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APPLICATION OF ACOUSTIC EMISSION FOR DETERMINATION OF INITIAL TEMPERATURE OF CASTING MOULD

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It was shown in this paper that, thermal stresses and accompanying them plastic strains, generated during solidification and cooling of casts of metal alloys, were the sources of acoustic emission. For casts, which phase α is deformed by slip, there is a possibility of determination of initial temperature of casting mould by means of acoustic emission.

1. Introduction

While cooling there arise thermal stresses in the metal alloy castings, which are caused by different temperatures of casting parts. The temperature difference depends on thickness of a casting walls and initial temperature of a mould. Thermal stresses should not cause plastic strain of material, which may lead to micro- and macro-cracks of the casting. In [1] the authors dealt with a problem of influence of plastic strain type of a solidified casting layer on acoustic emission (AE). For the research on casting solidification and cooling two alloys with different plastic strain type of a solidified layer were chosen: aluminium alloy AK9 and zinc alloy Z41.

The α phase (metallic matrix) in aluminium alloys undergoes a deformation by slip, and the η phase in zinc alloys undergoes a deformation by twinning.

2. Description of the experiment

Components of a synthetic AlSi8,6 (AK9) alloy were melted in a graphite melting pot under deoxidising and covering slay (degasal T200) in a chamber furnace. Metal oxides in the liquid alloy were refined by means of degasal T200, which in a quantity of 0.1% of charge was immersed and mixed with the metal. For gas refining "Probatem fluss Al 224" in a quantity of 0.1% of the charge was used and placed in a graphite bell. The process was carried out at the temperature of 740°C – 745°C. The mould was poured with the alloy of which the temperature was 755°C – 760°C.

The zinc alloy Z41 was melted in a graphite melting pot under the cover of charcoal. The mould was poured with the alloy at 490°C. Castings were made in a truncated cone mould with a volume of 79 cm^3 (castings solidifying with a free contraction) and a cone-with-rings mould with a volume of 97 cm^3 (castings solidifying with an inhibited contraction). Application of different materials for different parts of the mould allowed the authors to obtain directional solidification of the castings. The base of the mould was made of aluminium alloy AK11, the middle part — of carbon steel, and the upper part — of cast iron Zl200. In the upper part of the mould, for feeding of a casting, there was a feedhead which dimensions allowed to have metal in the liquid state for long enough.

The researches were carried out in different technological conditions. The castings made of AK9 alloy solidifying with a free contraction were tested changing in the consecutive experiments the initial temperature of the mould: 22°C, 155°C and 270°C. The initial temperature of the mould for castings solidifying with an inhibited contraction was 20°C. The Z41 alloy castings were tested in the mould with the initial temperature of 22°C for both solidification with a free contraction and solidification with an inhibited contraction. The temperature measured in two points of the casting axis and the mould temperature were recorded during solidification. The elastic wave of acoustic emission (AE) was received by means of two steel wave-guides, the tops of which were placed in the casting axis with a distance of about 3 mm from the tips of thermocouples. The wave-guides 1 and 2 were placed 17.5 mm and 52.5 mm from the base of the casting respectively. The AE signal was recorded as an envelope by means of Teac Data Recorder in the frequency band to 20 kHz. This recorder was connected to a PC equipped with an input card Data Recorder Interface Board model Quik Vu II, the software of which enabled automatic acquisition of the AE envelope.

3. Results of the experiments

During solidification of AK9 castings a slow increase in RMS value of continuous AE envelope was observed. A sudden decrease in RMS value of AE was observed during their cooling (see Fig. 1 a, b, d). The biggest decrease occurred in the castings, which solidified with an inhibited contraction, and it was not observed in the case of solidification in the mould with the initial temperature of 270°C (see Fig. 1 c). In this case the RMS value of continuous AE was slowly decreasing.

