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RESEARCH AND EXPERIMENTS REGARDING THE STRUCTURE IMPROVEMENT OF STEEL INGOTS

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ABSTRACT

The paper present the experiment made with the purpose of improving the structure of steel ingots undergoing smiting by adding microcoolers in the central part of the liquid ingot, to create a new crystallization and solidifying front. Application of this technology allowed the substantial increase in the homogeneity and spreading degree of the dendrite structure, the decrease in the stretch and width of the chemical in homogenates development area and that of the air holes placed at the edge of the primary grains, the reduction of segregation and gas content. It has also been ascertained the increase in the plasticity characteristics of the metallic material (at the same resistance) with 30-50%.

KEYWORDS*: steel, ingot, microcoolers, improvement, characteristics.*

1. INTRODUCTION

The solidifying of steel ingots is associated with important contractions, independent of the purity degree, fact that leads to a certain deterioration of the structure and the appearance of chemical and structural in homogeneity. The mechanism of the solidifying process in these ingots is determined a great degree by thermal phenomena that occur while transmitting the heat from the liquid steel to the environment [1]. These phenomena depend especially on the ratio between the ingot volume and surface, ratio that adjust the speed of heat evacuation from the liquid steel.

The problem that has to be saved to attenuate the deficiencies of classic solidifying is the adaptation of the efficient method of heat evacuation from the solidifying steel. An efficient influent technology upon the solidifying process consists of introduction in the liquid ally of the microcollers [2].

2. EXPERIMENTAL RESULTS

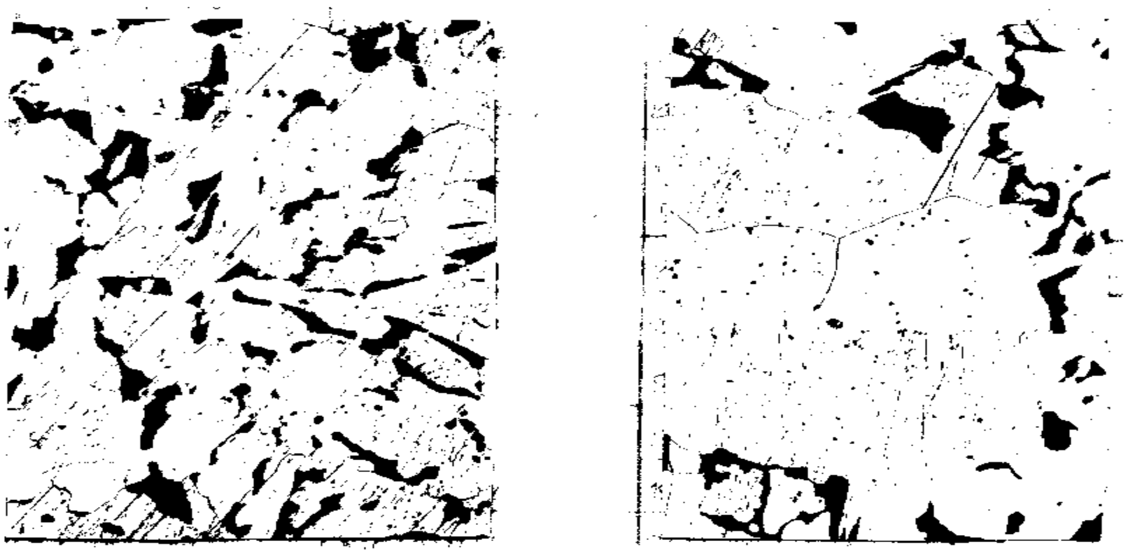
The researches concerning the possibilities of leading the solidifying process have been done on industrial charges of OLC 45 steel on this purpose it has been experimented the introduction in the cast-iron, of different types of microcoolers.

This, it has been administered grains obtained by cutting rolled wire of the same brand as the casted iron. The effect of the microcoolers has been studied in many versions depending on wire diameter and quantity added, at each version with grains experimenting on 20 ingots studied in parallel with ingots of the same charge casted classically.

