SECONDARY COOLING OVERLAPPED WITH BEARING HOUSING IN A CONTINUOUS CASTER

Jan KOMÍNEK [1], Tomáš LUKS [1], Michal POHANKA [1], Miroslav RAUDESKÝ [1], Jong-Yeon HWANG [2]

[1]Brno University of Technology, Technická 2, 616 69 Brno, Czech Republic, EU
Jan.kominek@vut.cz
[2]POSCO, 396, Gumho-ro, Gwangyang-si, Jeonnam, 545-711, Korea
jyhwang@posco.com

Abstract

This article deals with the secondary cooling in a continuous caster. In particular, it deals with homogeneity / inhomogeneity in places where surface of slab is partial shielded by rollers and bearing pocket between rollers. Influence of gap between rollers was also considered.

Homogeneity of cooling intensity distribution was experimentally studied in two stages (cold and hot tests).

In the first stage (cold tests) water flow and water distribution was observed optically using a transparent board with studied surface structures (rollers and bearing pockets).

In the second stage (hot tests) the cooling tests with steel plate (fitted with studied structures) were performed. Cooling homogeneity was studied based on temperature distribution of the non-cooled side of sample, which was recorded by infrared camera.

Keywords: Steel, continuous caster, cooling homogeneity, measurement, infrared camera

1. INTRODUCTION

Knowledge of cooling intensity and homogeneity is essential for controlling whole casting process including the surface temperatures which can influence quality of surface [1]. Cooling intensity of spray nozzle is dependent on many factors. The first group is formed by parameters of nozzle itself (for example geometry, water flow or water/air flow for mist nozzles, impact angle) [2]. The second group of factors is for example surface temperature [3] and roughness [4], temperature and chemical composition of coolant or structures close to the surface (as rollers) which can partially distort the water jet.

This article is focused to the influence of rollers to cooling intensity of nearby mist nozzles. The walls of the slab are support by rollers against the ferrostatic pressure. Rollers and slab are cooled by water or mist nozzles. Rollers can be split over the width to segments for case of wide width of slab [5]. In this case the rollers are divided by bearing pocket. Due to the different geometry of bearing pocket than rollers (especially the gap between pocket and slab) this structure can significantly influence water flow over the slab surface. Impact on cooling intensity and homogeneity was studied and results are described in this text.

2. COLD TEST

Setup of nozzles with rolls and slab were assembled for the cold test (model was built in real scale). Tests were focused to the study the water flow on the surface and through the gaps between the rolls. The slab was replaced by transparent glass, see **Figure 1**. This allowed observation from both sides (front and rear).

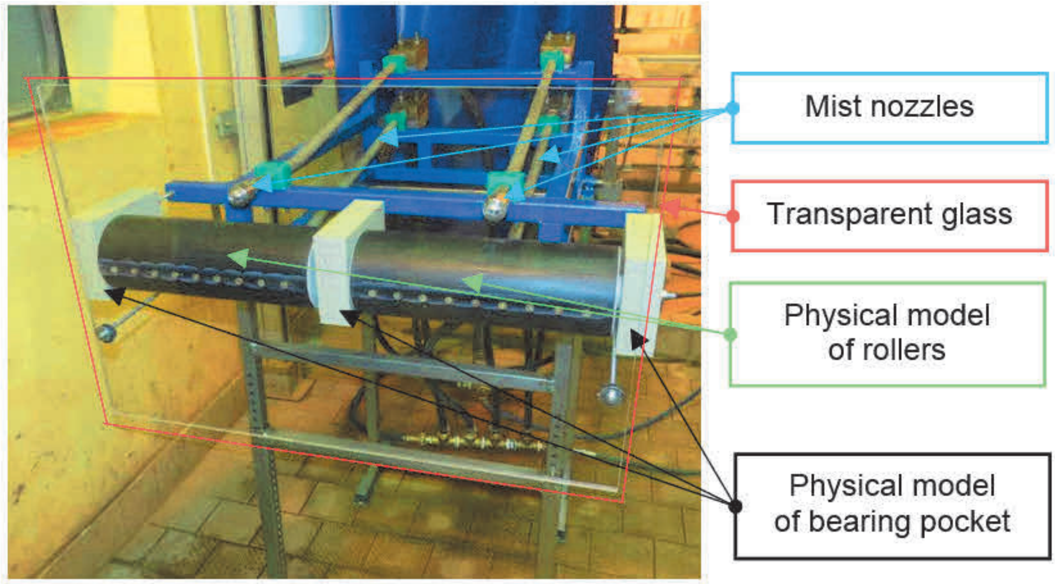

Figure 1 Experimental device for cold test

Homogeneity tests were performed with nozzles used in conventional caster - mist nozzles because they provide good controllability of the heat transfer coefficient (HTC) [6, 7]. Three various water/air flowrates and three different slab inclinations (30°, 45°, 60°) from vertical position were tested, both in positive and negative directions of inclination. Example of water distribution (water footprint) on slab surface (transparent glass) is shown in **Figure 2**.

