THE ANNALS OF “DUNAREA DE JOS” UNIVERSITY OF GALATI
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
N°. 4 – 2014, ISSN 1453 – 083X

IMPROVING SLAB QUALITY THROUGH CONTROL OF COOLING PARAMETERS IN CONTINUOUS CASTING PLANTS

Marian BORDEI, Ștefan DRAGOMIR
“Dunarea de Jos” University of Galati, Romania
e-mail: mbordei@ugal.ro

ABSTRACT

Coupling the continuous casting installations with the rolling ones is a modern process that brings considerable economic benefits. During the continuous casting process of steel slabs, necessary technological conditions must be met in order to obtain some semi-finished products with minimum probability of defect appearance, under the conditions of a maximum amount of heat conservation in development without negatively affecting the productivity of the continuous casting machine.

KEYWORDS: slab quality, cooling parameters, continuous casting

1. Introduction

The conditions which must be achieved by the continuous casting installations, in order to be correlated with the rolling ones (for direct rolling), are the following:

- flawless casting (especially surface casting);

- reducing the thickness of continuous casting slabs;

- maintaining the slab temperature to values over the range of plastic deformation.

In this sense, the temperature conditions for a continuous casting plant can be defined as follows:

- *initial conditions*: at entrance, the steel should be as “cool” as possible (10-30 °C distributor overheating);

- *final conditions*: at exit, the slabs should be as “hot” as possible (approx. 1200 °C) to be rolled directly.

On the surface, heat is removed by contact with a solid cold surface (in the mold) and by spraying with water, air, air-mist (in the secondary cooling zone).

The conditions of steel solidification during continuous casting differ from those during ingot casting by:

- higher cooling speed, especially at the surface, due to the contact with the walls of the mold and the direct spraying in the secondary cooling zone;

- high metallurgical length, which creates a high static pressure in the liquid metal cone;

- smaller casting sections with higher ratio lateral surface/volume, which favors a more rapid evacuation of heat;

- a more sensitive connection between the mechanical strength and the tensions in the solidified crust; overcoming this balance at the expense of the mechanical strength is more prominent in case of curved wire casting, leading to cracks, especially on the surface.

The heat extracted by conduction (through solidified crust – during cooling at the contact with the surface of the mold) is the outer limit of the product cooling, the specific thermal power being, at the beginning of solidification, 2-5 MW/m^2.

The shorter the period of time between the final moment of casting and the beginning of rolling, the higher the temperature of the semi-finished product (therefore, an energy gain). This stage can be reduced by eliminating the repair stage, which involves ensuring a consistently good quality of the continuous casting of semi-finished products. In addition, the temperature of the semi-finished product can be increased by setting some appropriate technological conditions (casting speed, primary and secondary cooling).

In this situation, it may be able to transfer, in hot state, the continuous casting semi-finished products.

The effects are the following:

- reducing the fuel consumption with the appropriate heating rate from ambient to rolling temperature;

- reducing metal losses caused by the scale obtained during the warming of the semi-finished products and defect repair;

- increasing the productivity of the casting plant by increasing the casting speed.

2. Analysis of the main parameters of the continuous casting process

2.1. Overheating liquid steel

Overheating the liquid steel (the difference between the steel temperature and the liquid temperature) is set in the distributor; the overheating must be as small as to prevent the formation of precipitates and to obtain a minimum interdendritic segregation (large equiaxial zone).

The control of the steel temperature in the distributor, meaning the decrease of overheating and maintaining it within narrow limits, has the following effects:

- increasing the casting speed, which results in the improvement of the semi-finished product quality and the increase in productivity of the machine;
- decreasing the exhaust temperature from the processing unit, with implications for energy consumption and refractory materials;
- improving the casting structure by reducing the area occupied by columnar crystals and obtaining a homogeneous structure.

In the experiments that were carried out to optimize the moulding process we followed the variation of the temperature in the distributor for 66 charges from the four groups of steel specified in Table 1.

At the charges followed, the temperature system practised in the distributor was generally low in comparison with the brand technological instructions presented in Table 2.

Table 1. *Temperature variation in the distribution of some steel charges*

Steel group	Charge no.	Temperature in the mold, [°C]		
		minim	maxim	average
I	15	1530	1557	1545
II	22	1527	1554	1541
III	17	1520	1549	1537
IV	12	1522	1555	1535

Table 2. *Comparison of temperature systems from technological instructions and experimental*

Steel group	Temperature in the distributor, [°C]		
	calculate (T_l + 15-30 °C)	recommended in technological instructions	experimental
I	1545-1560	1545-1555	1530-1557
II	1540-1555	1540-1550	1527-1555
III	1535-1550	1535-1545	1520-1549
IV	1525-1540	1525-1535	1522-1555

Several temperatures below the permissible minimum and further from the maximum limit were recorded. The average temperature value in groups, at the charges followed (except group IV), was at the lower limit of the range indicated by technological instructions.

The analysis shows that, while the cooling rate does not lead to the entry of the steel in fragile areas, the quality of the slab is impaired, particularly, by the temperature in the distributor (the overheating of the liquid steel), the metal efficiency is negatively affected by the interruptions in casting, first of all, because of too low temperatures in the distributor (Figs. 1-4).

