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THE INFLUENCE OF THE TECHNOLOGICAL PARAMETERS ON THE SECONDARY COOLING AT THE CONTINUOUS CASTING

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ABSTRACT

When cooling the semi-finished product in the mould, the secondary cooling takes place. During this, the solidification has to be performed on the entire cross section of the strand. In order to achieve this, beside a proper primary cooling, the factors that influence the secondary cooling have to be also correlated: the water flow on the three areas of the installation, the water pressure in the secondary line, etc.

All these have in view a proper solidification length; an intense cooling can generate cracks due to the thermal stresses, while a too slow cooling can generate a partial solidification of the strand up to the cutting machine area.

The paper shows also the differences that appear when continuously casting two different sections: 240x270 mm bloom and Ø 150 mm billet.

Keywords
Continuous casting, secondary cooling, water flow

1. INTRODUCTION

The purpose of the secondary casting is to continue the cooling of the strand after it has come out from the mould and to solidify completely the cross section of the strand. However, the developing of the solidification is limited by certain natural restrains, as: thermal conduction in the strand scum, cooling efficiency of the cooling agent, and last but not least, quality considerations regarding the semi-finished product.

The scum built in the mould ensures the shape of the cast section. In most cases, the scum does not present enough mechanical strength under the action of ferro-static pressure. In order to achieve a proper solidification and to lead the strand under proper conditions, the secondary area is arranged. Spraying directly water under pressure through nozzles performs this cooling. This water is able to penetrate the steam layer built by vaporization and to ensure the continuously and permanent water – metal contact.

The end of the secondary area is located in the point of balancing the inner heat of the metal that has reached its surface by conductivity with the heat exhausted by radiation from this surface.

The efficiency of the cooling in the secondary area is determined both by the water flow (proportional to the casting speed) and by the water distribution on the metal surface. The spraying has to ensure the continuously cooling, corresponding to a constant temperature decrease from 1200-1300°C when coming out from the mould, to 700-900°C at the end of the secondary area. The temperature decreasing is easily reached in the case of square or round sections, where the liquid area decreases quickly. The heat content in case of slabs is high for a longer time, fact that explains the existence of the solidification cone also in the extraction equipment.

The secondary cooling area is next to the mould. In generally, it lays on over 30 up to 50% of the liquid core length. This area is divided in under-areas, which are individually controlled. The cooling agent, water or water-air mixture, is sprayed through nozzles on the surface of the strand, and it is controlled in a manner that the temperature of the strand surface decreases steadily in casting direction. The temperature is to be steadily on the periphery of the strand. The spraying nozzles, the spraying angle, the distances between the nozzles and the water presure are to be regulated so that around the periphery of the strand, a steady or almost steady temperature at a certain level is achieved. Several cooling areas are sequentially arranged and controlled along the strand, in order to ensure the decreasing of the spraying flows and the cooling efficiency according to the speed and the liquid core of the strand.

2. EXPERIMENTS AND RESULTS

For studying the steel solidification when continuously casting, we have tested a number of 55 heats, OL 37-2k grade, cast as 240x270 mm bloom and respectively 55 heats, OLT 35 grade, cast as Ø150 mm billet.

Taking into consideration the issues that were mentioned in the introduction part of this paper, we have studied the interdependence between the average casting speed and the parameters of the secondary cooling water on all the three areas. So, Figure 1, 2 and 3 show this interdependence for the 240x270 mm profile.

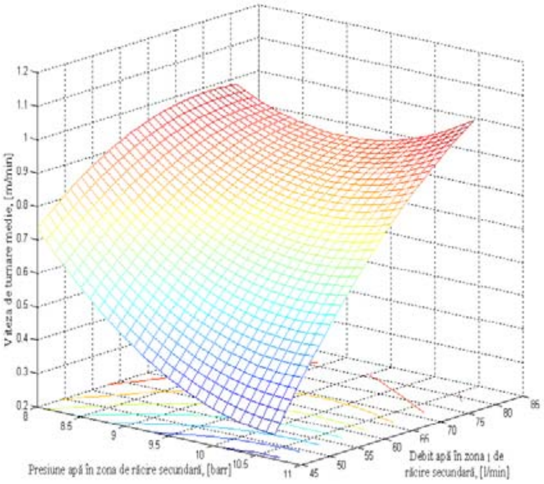

Fig.1 The interdependence between the average casting speed and the parameters of the secondary cooling water on first area

