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RESPECTS REGARDING THE USAGE MICRO-COOLERS TO CASTING STEEL

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ABSTRACT
Basic problem, which must solve to casting steel, consists in the smooth ingots procurance insurance from chemical point of view, structural and of mechanical ownerships. For the defects mitigation to solidification classic, it is the needed adjustment to an efficient methods exhaust of warmth from the steel under solidification through the administration of micro-cooler under form of grains to casting. Micro-coolers you utilize with the view of process directing of solidification must achieve conditions series: to have a heaved purity respecting the content of oxide inclusions; the wet micro-coolers uttermost 0, 25%; to not have surface oxidant; to have a certain granulometric composition.
The work clears the aspects related interaction micro-coolers you deal to casting steel over solidification to this. As parameters, which influence the process of solidification they were taken in the dimensions, study micro-coolers, the specific enlargement of micro-cooler, steel temperature in the enlargement moment while as the influenced parameter steel volume in which they acted micro-coolers. Through analysis of regression by the agency of program Excel and Matlab they obtained dependence between meal micro-cooler you utilize to casting ingots from temperature and steel of casting, correlations which they allow the optimal areas establishment variation for temperature of casting, the quantity of micro-cooler dealt respective affected volume percent of cooling to the administration micro-coolers.
Keywords: steel, ingot, solidification.

1. INTRODUCTION
The casting method with micro-coolers is recommended especially for casting long steel ingots that have the greatest tendency of flaw formation, such as: segregations, micro-shrinkages, shrinkage holes, axial porosities and hot cracks [1].
In the situation when the micro-coolants are distributed uniformly, it is created the premises of appearing the solidification grains inside the ingot, meanwhile with the solidification released from the steel interface with the environment (mould, gaseous environment).
The steel crystallization process with exogenous grains introduced through micro-coolers differs substantially from that of the common cast steels. After the analysis of the conditions where the exogenous crystallization grains are formed, there can be three situations, namely:
- the micro-coolers take over partially the steel overheating, in this case it is considered that they do not determine to appear the crystallization centres;
- the micro-coolers remove the steel overheating completely and reach the temperature from the beginning of crystallization, case when they determine to appear several crystallization centres;
- the micro-coolers determine to decrease the steel temperature under the liquidus temperature, they melt partially, becoming crystallization centres.
As a result, the micro-coolers - introduced in the melted alloy while casting – take over the overheating heat and a part of the solidification heat and part of them remain in the hot alloy as

crystallization grains. In order to obtain the desired effect, the micro-coolers have to be distributed uniformly in the hot steel, so that the zones of action and of subcooling created by each micro-cooler should lap or should be tangent.
The used micro-coolers for controlling the solidification process shall fulfil the following conditions [2]:
- to have a high purity regarding the oxide inclusion content;
- the micro-cooler humidity maximum 0.25%;
- the surface shall not be oxidized;
- it shall have a certain grading composition.

2. EXPERIMENTS IN INDUSTRIAL PHASE

The industrial experiments were made at an electrical steel plant having furnaces with a capacity of 100 t. The steel grade 1C45 was made and it was poured in ingots of 9 t (weight), aimed for processing by forging. The steel heat weight was within 110-112 t.
As micro-coolers there were used grains that were obtained from steel wire, cropped at length of 5 mm and having the chemical composition closed to the cast steel. Five grain classes were used, obtained from wire with 2, 3, 4, 5, and 6 mm diameter, having from this point of view 5 work variants. The micro-coolers addition (kg/t) for each of the 5-grain sorts was of 1, 2, 3, and 4 kg/t, so from this point of view we experimented 4 work variants.
The specific micro-coolers additions (kg/t) were established based on the experimental results made in the lab phase and on the data existing in the specialty literature [3].
The experimental lot has as term of comparison the ingots poured in the same conditions after the classical method. The micro-coolers addition was made when filling the mould in a ratio of 30%, 60% and 90% in equal quantities.
A number of 60 ingots were experimented, three for each variant, these being compared in each case with a witness ingot. The indirect method was chosen for casting.
Within the researches made, the industrial experiments were accomplished in the conditions existing in the steel plant, in order to have the possibility of obtaining results as representative as possible, on the one hand, and to be able to implement the obtained results directly in the production, on the other hand.
The experimental ingots were followed on in the technological flow of plastic deformation, sampling specimens for determining the structure and the physic-mechanical proprieties.
By analyzing the obtained structures it is noticed that the grain size is finer and the metallographic constituents are steadily distributed in case of the ingots poured with micro-coolers, while at the ingots classically poured the structure is rougher and the constituents have an unsteady distribution.
So the increase of the plasticity proprieties is determined by the micro-coolant effect upon the structure in solidification phase by stopping the rough dendrite formation and forming a finer structure even beginning from this phase, on the one hand and on the other hand by stopping the segregation.
The obtained data were processed in programs EXCEL and MATLAB resulting equations of multiple correlations and the regression surface.
Figure 1 presents the dependence of the volume affected by cooling on the casting temperature at an ingot of 9t for 3 kg/t micro-coolants added during the casting in order to improve its casting structure.
Figure 2 presents the variation of the used micro-coolant mass for casting an ingot of 9t for a percentage of 33% from it that is affected by cooling.
In Figure 3 there is shown the multiple regression surface between the dependent parameter – the volume percentage that is affected by cooling (V, [%]) and two independent parameters: the specific micro-coolant quantity (m [kg/t]) and the casting temperature (T_t, [^oC]).
Both the graphical representations and the high values for the correlation coefficient highlight the fact that the equations express very well the dependence between the cooling temperature and the volume percentage affected by cooling, respectively the used micro-coolant mass. It is seen that the volume ratio affected by cooling increases quickly enough at the decrease of the casting temperature, so that it is imposed a rigorous control of the micro-coolant mass, respectively of the micro-coolants added into the mould during the steel casting.