According to the data from the specialty literature and the results of preliminary trials, it has been established as best the experimenting with the following quantities of added microcoolers: 2-4kg/t with diameters 2-6 mm. The introduction of grains in the cast-iron has been administered in filling percents of 30%, 60% and 90%. In order to study the behaving of the microcoolers in the melted mass there have been introduced wire bands of the mentioned diameters, studying after solidifying their influence on the local solidifying phenomena and the manner of orientation of the solidifying front the melting-time difference (for bars 4 – 5 sec, for grains 3 sec, both from 6 mm wire) is determined by the fact that the specific surface of heat absorption is much bigger for grains than bars.

From these presented above it results that low-diameter grains will melt in a shorter time, which means that in all experimented versions the grains reached the liquid phase. This phenomenon allows a chemical homogenization and in the same time produces a local deep-freezing, accelerating the crystallization process.

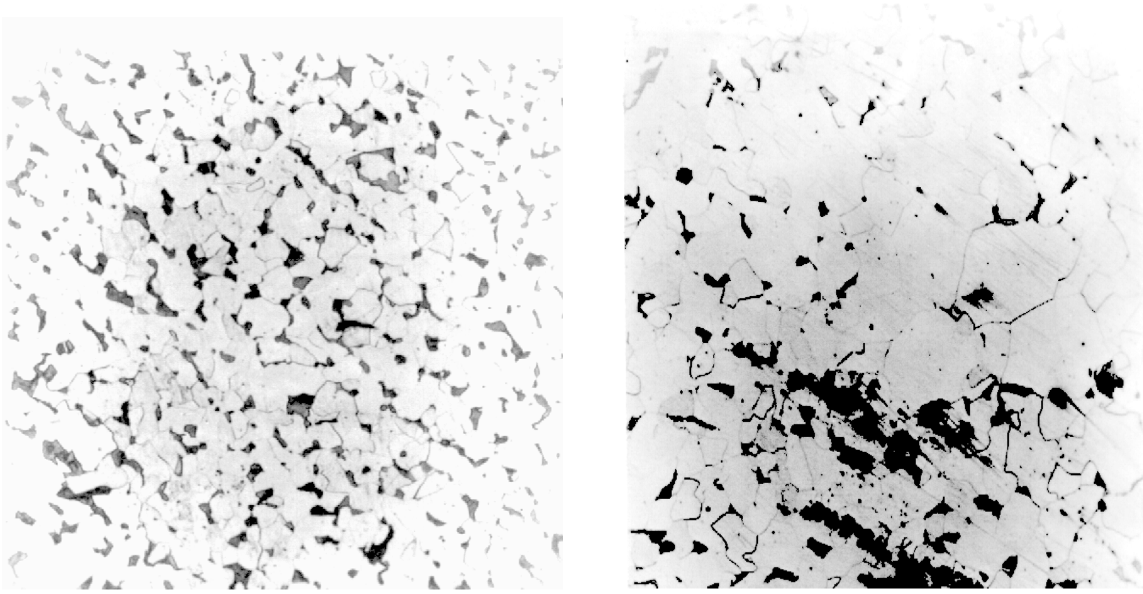
To clarify the real behaving of microcoolers in the mass of liquid steel undergoing solidifying, it has been experimented the introduction in probe moulds of microcoolers in the form of bars of steel wire of 3,5 mm ϕ, the same time with the casting in the moulds of witness ingots. Following the macro and microscopic analysis of taken samples it has been noticed that on a certain area around the microcooler finer crystals have been formed, which shoos that in this region the deep-freezing was more intense (fig. 1).



a. b.

Fig. 1. Sample microstructure:
a – with microcoolers; b – without microcoolers.