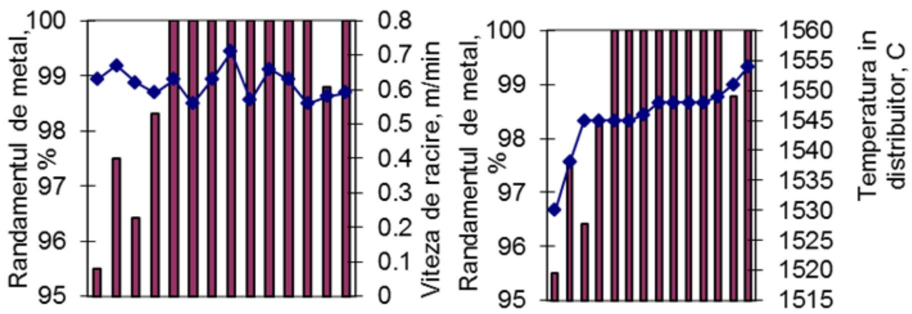

Fig. 1. *Metal efficiency depending on cooling and temperature rates of the steel in the distributor (for steels in group I)*

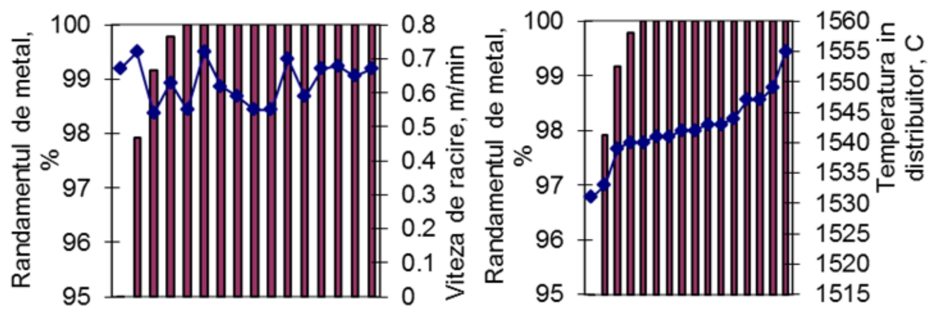

Fig. 2. *Metal efficiency depending on cooling and temperature rates of the steel in the distributor (for steels in group II)*

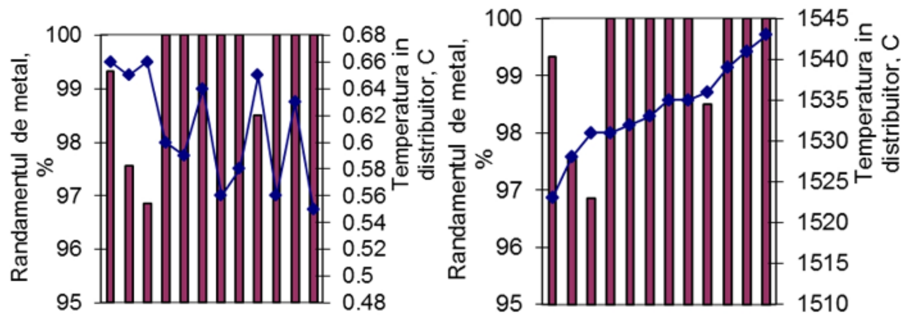

Fig. 3. *Metal efficiency depending on cooling and temperature rates of the steel in the distributor (for steels in group III)*

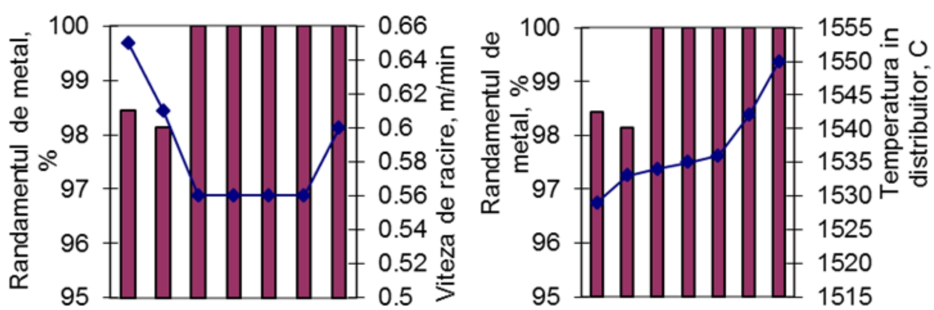

Fig. 4. *Metal efficiency depending on cooling and temperature rates of the steel in the distributor (for steels in group IV)*

3. Conclusions

The intensity of the axial segregation depends on the way the solidification takes place. Short solidification times and low overheatings are favorable to the reduction of the axial segregation with beneficial effects in terms of reduction of carbon, sulphur and phosphorus segregations.

To obtain a proper quality, it is required that the overheating 15-25 °C in the distributor to be reduced so that the waste overheating at entry in the mold to be only 1-7 °C, which can be achieved by using tubular jet nozzles (the role of heat exchanger and temperature controller).