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LOG-NORMAL DISTRIBUTION OF HETEROGENEOUS NUCLEATION SUBSTRATE IN THE AZ91/SiC$_p$ COMPOSITE

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1. Introduction

The grain size of magnesium primary phase in the AZ91/(SiC)$_p$ composite substantially affects their mechanical properties. The effect of the SiC particles in refining the grain size in the matrix phase is not attributed only to enhanced nucleation. There are other effects such as restriction of grain growth arising from the pushing of particles. Particles being pushed could, for example, impede solute redistribution at the solid-liquid interface [1].
The literature offers many examples of the application of the simulation method for the heterogeneous nucleation. One of this method is based on the hemispherical cap model proposed by Greer et al. [2, 3]. It allows a prediction of the grain size as a function of the particle size log-normal distribution, the volumetric content of ceramic inoculants, the cooling rate and the alloy constitution. Because used size of SiC particles (45μm) and fact that these particles are not good inoculants for AZ91 alloy, the aim in this work is to develop a log-normal distribution of heterogeneous nucleation substrates.

2. Experimental

The magnesium alloy AZ91, with about 9 Al, 0.6 Zn, 0.2 Mn, 0.03 Si, 0.002 Fe, 0.003 Cu and 0.001 Ni (all wt%), was selected as the matrix for this work. The sample contained 4 wt% sharp SiC particles (from *Polmineral*) with nominal arithmetic mean diameters of 45 μm. The AZ91 alloy was melted in a steel crucible, using an electric resistance furnace filled with SF_6/CO_2 shielding gas, and kept at 700°C for one hour before adding the SiC particles preheated to 450°C. The melt was mechanically stirred for two minutes to ensure a uniform distribution of the SiC particles (similar to the procedure of Luo [4]), and then cast into a resin-hardened sand mould. The mould was designed to produce four 100×100 mm plates with a thickness of 10, 15, 20 or 30 mm, giving a range of cooling rates.

3. Results and discussion

The developed algorithm is based on next input data: experimental values characterizing the composite (maximal supercooling, grain densities), thermodynamic parameters of the composite (volumetric entropy of fusion and interfacial energy at the boundary liquid/crystallite) and

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assumed total number of nucleation substrates, interval of substrate size, within which a value of geometric mean will be looking for, interval of a standard deviation, integration step, maximal number of integration steps and the assumed tolerance for integral calculations accuracy. The input data for algorithm are ΔS_V=6.51·10^5 Jm^{-3}K^{-1} and $\sigma_{l/c}$=0.115 Jm^{-2} [5]. These data allowed determining the nucleation substrate size distribution for the AZ91/4%SiC$_p$ composite described by equation (1) and showed in the Fig. 1.

$$N(d)=\frac{1\cdot 10^{11}}{1.675\cdot d\sqrt{2\pi}}\cdot\exp\left(-\frac{\left(\ln(d)-\ln(1.4357)\right)^2}{2\cdot 1.675^2}\right)=\frac{1\cdot 10^{11}}{4,199d}\cdot\exp\left(-\frac{\left(\ln(d)-0.361\right)^2}{5,611}\right) \qquad (1)$$

where: d – mean diameter of nucleation substrate, m.

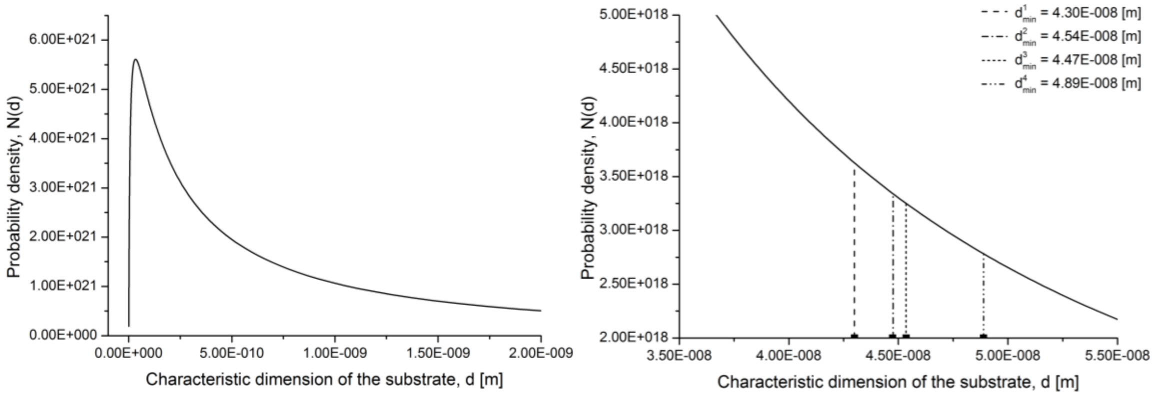

Fig. 1. Diagram of nucleation substrat size distribution for the AZ91/4%SiC$_p$ composite on the base of eqution (1)

4. Conclusions

Used algorithm allowed determining the nucleation substrate size distribution for the composite and described by equation (1). Equation (1) and given cooling rate used in the free-growth model allowed to calculated grain density of magnesium primary phase in the AZ91/4%SiC$_p$.

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