The ingots casted this was underwent smiting and from the resulted semiproducts samples have been taken to determine their mechanical characteristics. After the microscope study of metallographic samples collected, there was noticed that in the ingots with added microcoolers a grain refinement is obtained, which leads to chemical homogeneity (fig. 2). There is also obtained an increase in metal extraction, of about 90% in grains-casted ingots compared to 82% in the classical casted ones.



a. b.

Fig. 2. Microstructure:
a – with microcoolers; b – without microcoolers.

The charges have been studied on in the manufacturing flow, samples being taken from each ingot to determine the comparative physic-mechanical properties between the steel classically casted and that with microcoolers. It is noticed an increase in the resistance properties and the plasticity represented by stretching and striction is increased by 20%. Therefore the increase in the plasticity properties is determined by the effect of the microcoolers on the structure in the solidifying phase by stopping the formation of gross-dendrites and the formation still from this phase of a finer structure.

The data concerning the mechanical trials have been processed using the MATLAB and SIDHD 5 program and the results obtained showed in figures 3, 4, 5, and 6.

Equation of regression surface is:

$$R_{p0,2} = 3,578 \cdot m^3 + 0,231 \cdot d^3 + 0,908 \cdot m^2d – 0,541 \cdot md^2 – 25,903 \cdot m^2 – 8,868 \cdot d^2 + 5,806 \cdot md + 85,360 \cdot m – 22,75 \cdot d + 391,137$$

$$R_m = - 0,407 \cdot m^3 + 0,998 \cdot d^3 + 0,336 \cdot m^2d – 0,055 \cdot md^2 – 5,351 \cdot m^2 – 7,8 \cdot d^2 + 0,033 \cdot md + 61,6 \cdot m + 4,97 \cdot d + 599,10$$

$$A_5 = 0,230 \cdot m^3 + 0,220 \cdot d^3 – 0,032 \cdot m^2d +0,041 \cdot md^2 – 2,789 \cdot m^2 – 1,22 \cdot d^2 – 0,379 \cdot md + 12,650 \cdot m + 1,88 \cdot d + 19,828$$

$$Z = 0,602 \cdot m^3 + 0,415 \cdot d^3 – 0,029 \cdot m^2d – 0,013 \cdot md^2 – 6,822 \cdot m^2 – 2,06 \cdot d^2 + 0,0198 \cdot md + 24,720 \cdot m +0,757 \cdot d + 43,709$$

$R_{p0,2}$, R_m, A_5, and Z - mechanical characteristics;
m – specific quantity of microcoolers;
d – diametre of microcoolers.