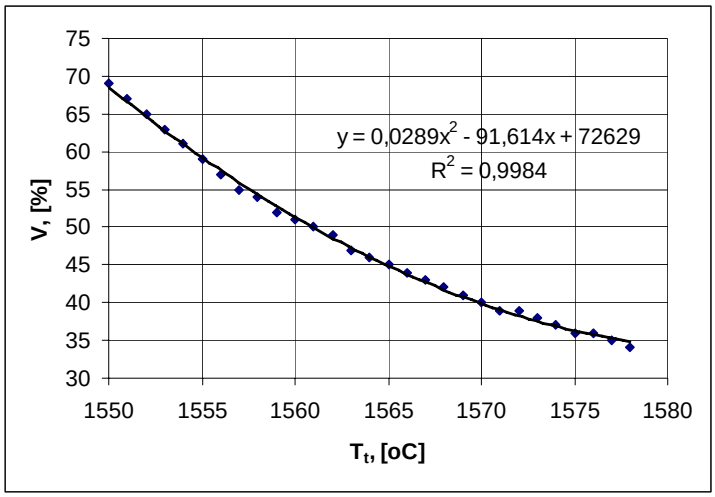

Figure 1. Dependence of the volume affected by cooling on the casting temperature at an ingot of 9t for a specific consumption of micro-coolants of 3 kg/t.

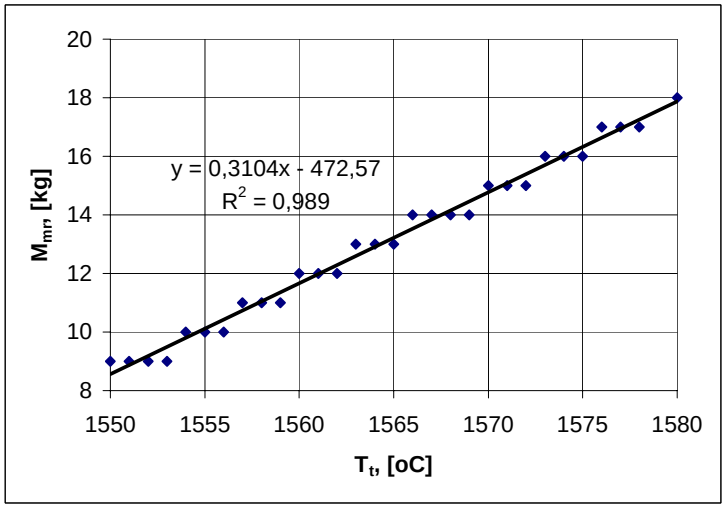

Figure 2. Dependence of the micro-coolant mass on the casting temperature at the ingot of 9t 33% of volume affected by cooling.

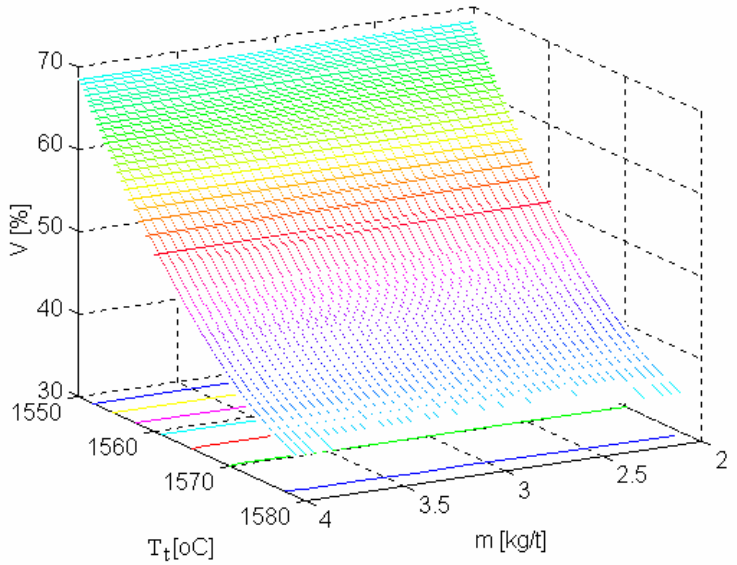

Figure 3. Regression surface for the volume percentage affected by cooling in case of casting the steel with micro-coolants.

3. CONCLUSIONS

The addition of micro-coolers in the steel cast in ingots influences the quality as follows:
- It improves the casting structure regarding its finishing;
- An increase of the strength (with 20-30%) and plasticity (with 15-25%) values is obtained;
- An increase of the structural homogeneity and of the qualitative characteristics takes place;
- Diminishing the shrinkage volume having as an effect the output increase.

Studying the correlation equations in analytical form, but especially in graphical form, it results:
- The micro-coolers diameter varies between 3-5 mm;
- The specific addition of micro-coolers varies between 2-4 kg/t;
- The casting temperature varies function of the steel quality, for the analysed one it is 1560-1580^{o}C;
- The graphic representations allow the plant engineer to establish the micro-coolers addition function of their diameter, the casting temperature and the desired value for the qualitative characteristics.

4. ACKNOWLEDGEMENTS

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