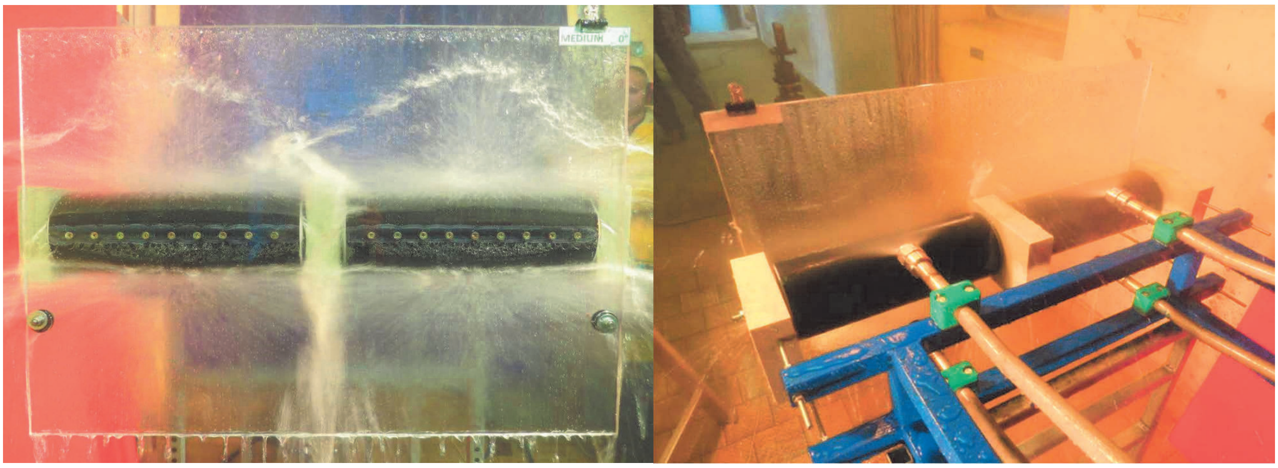

Figure 2 Example of observed water distribution front and rear view

3. HOT TEST

Hot test bench was built at Brno University of Technology. The hot heat transfer test was done as stationary test without movement of the test plate. Rolls with identical geometry as in plant conditions was made and connected to the test plate, see **Figure 3**.

Surface temperature of the non-cooled side was recorded by infrared camera, see **Figure 3**. Raw data from the camera were filtered (in space and time) and calibrated using emissivity for each point. Example of captured temperature distribution by infrared camera is shown in **Figure 4**.

Hot tests were performed with three initial temperatures of test plate (600 °C, 900 °C and 1100 °C) for inclination angle 0° and with initial temperature 900 °C for inclination angle -45°. Each test was performed for three level of flowrate rate (Small, Medium and Large).