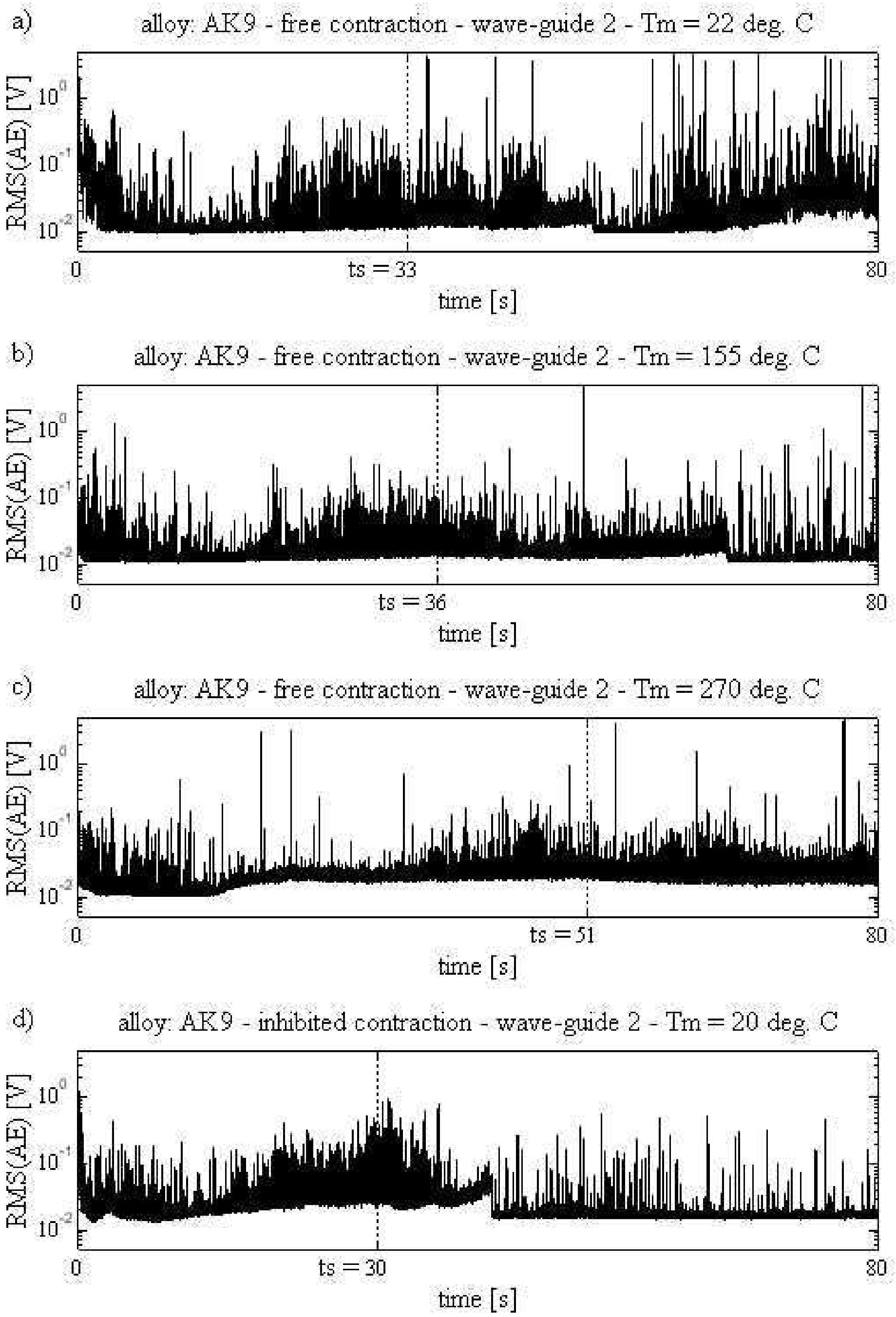

Fig. 1. AE signal envelope generated during solidification of AK9 alloys: a) casting solidifying with a free contraction, $T_{\text{in.mould}} = 22°\text{C}$, b) casting solidifying with a free contraction, $T_{\text{in.mould}} = 155°\text{C}$, c) casting solidifying with a free contraction, $T_{\text{in.mould}} = 270°\text{C}$, d) casting solidifying with an inhibited contraction, $T_{\text{in. mould}} = 20°\text{C}$. ts — the end of the solidification.

For the Z41 castings solidifying both with a free and with an inhibited contraction any sudden changes of the AE envelope were not observed. The influence of the contraction inhibition in the solidified layer (the resistance of the mould) can be seen as continuous AE. The inhibited contraction of the solidified layer is observed in the form of subsequent AE impulses.

There is a continuous strain of the material. In the castings solidifying without contraction inhibition this phenomenon is less intensive (see Fig. 2).

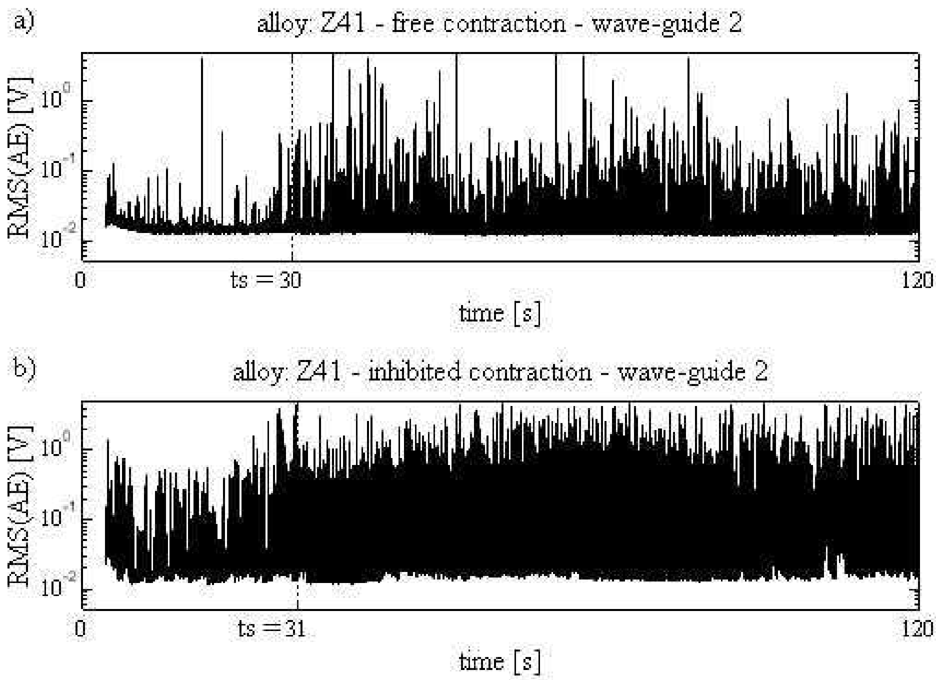

Fig. 2. Envelopes of the AE signal generated during solidification of Z41 alloy castings: a) casting solidifying with a free contraction, b) casting solidifying with an inhibited contraction. *ts* — the end of the solidification.

4. Conclusions

The results of research on solidification and cooling of AK9 castings show that the initial temperature of the mould, which ensures minimisation of thermal stresses in the casting, can be determined basing on the analysis of AE signals. In the experiment, in order to minimise plastic strain of the material and to avoid micro- and macro-cracks the initial temperature of the mould should be between 155°C and 270°C.

The explanation of the problem of influence of plastic strain in solidifying castings on acoustic emission and the development of a method of selection of the initial temperature of the mould basing on the analysis of AE signals, need further research and taking more alloys and more initial temperatures of moulds into account.

References

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