OPTIMIZATION OF THE COOLING TIME OF THE WORK ROLLS IN THE ROLL SHOP*

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Abstract
The present study was developed in the Hot Strip Mill area that has a Steckel Mill in use. This equipment is a four high reversible stand that has four rolls that are assembled one on the other in the horizontal. The center rolls are known as work rolls, and these are of smaller diameter. There are two other rolls, known as backup rolls, which are of larger diameter. The work rolls that were analyzed in this study have 900 mm of diameter of the work table and weight 18 tons. They are used in the hot rolling process and are responsible for the reduction of the cross section of the steel plates that arrive in the mill at temperatures around 1250ºC, transforming the steel plates into steel coils. Due to the direct contact of the heated plate with the work rolls, the same are heated and cooled during the process. After the rolling process and the finished campaign, they are with temperatures on the work table around 60ºC. In order to be regrinding and return the quality conditions of the surface, the rolls must be at temperatures of up to 30ºC. Thus, a system of cooling the rolls was provided, consisting of two pipes with holes that can project water on the surface of the rolls. About 90 minutes of forced cooling is required to meet this parameter. The creation of new rolls cooling system composed of two piping arrangements with heat extraction nozzles was focused by this development. Some data was collected on the cooling time of the rolls, as well as temperature measurements from all the rolls. The new system was able to reduce the forced cooling time satisfactorily, which impacted the total cycle time of the roll and had greater availability of this input. We also had a very significant environmental impact because, due to the shorter time, we consumed a smaller volume of water.

Keywords: Hot Strip Mill, Cooling system, Rolls, Environment.

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1 INTRODUCTION

The hot strip mill rolling process works with a mill stand which is a Steckel reversible mill consisting of four rolls mounted one on top of the other in the horizontal position, the middle rolls being known as working rolls, and the upper and lower known as backup rolls, this mill plays the role of rougher and finisher at the same time. [1]
The working rolls are those of smaller diameter, which are in direct contact with the heated plate and the material to be processed, the working rolls are relevant components in the production of hot-rolled coils, since they are one of the main responsible for its shape and surface finish. The life of the rolling rolls is limited by the degradation and wear of their surface during their rolling operating cycles. [2]
The working rolls undergo a heating at each turn due to contact with the strip and afterwards a cooling due to the action of the sprays of the cooling system [3]. A typical measurement chart is shown in figure 1, in which the temperature change of the rolls is given for the passage of the first plate through the rolls at the start of the rolling and cooled through a spray after the plate passes [4].

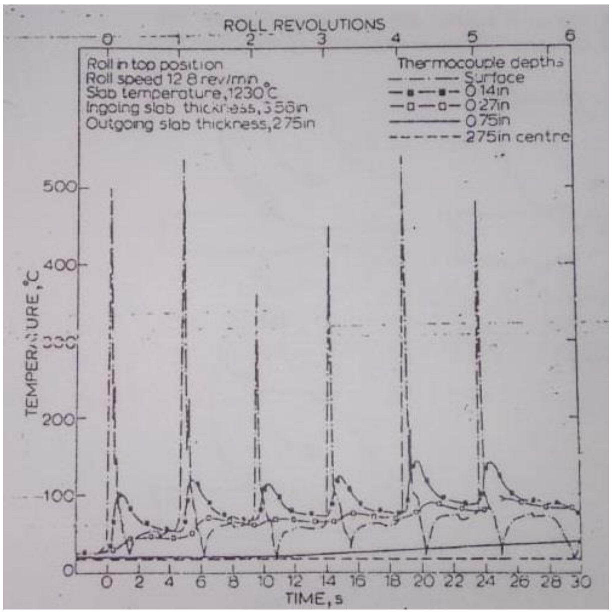

Figure 1: Variation of roll temperature during passage of first slab through stand

The rolls surface can reach approximately 600 ° C at the time of contact with the strip, returning to the initial temperature as it passes through the water jet of the cooling system. This temperature change decreases as it approaches the center of the rolls. This cyclical effect of heating and cooling is the main responsible for the mechanism of thermal fatigue wear in the work rolls [5].
After this stage, the rolls are removed and taken to the rollshop, which are areas of support of fundamental importance for the mill process. They contribute directly to the productivity of the rolling mills as well as to the quality and cost of the rolled products.
The work carried out by the roller mills has as main objective the supply of rolls for the rolling mills, according to the characteristics of each process.
Thus, it becomes necessary to use efficient controls to manage the efficiency of the services performed [6].
In order to have maximum performance in the grinding process of the rolls and, in order to guarantee the profile of the rolls, they must have a homogeneous temperature and less than 30°C. The objective of the work is to reduce the forced cooling time through water jets in the work rolls of the hot strip mill, which is currently an average time of 90 minutes, developing a new forced cooling system through heat extraction nozzles on the surface of the aiming to reduce the cooling time. Another important point is the environmental impact, as the new system will use a smaller amount of water and less electricity from water pumping engines.

