 14. After rolling the rails are hot stamped for heat number and strand number and then these are placed to the walking beam type cooling bed.

The cooling line for rails (rails cool) comprises.

- Turn up manipulators.
- Cooling line run in roller table
- Heat covers.
- Induction heater
- Cooling modules.
- Pyrometers.
- Pinch roll units.
- Low pressure water system.
- Water tank.

2. LITERATURE REVIEW

Impinging jets are known as a method of achieving particularly high heat transfer coefficients and are therefore employed in many engineering applications. Impinging jets have been used to transfer heat in diverse applications, which include the drying of paper and the cooling of turbine blades. Hollworth and Durbin [1] investigated the impingement cooling of electronics, Roy et al. [2] investigated the jet impingement heat transfer on the inside of a vehicle windscreen and Babic et al. [3] used jet impingement for the cooling of a grinding process. In these, and in other cases, research has been conducted with a specific application in mind but there have also been many fundamental investigations into the fluid flow and heat transfer characteristics. These have led to the identification of several parameters which influence heat transfer on the impingement surface. Thus, the main variables for jet impingement heat transfer are the angle of impingement, the jet Reynolds number and the height of the nozzle above the impingement surface. The current investigation is concerned with heat transfer to a submerged normally impinging axially symmetric air jet. Comprehensive studies of the mean fluid flow characteristics of both a free and an axially symmetric impinging air jet have been presented by Donaldson and Snedeker [4], Beltaos [5] and Martin [6]. In many investigations, including that by Gardon and Akfirat [7], the heat transfer to an impinging jet has been correlated with what is often termed the ‘‘arrival” flow condition. This is the flow condition at an equivalent location in a free jet. Jet flow characteristics are highly complex and can be influenced easily by varying the flow rate and nozzle geometry; the effects of nozzle geometry on the potential core length were investigated by Ashforth-Frost and Jambunathan [8]. Four jet exit conditions were studied, namely flat and fully developed flow for unconfined and semi-confined jets. For unconfined jets, it was shown that the potential core length can be 7% longer for the fully developed flow case. Semi-confinement has the effect of reducing entrainment and also elongates the potential core length by up to 20%. Comprehensive reviews of the heat transfer to impinging jets have been presented by Martin [6], Jambunathan et al. [9] and Polat et al. [10].

Objective of thesis

The objective of this work is to study about the enhancement in mechanical property of rail with the help of jet impingement process the study covers the effect of air flow rate and the water impingement density on the cooling rate. Single phase as well as two phases cooling with jet impingement method was found to be capable of removing large amount of heat flux using various coolants and surface enhancements. Compared with single jet impingement, multi-jet impingement achieved better thermal performance.

3. METHODOLOGY

An impingement cooling system is an array of jets of high velocity fluid which is made to strike a target surface. An impinging jet can be classified as a submerged jet or a free jet. In the case of confined, the jet remains bounded between two surfaces during its flow.

An impingement filter can be used to purify a polluted solution, be it gas or liquid. The impingement filter acts by inducing the solution to change direction and the particles to adhere to the filter medium. The gas or liquid, less impurities, is permitted free passage through the medium.

Impingement is defined as interference with the frictionless motion of graft in and about the exit points of graft from the bony tunnels, sidewall and roof of the inter condylar notch.

The initial temperature of the plate, before the cooling starts, is kept at 900 °C. The spray was produced from a full cone high mass flux and low turn down ratio air atomizer at a fixed nozzle to plate distance. The cooling rate shows that low turn down ratio air atomized spray can generate ultra fast cooling (UFC) rate for a 6 mm thick steel plate. After cooling, the tensile strength and hardness of the cooled steel plate were examined. The surface heat flux and surface temperature calculations have been performed by using INTEMP software. The result of this study could be applied in designing of fast cooling system especially for the run-out table cooling.

Head hardening of rails:

Blooms are casted by continuous casting process in caster and cooled in atmospheric temperature. Hardening of rails achieved by water jet impingement of rails after rolling.

Technogama BD,KV1R.H.F

Water jet impingement Induction Heater CCM

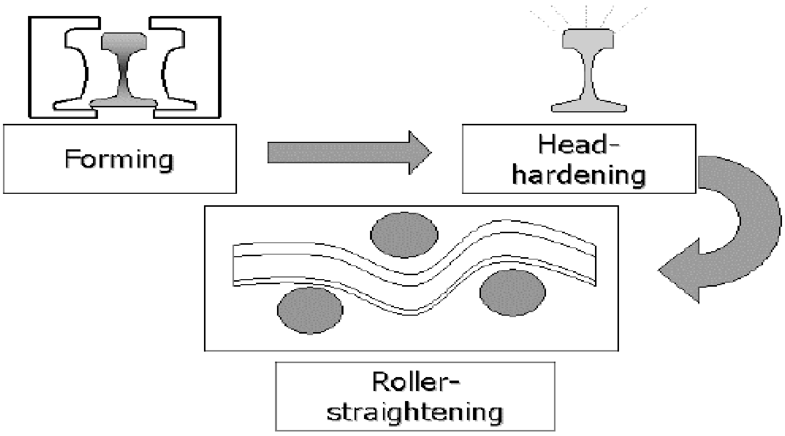


Fig: Block diagram of manufacturing of rail with head hardening.