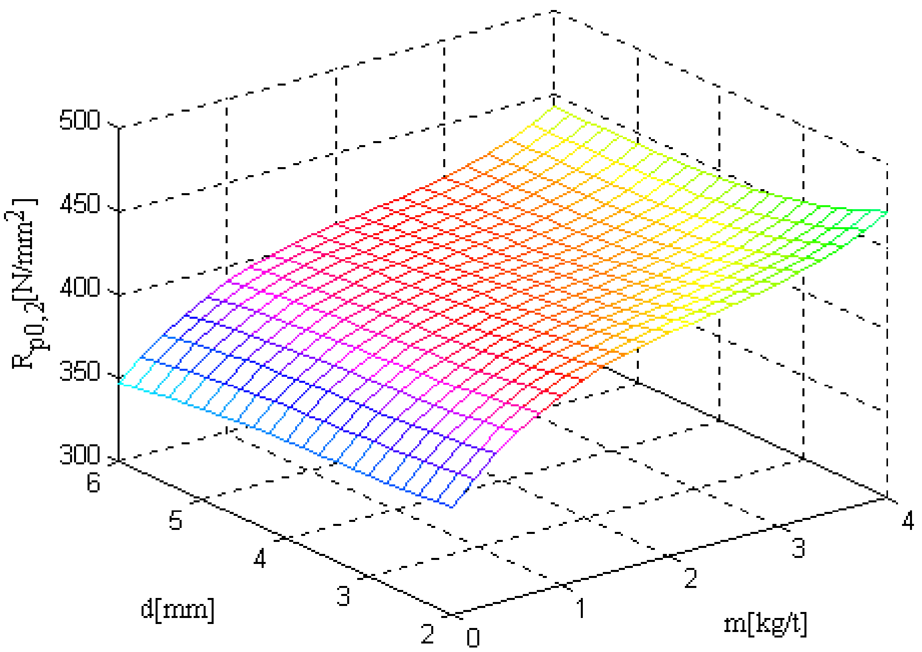


Fig. 3. Regression surface $R_{p0,2}$.

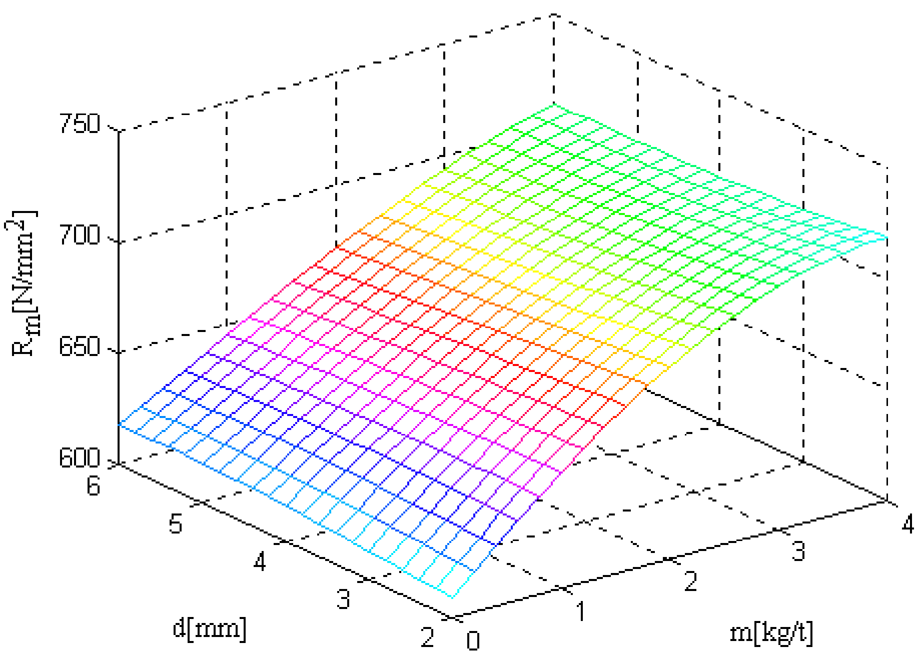


Fig. 4. Regression surface R_m.

