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Experimental Observation of Cooling Characteristics of hot Steel Plate in an ROT

Prahar Sarkar[1], Abhyuday Aditya[2], Avishek Ghosh[3] and Pranibesh Mandal[4]

[1,2,3,4]Jadavpur University
E-mail: [1]gracesaviour@gmail.com, [2]abhyuday.aditya@gmail.com
[3]avishek.silver@gmail.com, [4]m.pran11@gmail.com

Abstract—*The Cooling characteristics of hot steel billets under spray or jet cooling in Run out Tables [ROT] of Steel Industries depend on many factors like the initial temperature of the steel billets, flow rate of air or water or mist in the ROT, nozzle bank distance from the steel plate, linear velocity of the billet and many more. All these in turn affect the steel grade achieved in the process and proper control of the cooling behavior may help to produce new steel grades with preferable mechanical and metallurgical properties.*

Objective of the present work is to experimentally study the cooling behaviour of an MS plate heated to various desired initial temperatures in a furnace and different air flow rates while cooled under air jet in a laboratory scale ROT. The plate has been kept static while the nozzle bank distances kept constant. Experimental observations of the cooling behavior in terms of average temperature of the hot plate decreasing with time, have been presented for different initial temperatures and flow rates.

1. INTRODUCTION

In Steel industries cooling of hot billets is carried out under water or air jet or mixture of both under Run Out Tables (ROT) to impart various desirable metallurgical properties to the steel [1,2]. To produce steel of advance quality or grade, Modern and improvised techniques such as Ultra-Fast Cooling (UFC) under spray impingement along with precisely controlled cooling rates are being quite successful used. For a long time Ultra-Fast Cooling techniques such as high mass air flux [3] and water atomized spray with multi-cooling jets [4] have been favourite topics in engineering research. Controlled cooling refines grain structure of Steel, which in turn improves ultimate tensile strength (UTS), yield strength (YS), yield ratio (YS/UTS) and total elongation, and also increase the Charpy absorbed energy. Precisely controlled cooling techniques like moderated air and water pressure, nozzle bank distance from the steel plate and optimum concentration of the coolant along with optimum starting temperature under Ultra-Fast Cooling results in advanced steel grades [5,6].

In the present experimental procedure, quenching of a mild steel (MS) plate is being carried out on a laboratory scale run out table using ultra-fast cooling techniques. Various initial temperatures of the furnace and concentrations of air flux have been used to determine optimum heat transfer coefficient and the nature of relationships between average temperatures and individual parameters. The results obtained experimentally can be used to determine the uncertainty in the results by doing a numerical analysis of the same and can be used for research purposes on ultra-fast cooling of steel.

2. SYSTEM DESCRIPTION

A chamber type heating furnace with 18 nos. of heating elements on the two inner side of the walls is being used during the experiments. A separate control panel is installed which has a safety controller, voltage and current indicators and dials to set it to a maximum temperature. The heating furnace is shown in figure 1. A Mild Steel (MS) plate of dimension of 597mmx202mmx6mm has been heated in the furnace to a desired temperature and next cooled under air jet.

Figure 1(a). Closed Chamber Type Furnace

Figure 1(b). Furnace Control Panel

Figure 1(c). The Nozzle Bank Setup

Two nozzle banks, of twenty nozzles each, are mounted on both sides of the cooling bay so as to spray both upward and downward surfaces of the sample plate at the same time. The air is first compressed in a centrifugal compressor and is then directed to the nozzle banks through a simple air circuit. Both nozzle banks and the sample plate are shown in Figure.

8 nos. of K-type thermocouples have been attached at different locations on the plate to determine its temperature in real time. The average of the 8 temperature readings have been taken as the average temperature (T_{avg}). The temperature is recorded in real time using a NI 9211 Input Module in an NI cRIO that acts as the interface device between the hardware and a host PC. NI LabView is used as the software platform in the PC.

The results have been taken varying the initial temperature (T_{in}) at which the plate is heated in the furnace, and varying the air flow rate (Q) while the nozzle bank distance from the plate have been kept constant and the plate while cooling have been kept static.

