Principles of Ultrasonic Treatment: Application for Light Alloys Melts

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Abstract. Scientific and practical aspects of ultrasonic treatment of light alloy melts followed with development of acoustic cavitation in liquid metals are discussed. It is shown, that the ultrasonic melt treatment raises the rate of degassing and fine filtration of light alloy melts and very strongly effects ingot structure. Furthermore, an inherited effect of ultrasonic melt treatment on the structure and properties of wrought light alloy semis is shown.

Keywords: acoustic cavitation, non-dendritic grain, dendritic parameter, cavitation nuclei, solidification nuclei, fine filtration

Abbreviations

UST ultrasonic melt treatment
Usfirals-process fine filtration with ultrasound

The current consideration of the melt, on the one hand, as a complex microheterogeneic system and, on the other hand, the severity of requirements for the quality of wrought light alloy semiproduts leads to the need for the search for new physical means to act on liquid and solidify metal. At present, some techniques have found their commercial application—vacuum treatment of the melt, electromagnetic stirring, continuous casting in an electromagnetic mould and oscillation.

Among physical means of action on the melt, the treatment of the melt with powerful ultrasonic waves plays as important role.

Although the effectiveness of such treatment was found long ago [1–4], this technique of an active treatment of the melt during melting and casting of light alloys has been brought into a commercial level only recently.

Acoustic cavitation in light alloys melt

One of the remarkable features of the action of a powerful ultrasound on liquid metal is the creation of cavitation phenomenon in the melt. Application of an alternating pressure above a specific threshold (about 0.8–1.0 MPa), as it takes place at propagation of a powerful ultrasound, leads to breaks of the liquid in places, where discontinuities present and to formation of fields of cavitation spaces.

Spaces (bubbles) generating in places of breaks behave differently under action of ultrasound. Some of them can pulse without the change in gas content over their whole volume.
On the contrary, the others grow actively due to the action of tensile stresses of the sound wave and one-direction diffusion of hydrogen from the melt into a bubble.

A part of the formed cavitation bubbles does not have time to fill with gas solved in the melt and collapses under the action of compression of the sound wave. In this case, local pressure pulses (up to 1000 MPa) and cumulative liquid jets, with their speed being up to 100 m/s are formed.

Figure 1 shows typical oscillograms of three regimes of ultrasonic treatment of light alloy melts: a) no cavitation; b) beginning or the threshold of cavitation and; c) developed cavitation.

The most important feature of formation and development of cavitation effects in melts is the connection of cavitation with the liquid metal purity in terms of non-metallic dispersive impurities. As a liquid, the real melt is a long way from ideal and contains many non-soluble impurities (so called “plankton” of particles). Cavitation strength of the melt and its structure, after solidification, is strongly related to metal purity in terms of these hard nonmetallic inclusions. As a rule, hard dispersive inclusions present in a real melt adsorb gas phase through their surface. That is why the cavitation develops in a real melt just on “melt-hard non-wettable particle of inclusion” interface.

As for melts of aluminium and magnesium alloys actively interacting with hydrogen and oxygen, these inclusions consist of, mainly, their own oxides, i.e., stable chemical compounds with a low degree of thermal dissociation. It is well known, that these dispersive particles are not wetted by melts and do not take part in the solidification process. On the other hand, these dispersive non-metallic impurities are perfect nuclei of cavitation and degassing of the melt.

**Refining of melts in an acoustic cavitation field**

Ultrasonic melt treatment (UST), before the beginning of solidification, has a noticeable effect on melt refining processes and thereby eliminates gas and solid non-metallic inclusions.