2 MATERIAL AND METHODS

2.1 Work Rolls

The work rolls under study have as main characteristics: weight of 18,665 kg; total length of 6,600mm; table length 2,500mm; minimum diameter of 810mm and maximum of 900mm.

2.2 Air Cooling System

Cooling to air occurs by conduction with air and radiation from the surface to the environment. Conduction is a process by which heat flows from a region of higher temperature to a lower temperature within a solid, liquid or gaseous medium. The rolls leave the mill with a surface temperature in the range of 60 to 80°C and undergo an air cooling until the moment they arrive in the rollshop.

2.3 Forced Cooling System

Forced cooling happens through water jets thrown on the surface of the rolls and, cooling occurs by convection which is important mainly as a mechanism of energy transfer between a solid surface and a liquid. It is known that a heated metal plate will cool faster when placed in front of a fan than exposed to still air. [8] In both cases the mechanisms of heat transfer of smaller magnitude must be considered.

2.4 Original Cooling Device

The forced cooling device is designed to cool the work rolls with a rolling temperature of 60 to 80°C to the ambient temperature of 30°C, depending on the temperature of the available cooling water. The cooling device according to figure 2 is located on a concrete base and consists of a set of bases to support the pair of working rolls, a piping system with cooling nozzles for spraying, a water tank integrated in the foundation, a water compressor for occasional rolls cleaning and flow control system.

Figure 2: Actual cooling system device.

This device uses industrial cooling water, the pickup point of 1.5 m in height, with a water pressure of approximately 3.5 bar and a continuous cooling volume of approximately 3 m³ per minute. The return of the cooling water is by descent to the water treatment area of the plant.

2.5 New Cooling Device

The new cooling system, as shown in Figure 3, is designed to improve efficiency and reduce cooling time and water consumption by optimizing water flow and better directing this flow to the rolls table, avoiding the obstacles that are mounted.

Figure 3: New cooling system device

This system was manufactured in stainless steel, with a format that accompanies the radius of the rolls, has 5 cooling ducts on each side of the rolls and 7 spray nozzles in each duct that guarantee the formation of a fan and a better standardization in the cooling. The system also has a rotary joint that allows opening the assemblies to position the rolls and then closes them to ensure the correct positioning of the cooling.

The uniformity in the distribution in spray systems is given by the conditions of assembly and operation of the showers, such as spacing between nozzles, bar height, opening angle of the jets and working pressure.

Each spray nozzle has its own volumetric distribution characteristic and the nozzle cover generates a jet overlap with the adjacent one to achieve a uniform distribution curve of the sprayed liquid.

2.6 Environment Impact

Lately awareness campaigns on the importance of water and responsible drinking have grown significantly. The increase in these actions is due to the high consumption and waste that has been discussed for years. In times of scarcity, it is fundamental to discuss alternative, and especially effective, plans to reduce water consumption and waste. The aim is to minimize the consequences of the water crisis that the country has faced for some years. [9]

With the new design, the water flow in the nozzles is smaller and the forced cooling time is also smaller, thus generating lower industrial water consumption and also a lower consumption of electric energy from water pumping engines.

2.7 Thermographic Camera

The instrument for measuring the surface temperature of the rolls used in this study was the thermographic camera.

A thermographic camera is an equipment capable of capturing infrared light and converting it to the visible spectrum range allowing us to see the heat generated by objects.

The camera used for the tests was a FLIR E4 camera with an infrared resolution of 4,800 (80 x 60) pixels and a spectral band of 7.5-13 µm.

3 RESULTS AND DISCUSSION

To obtain the surface temperature data of the rolls, ten points were selected along the rolls table, according to figure 4. To collect these temperatures, a thermographic camera was used that allows photographing the rolls table. The images obtained are opened within the camera program and we have been able to define the ten points of analysis, as shown in figure 5.

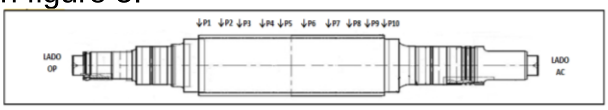

Figure 4: Work roll points of analysis.

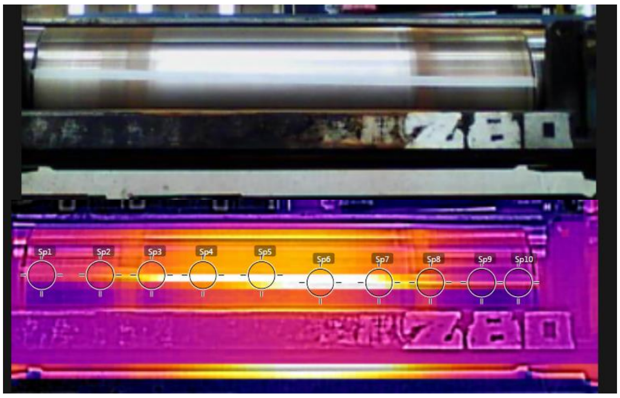

Figure 5: Real and thermografic image of rolls table.