3. RESULTS AND DISCUSSION

The data obtained experimentally is analysed by means of curves, taking T_{avg} (°C) as the ordinate and time (sec) as the abscissa, as shown in the figures that follow.

Figure 2 shows T_{avg} plotted against time keeping the initial temperature in an experimental range from 550°C to 650°C while the flow rate Q (in m^3/H) is varied. The curves demonstrate the relative cooling behaviour of the test plate under varying compressed air flow rate. It is observed that with increasing flow rate the curves get stacked above the previous ones and hence we can safely state that an increase in flow rate directly improves the cooling rate.

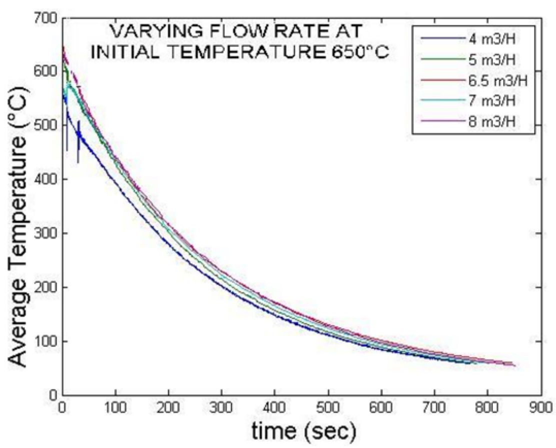

Figure 2: Cooling behavior for varying flow rates at a constant initial temperature of 650°C

Fig. 3-7 show a set of curves with T_{avg} plotted against time keeping the flow rate Q (in m^3/H) constant at a value of 6.5 m^3/H (average) while the plate has been heated to 5 different initial temperatures of 100°C, 200°C, 300°C, 400°C and 500°C and then cooled down to room temperature. A set of 10 experimental observations have been taken to observe the cooling behaviour for each particular T_{in}. This part of the experiment also helps to observe the uncertainty in the system characteristics. The kinks observed in the curves during initial cooling stage are due to experimental error.

