THE EFFECT OF WATER MIST COOLING OF CASTING DIE ON THE HEAT FLOW KINETICS, MICROSTRUCTURE AND MECHANICAL PROPERTIES OF HYPEREUTECTIC Al-Si ALLOYS

Author: Artur Kozuń 800506

The effect of water mist cooling of casting die on the heat flow kinetics, microstructure and mechanical properties of hypereutectic Al-Si alloys were investigated.

The presented results of the study refer to the improvement of castings properties of hypereutectic Al-Si alloys by impact on the solidification. The interaction was carried out by using a water mist application on the wall of the mold which cooled the melt. Water mist is a highly efficient refrigerant that receives heat from the mold through the wall of the mold, reducing the solidification time.

The research was carried out in an aluminum die, designed optimally for effective water mist applications. The ATD-IR method was developed based on a conventional thermal derivative analysis method. The reason of development was to further accurately record the temperature during fast-changing thermal processes in the solidifying alloy. Replacing the thermocouple with a infrared camera allowed to increase up to 10 times the frequency of the measurement and, above all, made it possible to carry out tests in a reusable sampler that enabled the application of water mist. Two-component Al-Si alloys with silicon content of 15, 17, 19, 20, 22, 26% were subjected to the study. Experimental studies were preceded by the simulation of solidification in the MAGMA system.

Intensive heat reception from the casting during solidification resulted in a change in the heat flow kinetics. The crystallization time was shortened several times, cooling rate increased and the liquidus and solidus temperatures decreased. Large overcooling led to an increase in both nucleation rate and linear rate of crystallization.

Changing the kinetics of thermal processes caused significant changes in the microstructure. There was an increase in the boundary zone of the cast with columnar crystals, at the expense of the central zone in which the equiaxed crystals were dominant. Primary silicon particles size was reduced, and the amount of them was also reduced. Size of the particles of eutectic $\alpha + \beta$ was reduced as well. In case of AlSi20 complete change of the morphology of the microstructure was observed. Water-mist cooled samples showed the presence of dendritic-type primary silicon in the microstructure. The center of the dendrite was visible and the branches of the first row were removed from it along with the branches of the second row as well. The change was probably due to concentration of supercoagulation, as a result of the rapid removal of heat from the casting, which made it impossible to even out the chemical composition of the solidifying cast.

Changing the microstructure has improved the mechanical properties of the casting. About 15-20% improvement in Young's modulus, yield strength, tensile strength and elongation was observed. A few percent improvement in hardness has also been reported. The wear resistance has been increased by more than 20%.

Research has shown that cooling the mold with water mist allows the formation of microstructure and the properties of hypereutectic Al-Si alloys. The parameters of microstructure and properties have been described by statistical dependencies as a function of the kinetics of thermal processes.

Łódź, 06.13.2017

Artur Kozuń

Artur Kozuń