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Shaping the Al-Si alloy microstructure and properties using the multipoint water mist cooling system

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The paper presents the test results of crystallization process, structure and mechanical properties of several near- and hyper-eutectic Al-Si alloys casted in metallic mold. In casting process was used the multi-point water mist cooling system of mold. The cooling system increases the intensity of heat transfer in a cast-casting die setting and causes the local occurrence of directional solidification effect. The paper presents the results of the crystallization process that was investigated by the TDA thermographic method with use of metallic probe that was cooled during the tests with water mist. It was shown that the use of mold cooling water mist enables the development of microstructure and mechanical properties of Al-Si alloys. In addition, a wide range of solidification temperature of hypereutectic Al-Si alloys particularly increases the possibilities to influence of cooling rate on the size and the phase morphology of microstructure and properties as well.

Keywords: *Casting Die, Cooling, Al-Si Alloy.*

1. Introduction

The ongoing work is a part of studies on the application of water mist system for multipoint sequential cooling of casting die to produce Al-Si alloys castings [1-6]. The essence of the research is the efficient cooling mist of water through evaporation of water droplets on a hot surface of the casting die. An analysis of knowledge subject and earlier studies indicate that the cooling of mold with the water mist stream enables the fast directional crystallization, shaping of microstructure and then achieving high quality casts made of neareutectic and hypereutectic Al-Si alloys [7]. Efficiency of heat transfer process is largely determined by the characteristics of generated stream, optimization amount of air and water in the mist stream and adequate spraying of water and also wall thickness of casting. The aim of the study was to investigate the effect of water mist cooling on microstructure and mechanical properties of Al-Si alloys: AlSi11 and AlSi20 (Table 1) that was casted in casting die cooling with use of multipoint opened system (Fig.1).

Table 1. Chemical composition of Al-Si alloys (mass%).

Alloy	Si	Mg	Cu	Fe	Mn	P	Al
AlSi20	21.5	0.01	0.2	0.22	0.01	0.03	Bal.
AlSi11	10.8	0.02	0.3	0.17	0.01	0.03	Bal.

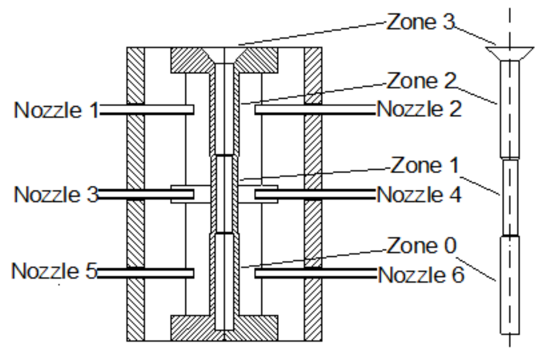


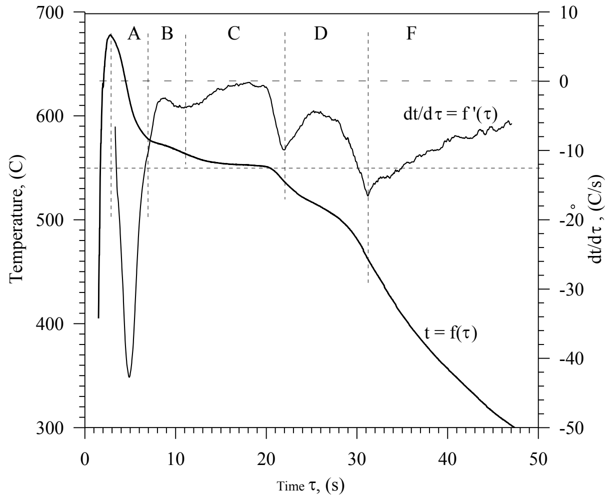
Fig. 1. Section of research casting die and casting, zones and nozzles of cooling system

2. Results

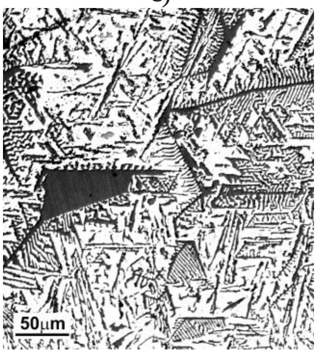
The crystallization of neareutectic alloy AlSi11 contets of 2 stages: of 1-preeutectic Al and 2 – Al+Si eutectic. The hypereutectic alloy AlSi20 in cooled casting die (Fig. 2a) starts from the initial crystallization of silicon walled crystals and also a dendritic silicon crystals (Fig. 2c). They are good nucleate pad for growing dendrites of Al phase. Farther lowering the temperature causes the alloy enter into a zone of eutectic coupled growth and in terms of irregular eutectic crystallized lamellar (Al+Si) that's the same like in the neareutectic alloy AlSi11 (Fig. 2b).

The results of hardness tests were presented in Fig. 2d. They proved that cooling of casting die with use of water mist significantly increases hardness of casting by refinement of structure and shaping additional dendritic phase of silicon that are characterized by high values of Vickers hardness. While tensile stress tests for AlSi11 alloy show that results are much better compared to non-cooled castings.

a)



b) c)



d)

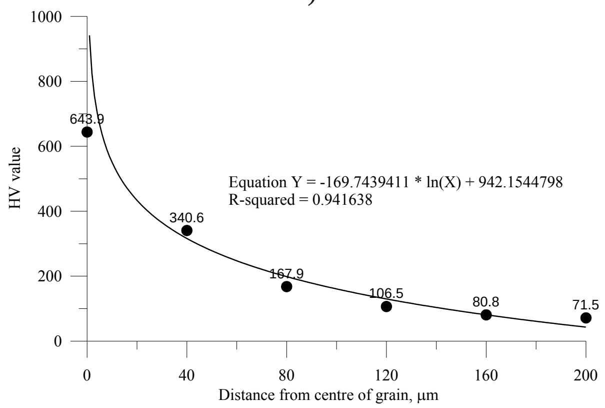


Fig. 1. Thermal and derivative curve (TDA) of AlSi20 alloy (a), microstructure of AlSi 11 alloy (b) and AlSi20 (c), Vickres hardness of dendritic grain of AlSi alloy (d)

The largest average values of Rm = 222 MPa were obtained for castings cooled using the sequence with priority for bottom part of the die and casting. The values of the other tested properties were as follows: $Rp_{0,2}$ = 117 MPa, A_5 = 2.7% and HB = 86. It is a result of decreasing of shrinkage defects and porosity in the casting and also of microstructure refinement due to the increased cooling of the liquid alloy during solidification of casting.

3. Conclusions

Al–Si alloys prepared by rapid cooling of melt were used to explain the effect of casting die cooling with water mist on the solidification process, the structure and mechanical properties of near- and hypereutectic Al-Si alloys. The study shows that the treatment is able to form preeutectic silicon dendrites and dendritic Si eutectic in the structure of hypereutectic Al-Si alloys. It was proved by thermal effects on the curves of solidification process.

The structure has a several times refining grain, compared to the casting obtained from uncooled permanent mold and from shell mold casting as well.

The refinement and homogeneity of the structure were increased the mechanical properties of Al-Si alloys.

Acknowledgments

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