For data analysis and comparison of the current cooling device and the new device, temperature and time graphs were constructed, where it was possible to analyze the cooling profile of the upper and lower rolls, until the rolls is at the ideal temperature to be regrind.

3.1 Rolls Cooling Profile with Actual Device

The images of Figure 6 and 7 show the cooling profile of a set of rolls after use and shows us at various measurement times the behavior of this over the forced cooling period using the new cooling device. For this case, the measured cooling time was between 75 and 90 minutes.

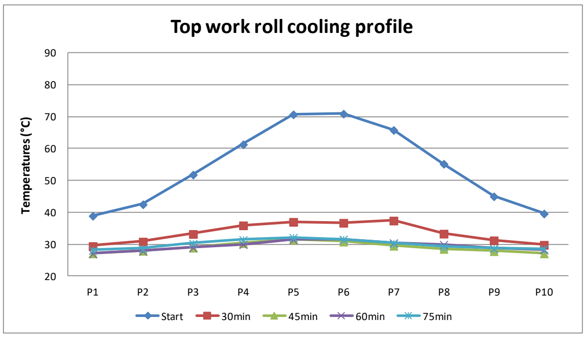

Figure 6: Top work roll cooling profile.

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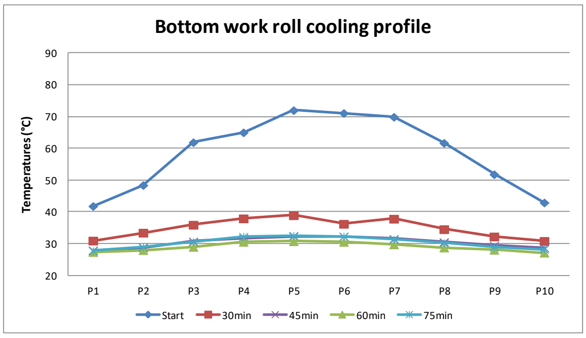

Figure 7: Bottom work roll cooling profile.

3.2 Rolls Cooling Profile with New Device

The images of Figure 8 and 9 show the cooling profile of a set of rolls after use and shows us at various measurement times the behavior of this over the forced cooling period using the new cooling device. For this case, the measured cooling time was between 75 and 90 minutes.

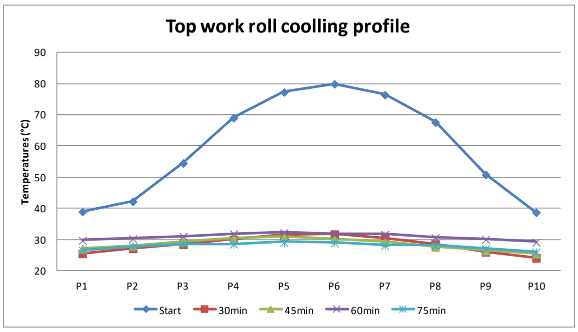

Figure 8: Top work roll cooling profile.

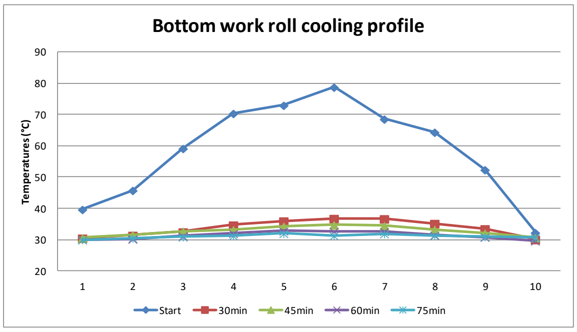

Figure 9: Bottom work roll cooling profile.

4 CONCLUSION

Currently, several studies and analysis are being done to optimize the processes within the rollshop, seeking to reduce the time of each of them.

With the increasing demands of production, more and more this becomes critical to the outcome of the business.

In the specific case of this development, a very high cooling time has been identified for the working rolls of the mill. In some cases, close to 90 minutes. With a new cooling device, you can reduce the total cooling time by 15% per set of rolls.

As shown by the cooling profile graphs, the rolls arrived in the rollshop and after 30 minutes of forced cooled, using the actual device, the temperature is between 30° to 40°C. The same analysis, using the new device, the temperature 28° to 32°C. Another think is that rolls return part of temperature after close the cooling and we can identify the difference between this two process and beneficiates.

The main reason for guaranteeing the final quality of the regrind rolls is related to the curve of the rolls. If the rolls are hot grinding, we lose this important feature. The new cooling device has met this parameter very well.

Another aspect of great importance in this development was the possibility of reducing the electric power consumption of the engines of the system responsible for pumping water to the coolers.

We also had environmental issues, due to the lower consumption of industrial water, which was in the order of 20% lower than the original, representing a great reduction of this water resource.

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