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INTERNATIONAL CONFERENCE of SCIENTIFIC PAPER
AFASES 2011
Brasov, 26-28 May 2011

VIBRATING THE COOLING MELTS METAL FINISHING SOLUTION STRUCTURES

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ABSTRACT:*The influence of purifying processes by metallic melts degassing and refinement it is not a recent technological news. The processes of local undercooling, nucleation, crystallization and solidification of metallic melts represent a future technical solution in quality increase of castings. The work presents the results of some research experiments in this field.*

INTRODUCTION

At high undercoolings appear many centres of crystallization embeding all impurities. At low undercooling, crystals grow in dendritic form, and impurities are also embeded by the growth of branches I and II type.

Analysis of the thermophysiscs conditions of crystallization pressure development shows that is has a peculiar role in ingots and castings solidification. To identify the influence rate of different parameters on the movement process or impurities embedding, we will show how forces influence in the area of stranger particles for the alloy in solidification progress (fig.1).

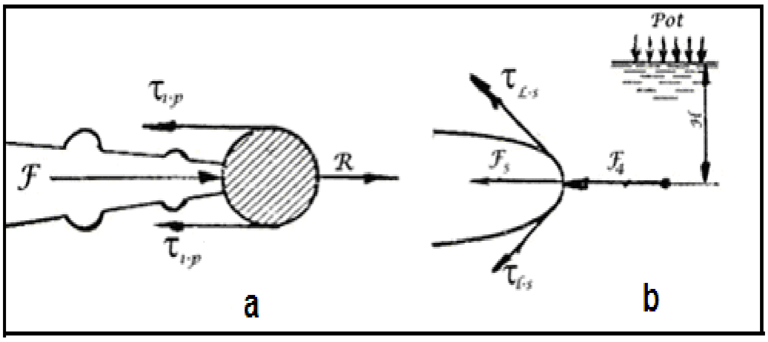

Fig.1. Representation of forces action in area of stranger particles in the liquid alloy :a) interaction with particle; b) exceeding the ferrosstatic pressure

METODOLOGY

Greatest effects of ultrasonic cavitation are those observed in the metals crystallization process.

More higher the nucleation speed and lower the growth speed is, more finer the grains structure will be. Number of grains is determined by relation:

$$N=\sqrt{\frac{n^3}{c^3}} \quad (1)$$

n – crystallization centers

c – growth speed.

The cavitation will appear in ultrasonic melts, if the acoustic pressure exceeds a specific value (table 1) feature to every metal.

Table 1. Values of P_t and P_c for some metallic materials

Material	**Threshold power P_t [W]**	**Incepient power of cavitation [W]**
Aluminium	400	400
Bismuth	60	50
Cadmium	400	-
Lead	250	200
Antimony	300	300
Tin	350	250
Zinc	500	-

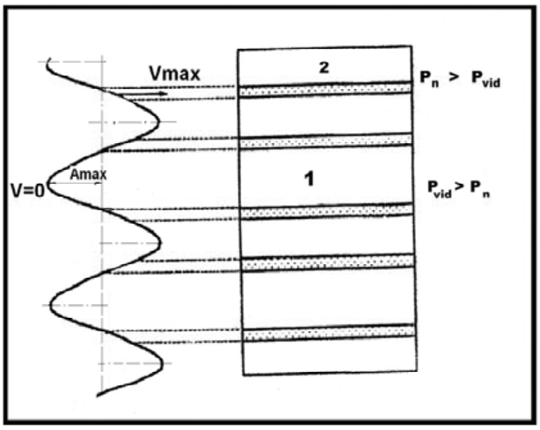

Fig. 3. Distribution of elastic wave in molten liquid mass : 1 – compression zone; 2 – dilatation zone

RESULTS

Microstructure of the sample obtained without vibration is presented in fig.4.a. Characteristic elemenents can be observed: columnar and equiaxed crystal, shrinkage, inferior cone formed by individual crystals precipitation zones. Obtained sample by vibration action in crystallization period has a different macrostructure than the control sample fig.4.b.

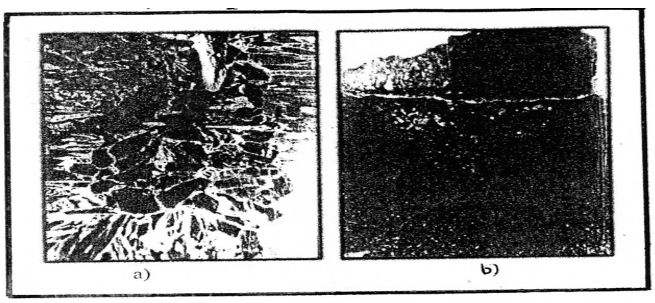

Fig. 4. Aspect of microstructure in a salol sample: a) without vibration; b) after vibration

CONCLUSIONS

In fig.5.a are presented the typical diagrams recorded during the crystallization process of samples without vibration, and fig.5.b shows the diagrams by vibration action with a frequency of 94Hz and amplitude 1mm. OA sector corresponds to the thermostatic period of molten mass, and AB corresponds to the cooling period. At the beginning moment of crystalization latent heat of phase transformation is released, and thus, it is explained the bounce of temperature of BC sector. CD sector corresponds to the cooling of solid phase.

