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"STATISTICAL DETERMINATION OF FITTING PARAMETERS IN MODEL FOR PRIMARY PHASE MAGNESIUM NUCLEATION: AZ91/SiC COMPOSITE"

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INTRODUCTION

Grain size is one of the most important structural characteristic that determining mechanical properties. Knowing element properties, the proper application regions for it can be chosen to achieve best mechanical properties and performance.

MODEL DESCRIPTION

In the mathematical model it is assumed that heat transfer is governed by Fourier – Kirchhoff (FK) equation:

$$\frac{\partial T}{\partial \tau} = \frac{1}{c_p \rho} div(-\lambda grad T) + \frac{q}{c_p \rho}$$

where:
T[K] – is temperature; τ [s] – time; c_p [J kg^{-1} K^{-1}] – specific heat; ρ[kg m^{-3}] – density; λ [W m^{-1} K^{-1}] –thermal conductivity;
$q = L\,(df_s/d\tau)$ [W kg^{-1}] – heat of crystallization.

q - is a parameter determining the amount of heat evolved in the crystallization process, and is a function of fs depend on the number of grains appearing over time and the radius growth rate of grains. After a period of nucleation only receive an increase of grains.

Table 1. Chemical composition of AZ91 alloy, wt. % determined using ICP - OES VARTIAN Vista MPX

AL	Zn	Mn	Fe	Be	Si	Cu	Ni
8.5	0.64	0.23	<0.002	10 ppm	0.03	0.003	0.001

NUCLEATION RATE

Nucleation rate can be described on the basis of models of nucleation of grains such as:

-Oldfield nucleation model :

$$N_V(T) = \psi (T_N - T)^m, \left[m^{-3}\right]$$

-Fras nucleation model:

$$N_V(T, d_{SiC}) = \lambda(d_{SiC}) \exp\left(-\frac{b(d_{SiC})}{(T_N - T)}\right)$$

where:
T[K] is actual temperature; d_{SiC} [m] is the particles mean diameter; λ [m^{-3}], b [K] denotes model adjustment parameters; T_N – is nucleation temperature; ψ, m – ucleation parameters determined experimentally.

EXPERIMENTAL PROCEDURE - COMPOSITE CASTING

The composite with AZ91 (Table 1) metal matrix and SiC reinforcement particles was prepared. Three castings were prepared for different SiC particles size, the sizes were: A – 10 μm, B – 40 μm, C – 76 μm.
The specimens were taken from the region near to the thermocouple. Thermoanalysis data was used for cooling speed and under-cooling determination for each sample.

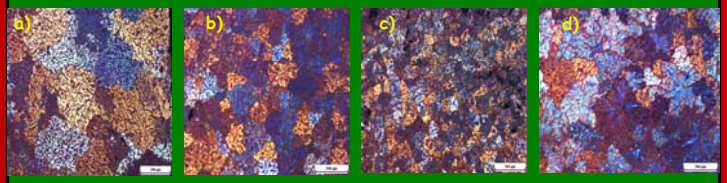
Table 2. Conditions comparison for castings made in Chair of Casting Research, Leoben

Casting conditions			
Casting symbol	A	B	C
Particles size, [μm]	10	40	76
AZ91 mass, [g]	5960	6250	5800
Ambient temperature, [°C]	22	22	24
Furnace temperature, [°C]	750	750	750
Particles temperature, [°C]	320	320	320
In-mould temperature, [°C]	100	100	100
Stirring time, [s]	240	180	180

ETCHING

Etching of the specimens was performed according to the procedure described by the Maltais.The etched specimens were examined using a light optical microscope Carl Zeiss AXIO Imager.A1 with cross polarized light and λ filter. The images on computer display reveals arms of different dendritic grains as areas with different colours.

Optical micrographs of the etched samples viewed under cross polarized light using λ filter for different AZ91/SiC composites (Examples of the etching effect): a) 0% of SiC; b) 2% of SiC, particles mean diameter 40 μm; c) 0.1% of SiC, 10 μm; d) 3.5% of SiC, 76 μm.



GRAIN DENSITY MEASUREMENT

Data gathered from optical micrographic analyse was then used to calculate the grain density N_V. To find this value from optical analysis data, the Saltykov can be used:

$$N_V = \frac{2}{\pi} N_a \left(\frac{1}{d}\right)_{mean}$$

RESULTS OF THE ANALYSIS

N_V on undercooling dependence for **10 μm** particles:

$$N_V(T) = 1.7 \cdot 10^{14} \exp\left(-\frac{43.21}{T_N - T}\right), \quad R^2 = 0.993,$$

N_V on undercooling dependence for **40 μm** particles:

$$N_V(T) = 3.9 \cdot 10^{15} \exp\left(-\frac{93.83}{T_N - T}\right), \quad R^2 = 0.984,$$

N_V on undercooling dependence for **76 μm** particles:

$$N_V(T) = 9.4 \cdot 10^{16} \exp\left(-\frac{135.09}{T_N - T}\right), \quad R^2 = 0.999.$$

Effect of statistical analysis:

$$N_V(T, d_{SiC}) = 9.1 \cdot 10^{14} \exp\left(3.1 \cdot 10^4 - \frac{32.6 + 1.4 \cdot 10^6 d_{SiC}}{T_N - T}\right) \quad R^2 = 0.932.$$