Electric Arc Furnace

The shell of a modern electric furnace is usually cylindrical and is built of steel plates. The shell has a circular flat bottom which is laid first with clay, magnetize or silica brick as required. The roof is a simple a dome with three openings near the center for the electrodes. Two doors are usually placed in the shell of the furnace on the charging door diametrically opposite to the tap-hole and other the working door 90 degree away.

Fig: EAF

Operation of EAF

The charge generally consists of about 40% heavy scrap, 40% medium scrap and 20% light scrap. Ferro alloys, alloying oxides and virgin alloys which are not easily oxidized, can be and usually are charged in the furnace prior to melting down. The charge usually contains excess carbon on the bath to permit proper shaping of the heat. The ore is added to lower the carbon. This ore may be added with the initial charge or when the charge is totally melted.

Re-Heating furnace (RHF): Temperature of various zone of reheating furnace, heating of blooms up to soaking zone temperature at around 1220°c for homogeneous austenization.

BD: Break-down mill is the stage of rolling which work is to break the bloom structure and elongate the bloom length.

KV: KV is the intermediate stage of rolling where further reduction of bloom occurs in many passes of rolls.

Technogama: Technogama is online profile measuring gauge which works on the principle of leaser system.

Rolling of Rails

The blooms are rolled in a series of roll passes to form the rail to template in the dimensions. To reduce the section size and elongate the piece a large amount of work is done in the first few passes known as roughing. In the next stage known as finishing, actual shaping of the rail takes place in a few passes. The third stage is the finishing pass in which the rails are formed exactly to template dimensions without reduction in section. A typical series of section changes occurring during the rolling process. While rolling is done, spraying of water at 250 bar pressure is done to remove furnace scale. By the time, rolling is complete; the temperature of rails comes down from 1250 C to 800 C.

4. RESULT AND DISCUSSION

Effect of induction heating and heat treatment on hardness of rail.

It was found that hardness of rail measured on the head portion significantly as seen from table below we can see that hardness in 1080HH rail is about 345BHN at 2mm below the rail surface which is measured significantly as compared to 880 gr ade rail in which hardness below 2mm of rail surface is about 270BHN.

The hardness values were measured at distance of 2mm, 5mm, 10mm, 20mm, 30mm, 40mm, and 45mm from the top surface

Distance from head top	Hardness (BHN)
2mm	345
5mm	355
10mm	353
20mm	335
30mm	330
40mm	315
45mm	322

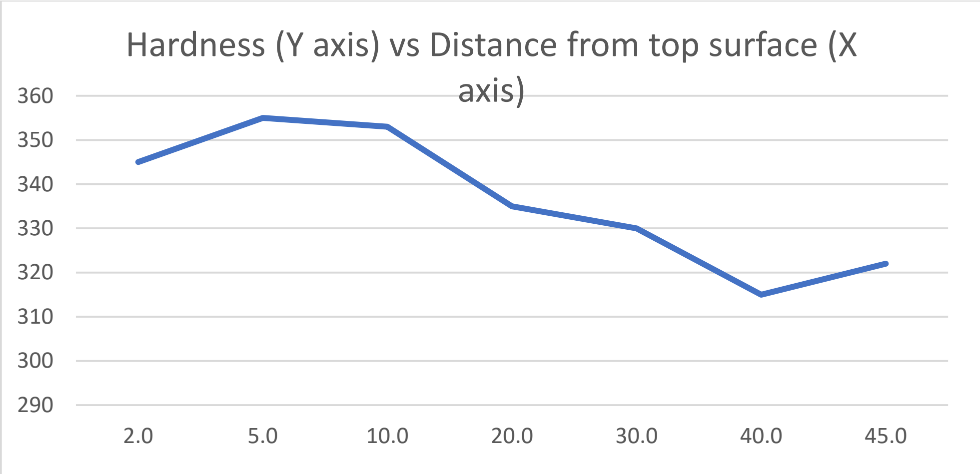


Fig: hardness Vs distance from top

As we can see that hardness has increased upto10mm depth as we go further hardness value decreases because of rate of heat transfer get slower as depth increases.

Thus we get a hard surface and toughened core.

The hardened surface gets wear resistant.

The above graph shows the variation of wear rate with respect to hardness.

Effect of induction heating and heat treatment on yield strength and UTS.