Comparative analysis of crystallization process diagrams (thermograms) of ingot in control experiments and by the vibration action indicates that vibration in beggining state of process (AB sector) contributes to temperature equalization in the whole wolume of sample.

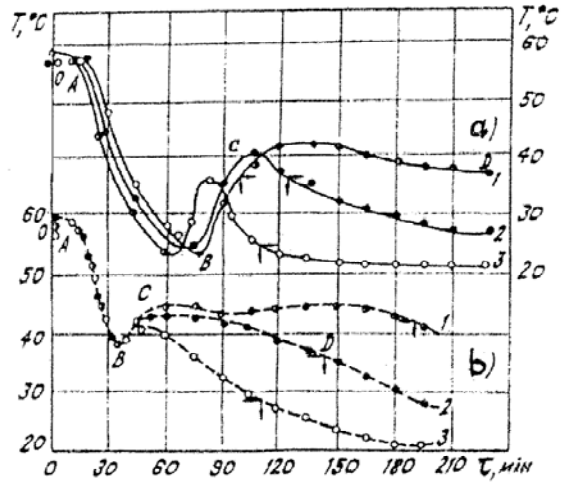

Fig.5. Solidification diagram of salol sample: a- no vibration; b - vibration

In fig.6. it's been highlighted the dependence of maximum undercooling with elastic oscilations frequency. It can be noticed that an oscilations frequency takes place, which leads to the decrease of maximum undercooling zone of molten mass (hatched section).

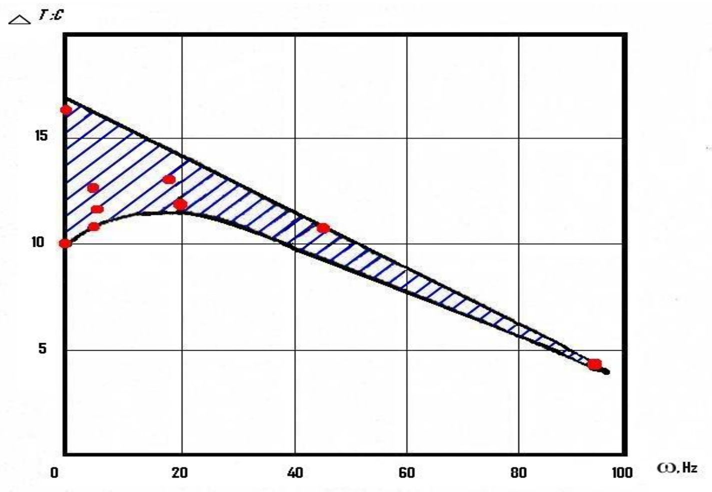

Fig.6. Dependence of molten mass undercooling with elastic oscilations frequency

Main effect of forced oscillations is the movement of waves by pressure and depression which alternates forcing the cyclic movement of alloy mass, with formation of extra crystallization centers and dendrites fragmentation.

Once the amplitude increases, it increases the proportion of equiaxed crystals and decrease the columnar ones. Alloy vibration during all the solidification time, leads to the decrease of grains by about three times. Influence of mechanical vibrations at metals casting are characterized by:

- increase of undercooling degree by increase of alloy - mould heat transfer;
- creating new nuclei for fragmentation of forming solid phase;
- activity of crystallization surfaces;
- at high solidification rates and small temperature gradient it appear nuclei in whole casting section, when the mould can continuously remove the crystalliyation latent heat;
- mechanical vribrations decrease the thermal gradient and increase the solidification rate favoring endogenous growth;
- the decrease of distance between dendritic branches leads to shorter time of homogenization thermal treatment;
- materials with fine grains are recomanded as materials subjected to plastic deformation;
- improvement of properties results from the fine distribution of microporosity and secondary phases during blocking the dislocations at grains bonders;
- columnar crystals zone can be eliminated for non-ferrous materials: Al, Cu, Sn, Zn, etc. And especially for their alloys (bronze, brass);
- mechanical vibrations influence the interphase surface tension (solid – liquid) by decreasing it, which leads to the decrease of minimum radius of nuclei from which they can't melt anymore but develops.