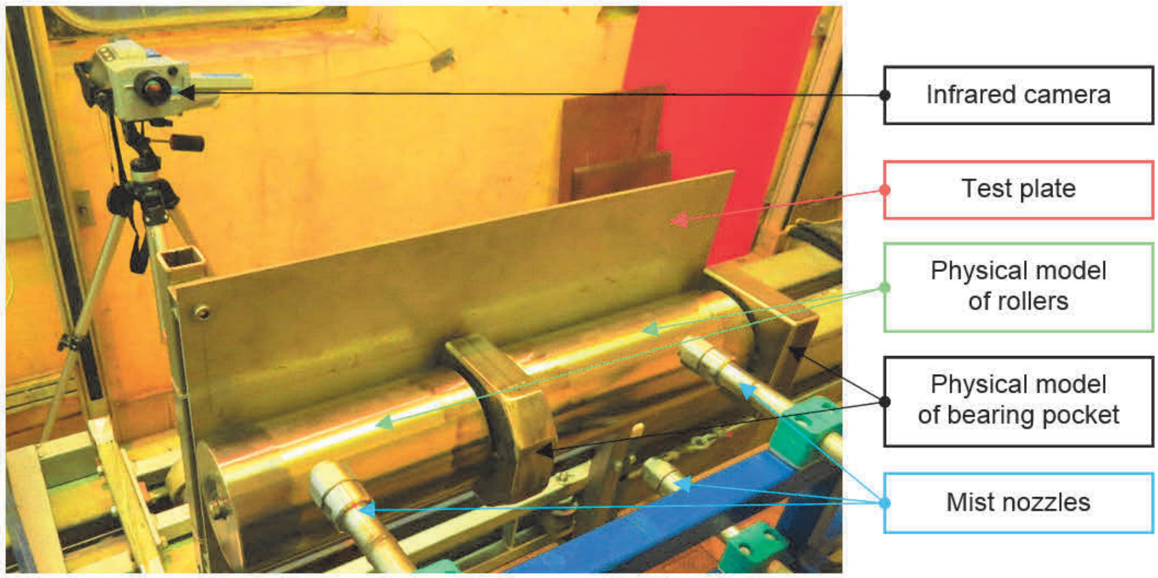

Figure 3 Experimental device for hot test

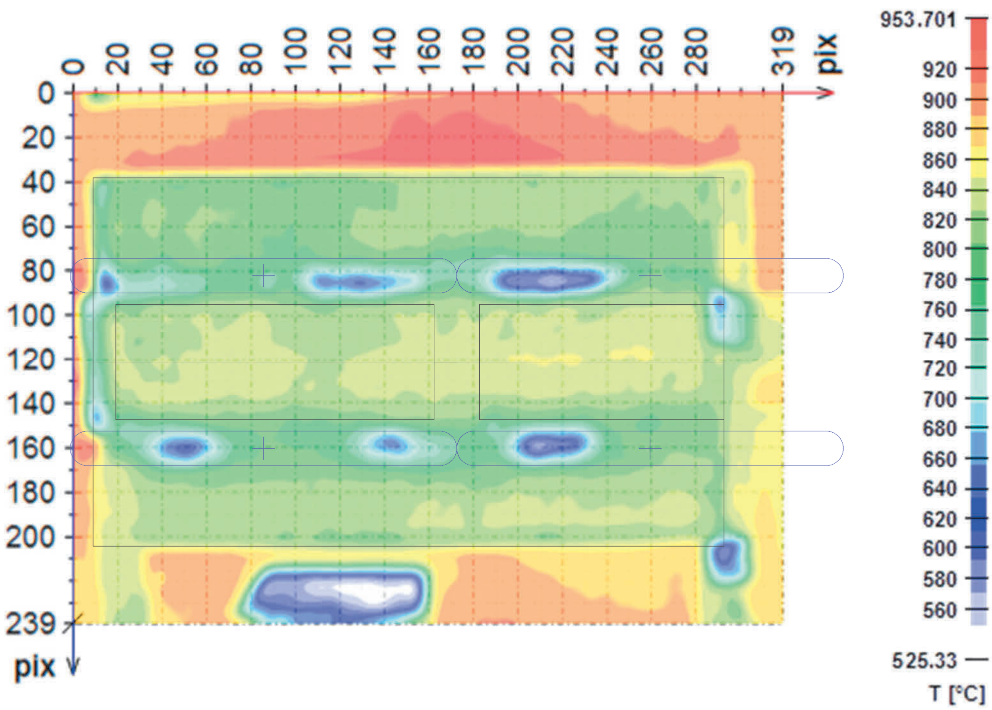

Figure 4 Example of temperature distribution captured by infrared camera

Inverse task was used for evaluation of HTC on the cooled surface [8, 9]. Relative HTC values for three level of flow rates are plot in corresponding figures from cold test, see **Figures 5, 6, 7**.