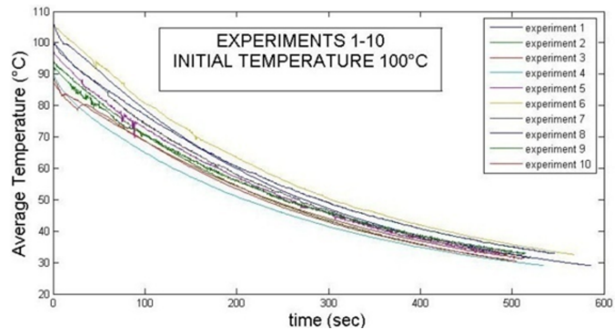

Figure 3: Cooling behaviour at T_{in} = 100 °C

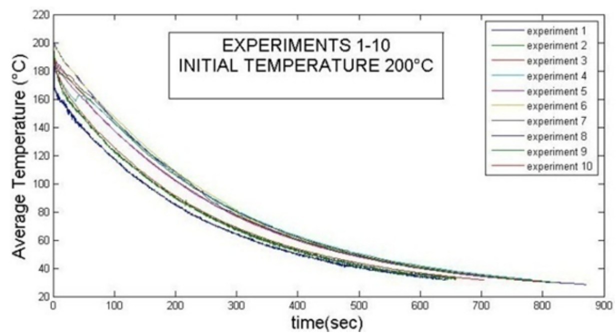

Figure 4: Cooling behaviour at T_{in} = 200 °C

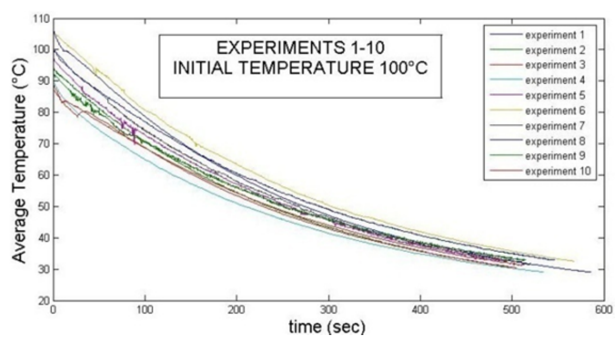

Figure 5: Cooling behaviour at T_{in} = 300 °C

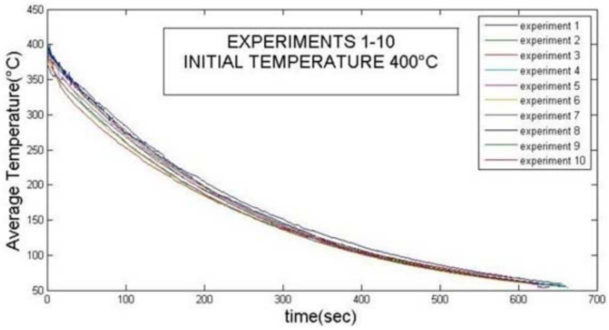

Figure 6: Cooling behaviour at T_{in} = 400 °C

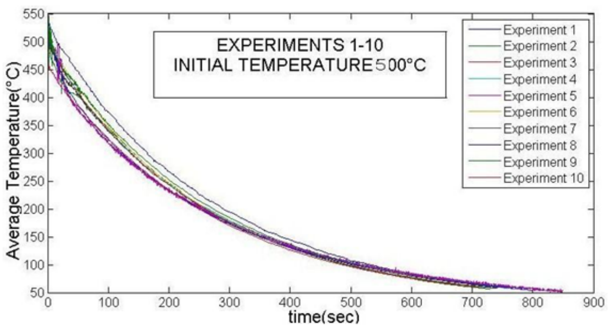

Figure 7: Cooling behaviour at T_{in} = 500 °C

4. CONCLUSION

The data collected and analysed as part of the uncertainty experiment will allow to develop controlled simulation conditions for the laboratory scale cooling of the test MS plate similar to that of the actual hot rolling in steel mills. Together with the application of the Electro Hydraulic Actuation System (EHAS) to simulate actuation motion to the test plate and the data analysed from the uncertainty tests, the experiment has promising scopes of delivering conditions for faster and efficient cooling in industrial Run Out Tables. Future work will also include use of water and air mixture to carry out cooling rate tests.

5. ACKNOWLEDGEMENTS

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REFERENCES

[1] Heung, N.H., Lee, J.K., Kim, H.J. and Jin, Y-S., "A model for deformation, temperature and phase transformation behavior of steels on run-out table in hot strip mill", *Journal of Materials Processing Technology*, 128, 1, 2002, pp. 216-225.

[2] Phaniraj, M., Shamasundar, S. and Lahiri A.K., "Relevance of ROT control for hot rolled low carbon steels", *Steel Research International*, 72, 5-6, 2001, pp. 221-224.

[3] Mohapatra, S.S., Ravikumar, S.V., Jha, J.M., Singh, A.K., Bhattacharya, C., Pal, S.K. and Chakraborty, S., "Ultra-fast cooling of hot steel plate by air atomized spray with salt solution", *Heat and Mass Transfer*, 50,5, 2014, pp. 587-601.

[4] Nayak, S.K., Mishra, P.C. and Parashar, S.K.S., "Experimental Investigation and Optimization of Air-Water SprayImpingement Cooling to Enhance Heat Transfer", *International Journal of Engineering and Technology*, 8, 1, 2016, pp. 379-390.

[5] Muhammad, A., Liao, Q., Zhu, W.H.X, Song, S. and Muhammad, S., "Transient heat transfer behavior of water spray evaporative cooling on a stainless steel cylinder with structured surface for safety design application in high temperature scenario", *Heat and Mass Transfer*, 53, 2, 2017, pp. 363-375.

[6] Longhai, L., and Qiong, Z., "Analysis on Influence Factors of the Cooling Efficiency of Moderate Thick Plates in the Quenching with Controlled Cooling", *Second International Conference on Computer Modeling and Simulation*, Vol. 2, 2010, pp. 390-393.