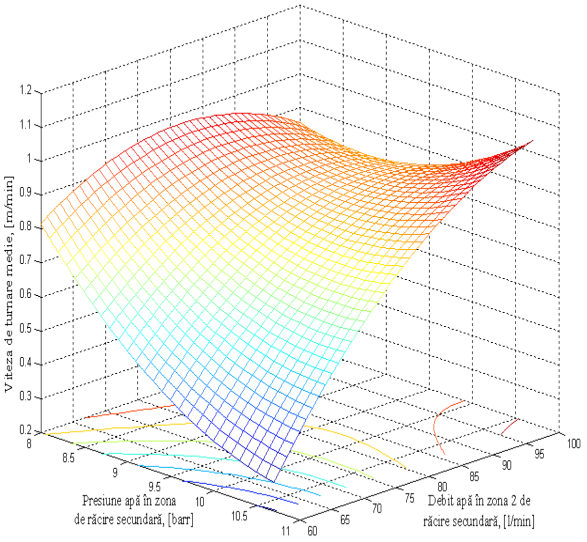

Fig.2 The interdependence between the average casting speed and the parameters of the secondary cooling water on the second area

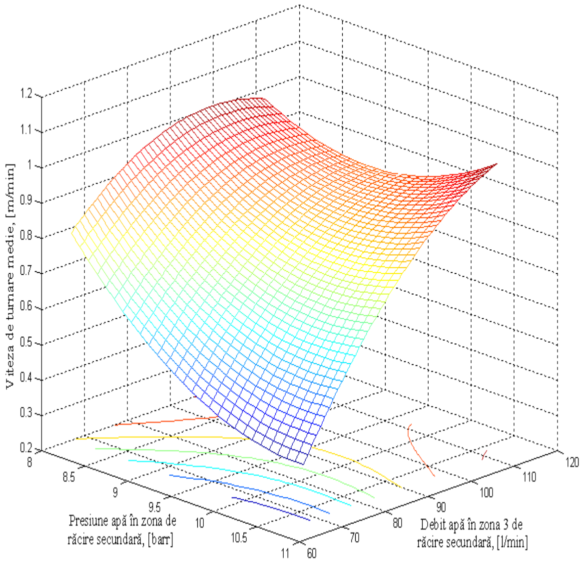

Fig.3 The interdependence between the average casting speed and the parameters of the secondary cooling water on the three area

By analyzing the previous presented surfaces, it can be noticed a similar dependence: at low casting speeds, the cooling water pressure admits relatively high values but also minimal values for water flow. But, together with the increasing of the casting speed, the flow increases and the cooling water pressure decreases slowly (a certain cooling programme), or both flow and cooling water pressure increase. If the pressure admits relatively constant values for the three cooling areas (8,6 – 10,7 bar), then the flows admit values as follows: 54 – 81 l/min for the first cooling area, 63 – 100 l/min for the second cooling area and 73 –

112 l/min for the third area, hence higher and higher flows in order to solidify the continuously cast semi-finished product on its entire cross section. All the three obtained surfaces show a saddle point in the technological field, being easy to notice graphically.

For the three surfaces the global correlation coefficient together with the equation of the regression surface is:

- for Figure 1: the global correlation coefficient: ryx1x2 = 0.8531 and the equation of the regression surface

$$z = 7.7904 - 1.5080*u - 0.0029*v + 0.0053*u.*v + 0.0588*u.^{2} - 0.0003*v.^{2} \tag{1}$$

- for Figure 2: the global correlation coefficient: ryx1x2 = 0.8122 and the equation of the regression surface

$$z = 8.0186 - 1.5857*u + 0.0022*v + 0.0065*u.*v + 0.0533*u.^{2} - 0.0003*v.^{2} \tag{2}$$

- for Figure 3: the global correlation coefficient: ryx1x2 = 0.8205 and the equation of the regression surface

$$z = 7.4566 - 1.5436*u + 0.0099*v + 0.0039*u.*v + 0.0603*u.^{2} - 0.0002*v.^{2} \tag{3}$$

In case of the Ø150 mm billet, the diagrams have the shape presented in Figure 4, 5 and 6, also for all the three cooling areas. It can be noticed that in case of the round profile, the cooling programme is changed – taking also into consideration the smaller section of the strand. In this case, for a pressure of 8,2 – 8,6 bar, the flows in the area 1 and 3 have similar values: 41 – 60 l/min and respectively 44 – 73 l/min and they increase for the area 2 at 53 – 84 l/min. The dependence for the analyzed parameters is directly proportional: if the casting speed increases, the flow increases and the cooling water pressure also increases, but slowly.