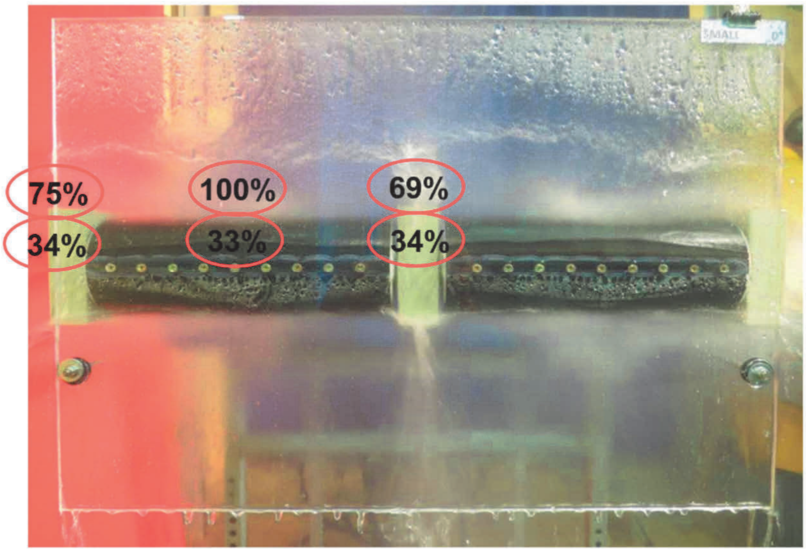

Figure 5 Relative cooling intensities for small flowrate

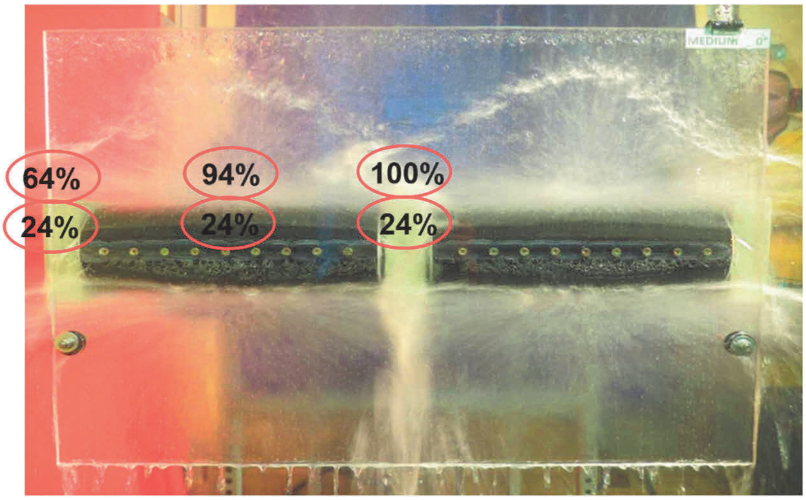

Figure 6 Relative cooling intensities for medium flowrate

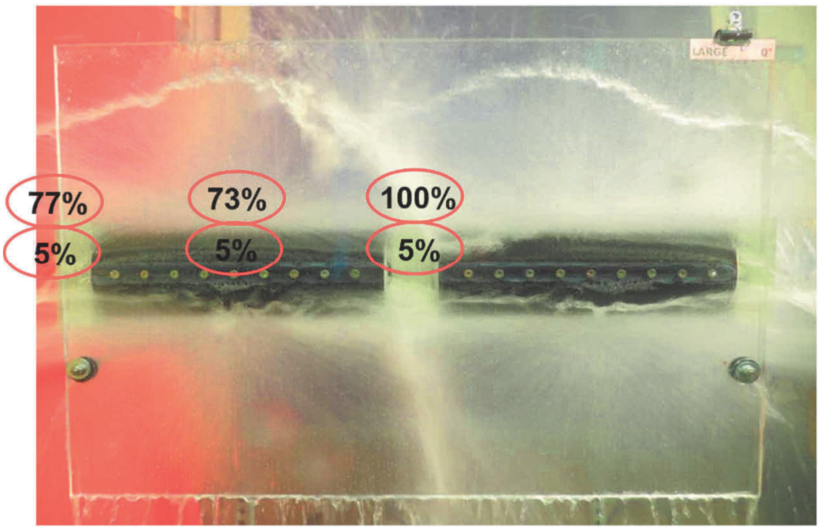

Figure 7 Relative cooling intensities for large flowrate

4. RESULTS

Nozzles have significant inhomogeneous cooling intensity along the spray width. Moreover, the cooling intensity distribution in nozzles footprint is dependent on water flowrate. Relative cooling intensities for different flowrate are showed in **Figures 5-7**. Maximum cooling intensity is a under the nozzle for small flowrate (**Figure 5**). For increasing of the flowrate the maximum cooling intensity is shifting along the spray width from center to the overlap region (**Figure 6** - medium intensity). The maximum cooling intensity is shifted to the end of spray width for large flowrate and maximum cooling is near and in the overlap (**Figure 7**).

However, the different situation can be observed for high starting temperature (1100 °C) where no difference in cooling intensity was found as the water is separated by vapor layer from the surface (Leidenfrost effect [10]).

Hot test also showed that is no significant influence of gap between rolls to the cooling rate.

5. CONCLUSION

Design of experiment for homogeneity tests (hot and cold test) was developed in Heat transfer and fluid flow laboratory. Cold tests were performed with transparent plate to allowed observation both from front and rear sides.

Infra-red camera was used to record temperature distribution on the rear side of test plate during hot tests. Pour homogeneity of cooling intensity under the nozzles can be easily observed from the temperature profiles (for example **Figure 4**). Hot test proved that the water flow in gap between rolls has very small influence to increase the cooling rate. The reason is small water flow through the gap with low impact pressure. Greater inhomogeneity can be observed under the spray along the spray width which is different for each tested flow rate (low, medium, large).

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