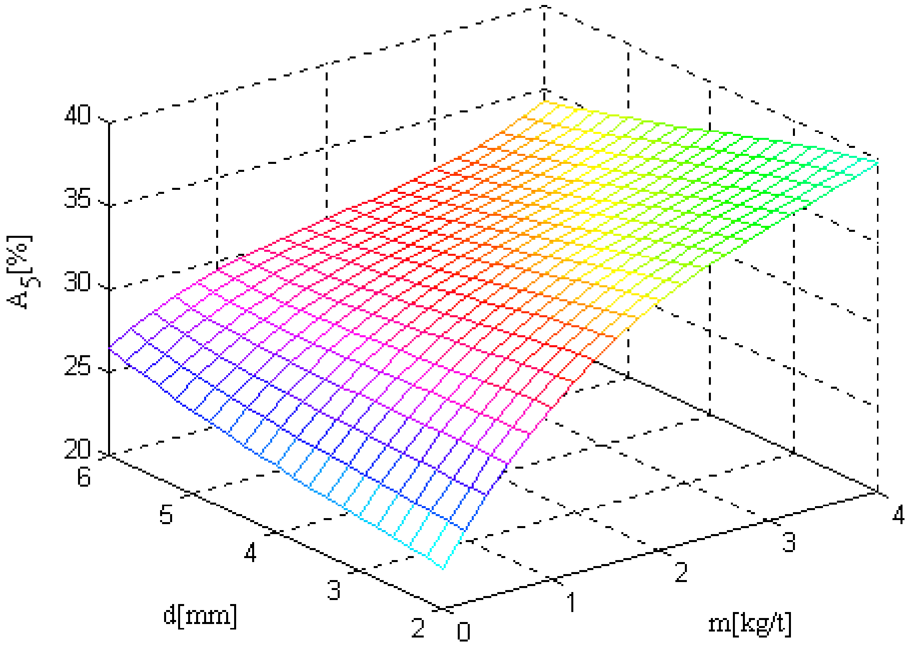


Fig. 5. Regression surface A_5.

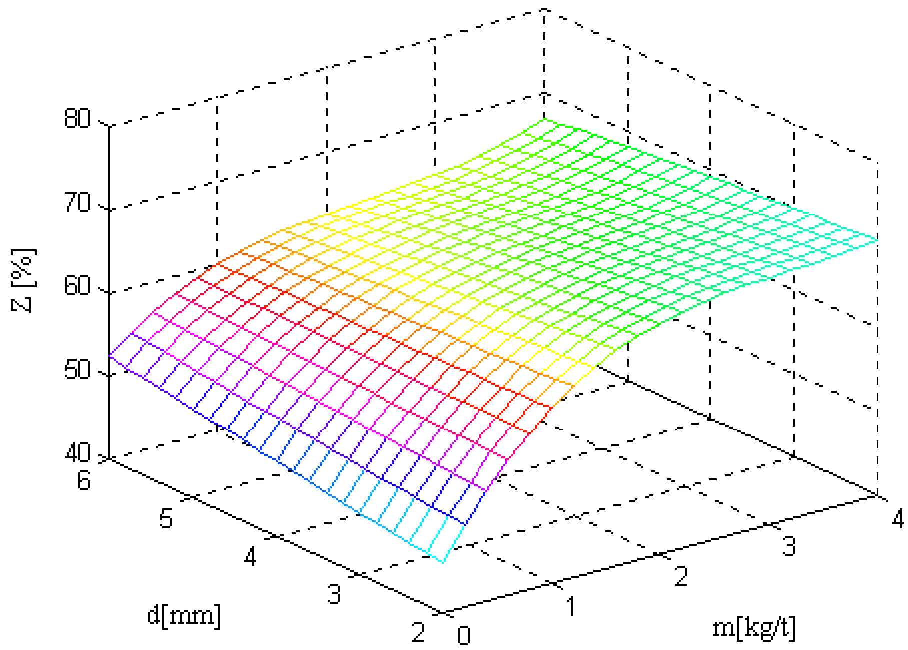


Fig. 6. Regression surface Z.

It has been remarked, after studying the curves variations for the determined mechanical characteristics, a certain increase in all mechanical ($R_{p0,2}$, R_m, A_5, and Z) characteristics and a significant homogeneity of their values.

3. CONCLUSIONS

Following these experiments, the following conclusions have been drawn:
- the modification of marginal air holes zone meaning their migration to the interior of the ingot;
- the microblisters from the head of the ingot stretch on a smaller surface compared to the classically casted ones;
- it has been obtained a flattening of the blisters format in the ingots casted with microcoolers and the reduction, this way, of their volume, resulting in a substantial increase of metal extraction, this effect of increase being proved to be direct proportional with the reduction of casting temperature and the increase in the quantity of added microcoolers;
- it has also been obtained a reduction of the temperature gradient in the steel crystallization interval of 1,5 – 2 times and a more rapid uniformization of it on the ingot's cross-section;
- a substantial increase in the structural homogeneity and the qualitative properties represented by resistance and plasticity;
- a refinement of the casting structure;
- an increase in extraction, an average of 88 – 90%.

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