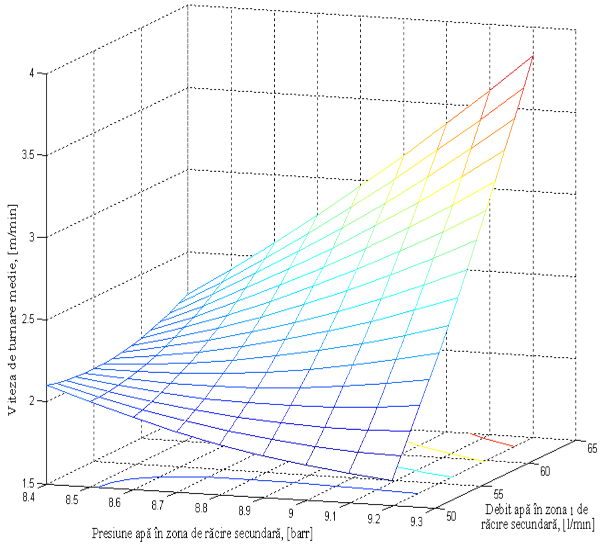

Fig.4 First cooling area for Ø150 mm billet

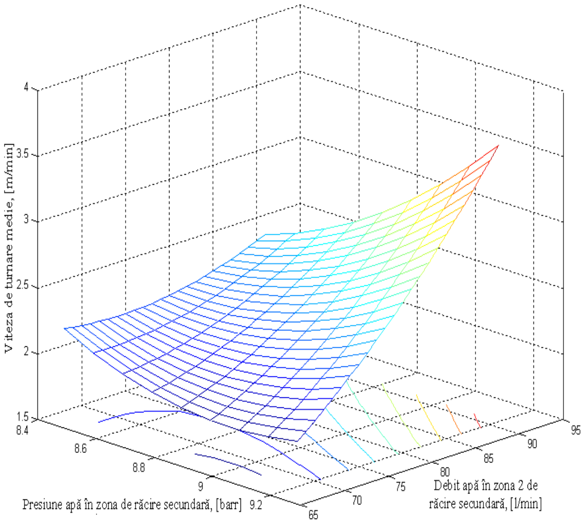

Fig.5 Second cooling area for Ø150 mm billet

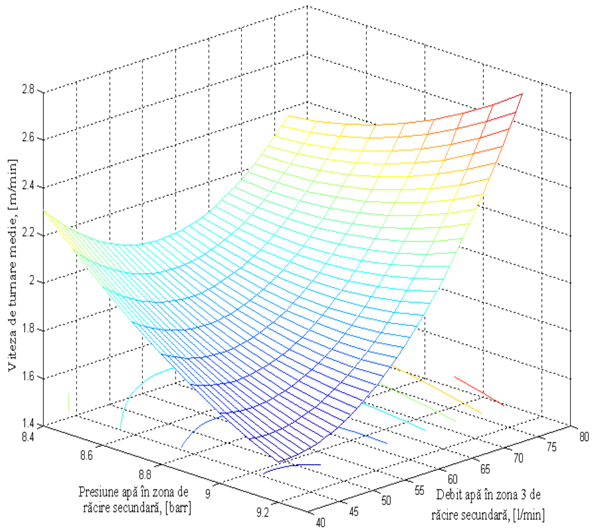

Fig.6 Three cooling area for Ø150 mm billet

For the next three surfaces the global correlation coefficient together with the equation of the regression surface is:

- for Figure 4: the global correlation coefficient: ryx1x2 = 0.7922 and the equation of the regression surface

$$z = 117.4840 -16.8878*u -1.6084*v + 0.1694*u.*v + 0.4466*u.^2 + 0.0017*v.^2 \qquad (4)$$

- for Figure 5: the global correlation coefficient: ryx1x2 = 0.7424 and the equation of the regression surface

$$z = 142.0105 -25.2259*u -0.8354*v + 0.0833*u.*v + 1.0917*u.^2 + 0.0009*v.^2 \qquad (5)$$

- for Figure 6: the global correlation coefficient: ryx1x2 = 0.5080 and the equation of the regression surface

$$z = 62.8048 -10.8913*u -0.4316*v + 0.0388*u.*v + 0.4782*u.^2 + 0.0009*v.^2 \qquad (6)$$

3. CONCLUSIONS

The following conclusions result by analyzing the previously presented data:

- the secondary cooling programme has to be chosen depending on the section of the profile that is to be cast, on the continuously cast steel grade and last, but not least, it has to be correlated with the technological parameters of the casting process. This fact requires in certain cases the correction and the using of another cooling programme, exactly during the casting process, fact that is performed by the process computer;
- for the 240x270 mm profile, the tendency was that of gradually increasing of the colling water flow on the three secondary cooling areas;

- for the 150 mm round, the second area has admitted 30 – 40% higher values in what concerns the cooling water flow comparing to the other two cooling areas;
- the global correlation coefficients have relatively high values, that means a lower dispersion grade and thus the surface equations are possible to be applied with small errors in the industrial practice.

4. REFERENCES

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