The YS and UTS (Ultimate tensile strength) depends cooling stop temperature apart from chemistry of rail.

It was found that as we decrease the cooling stop temperature the YS and UTS increases.

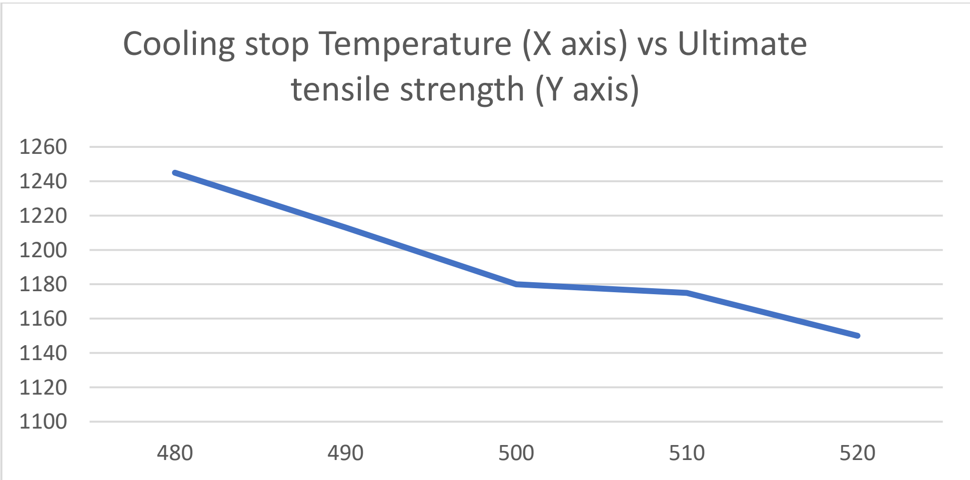


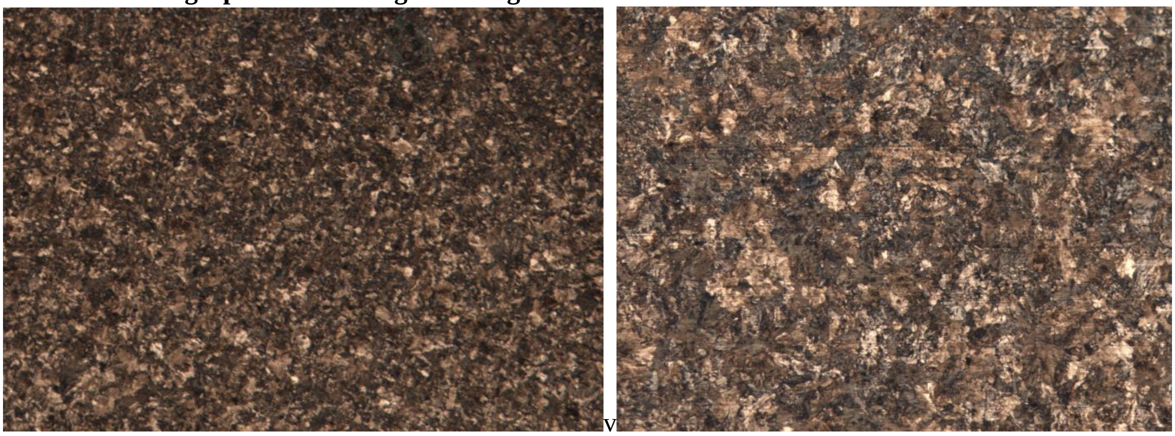
Fig: Strength, YS and UTS Vs cooling stop temp

This effect on UTS and YS with respect to cooling stop temperature is due to size of pearlite grain. As cooling stop temperature decrease the pearlite grain size decrease and number of grain boundary area increases and it becomes difficult for the dislocation to move.

- Effect of Induction Heating on microstructure.

- In 880 grade rail coarse pearlite is founded of ASTM no. 7.5 and in 1080HH grade fine pearlite is founded of grain size 9.5.

Microstructure graph of different grades as given below-



Gr 1080 HH **Gr 880**

Fig: Microstructure graph of Gr 1080HH Vs Gr.880.

Further we studied the effect of pearlite interlamella spacing on hardness and YS. We found the increase in pearlite interlamella spacing the hardness and YS values decreased.

5. CONCLUSIONS

From the above discussion we can conclude that with the help of induction hardening we could significantly increase the rail surface hardness while core steel remains toughened. Thus, by increasing the hardness we make the rail surface more wear resistance and also increase in fatigue life of the rail is observed.

As the microstructure of the rail is also changing there is change in Ultimate Tensile Strength and Yield Strength of the rail. The UTS and YS have increased significantly as paralytic interlamella spacing decreases. Further, there is reduction in percentage elongation (ductility) with this process.

Thus, we can conclude that by compromising the ductility within the specified range we could enhance the UTS, YS and wear resistance by induction hardening process of rail.

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