Journal of Achievements in Materials and Manufacturing Engineering
VOLUME 25
ISSUE 1
November
2007

Results of cooling of dies with water mist

S. Pietrowski, R. Władysiak*
Department of Material Technologies and Production Systems,
Technical University of Łódź, ul. Stefanowskiego 1/15, 90-924 Łódź, Poland
* Corresponding author: E-mail address: ryszard.wladysiak@p.lodz.pl

Received 18.04.2007; published in revised form 01.11.2007

Materials

ABSTRACT

Purpose: Intensification of die casting of car silumins wheels with use of the water mist instead of compressed air dies cooling in low pressure casting process were presented in the paper.

Design/methodology/approach: Examinations of casting process parameters were carried out on the industrial workstation of casting car wheels under the low pressure and also with Magma computer simulating system.

Findings: The temperature and the range of its variation were presented in characteristic points of the casting and the cooled die with use the compressed air and with the water mist. A scheme of the device for generating the water mist cooling the die and also the pictures of simulation of wheels casting process for researched cooling methods was given.

Research limitations/implications: The manufacturing technologies with the permanent mould.

Practical implications: Using the water mist to cooling of dies in die casting and low pressure casting process to intensify of cooling the die and to reduce the amount of casting spoilage.

Originality/value: Using the water mist to cooling increases intensity of cooling of the die and the cast. It makes shorter the cycle of casting process as well as reduces the porosity of casts and increases mechanical properties: $R_{p0,2}$, R_m, A_5 and HB.

Keywords: Metallic alloys; Casting; Die; Cooling; Mist

1. Introduction

Cooling dies using water mist is not widely spread in casting of aluminium alloys with silicon (silumins). It is result of many technical and techno-organizational factors. However it is the most effective way intensification of the die casting, it makes shorter the cycle time of manufacturing casts and it reduces size its microstructure. Mostly doesn't require an additional water installation system on die casting stations, because it is possible to choose parameters of the water mist production in order to water evaporate contacting die's walls [1].

This publication is showing intensifications of the die casting of car silumins wheels with using water mist instead of compressed air dies cooling.

Research were carried out in production conditions RH Alurad Wheels Polska Sp. z o.o. company in Gorzyce as a part of the Industrial Grant Project realization [2].

2. Experimental

Examinations were carried out on the industrial workstation of casting car wheels under the low pressure. The casts were being produced from AlSi7Mg silumin with Ti, B, Sr modified and Ar refined. The research die installed on the machine consisted of 4 side jaws, the upper and lower core. The temperature of her preliminary heating was included in the 350-460°C range. Filling the cavity of the die up followed under the influence of the pressure in the range 0.01- 0.09 MPa exerted on the surface of molten metal in the holding furnace.

Cooling the die was carried out with the multi-circuital hydro-pneumatic installation, for which nozzles were put in prepared holes on the outside surface of the die. Thermocouples were installed in characteristic 10 points of the die of the cast chosen for examinations. The layout points of the measurement of the temperature and cooling nozzles were showed in figure 1.

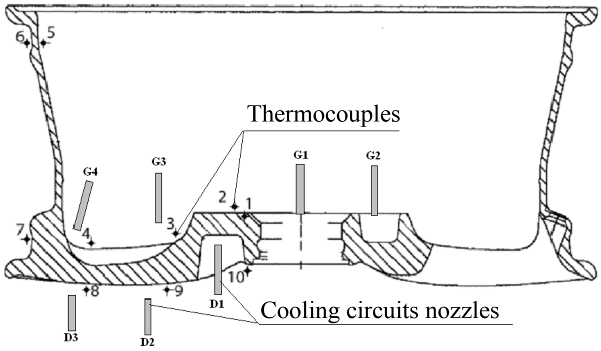

Fig. 1. Layout of thermocouples and of cooling circuits nozzles

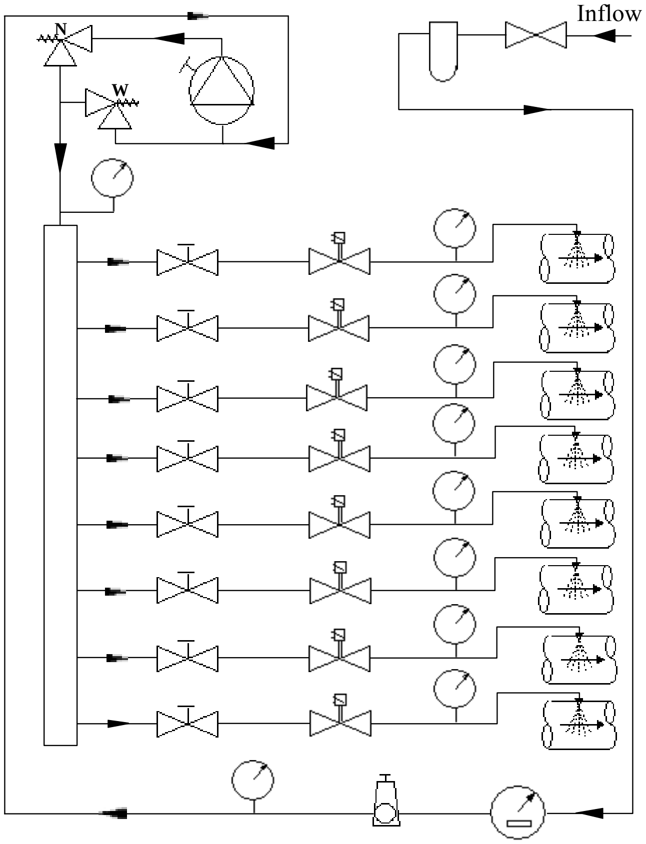

Fig. 2. Scheme of the device for generating the water mist

The recording of the temperature was being kept with JUMO Logoscreen device with automatic recording of the 10 measuring channels. in every second. The recording of the process of self-cooling of the die and the wheel's cast was fundamental to a computer simulation carried out of the casting process with use the Magma system.

Cooling the die with mixture of air and water were executed with use the Automatic Cooling Servo device, that was constructed at the Department of Material Technologies and Production Systems of the Technical University in Lodz.

The device, of which the scheme was shown in figure 2 enables simultaneous feeding eight circuits with the water mist

The initial part of the installation is consist of the stop valve, fine filter, flowmeter and of the pressure regulator. Cleaning, the measurement of the amount and the stabilization of the pressure of delivered water are setting her to the entire arrangement.

A volumetric pump guaranteeing delivering water to the eight-way divider was the second part of the device. The amount and the pressure of water could be regulated in the range from 0.05 to 0.80 MPa.

Eight dose-spraying lines constitute the third part of the device. It consists of the control valves, the electromagnetic stop valves and the sprayers. Producing the water mist by the device is being carried out at the same time as a result of spraying water with the specially designed sprayers and as a result of mixing up sprayed water with compressed air in wires of the cooling installation. An image of the water mist stream example that was obtained with use this device was shown in figure 3.

Steering cooling circuits took place automatically with use the control system of casting machine.

Fig. 3. The image of the water mist stream example

3. Results and discussion

Explored temperature distribution of the die in points 1-10 (fig.1) during next cycles car wheels casting showed its considerable diversity. In the cooling process of the dies with air pressure the distribution of the temperature in casting cycle is presented in figure 4.

Temperature distribution of die cooled with water mist has air pressure equal 0.45 MPa and water equal 0.50 MPa is presented in figure 5. Comparing data from figures 4 and 5 results considerable decrease of die temperature cooled with water mist. As a result time of cooling dies using individuals circuit is shortening what is presented in figure 6 (a, b).

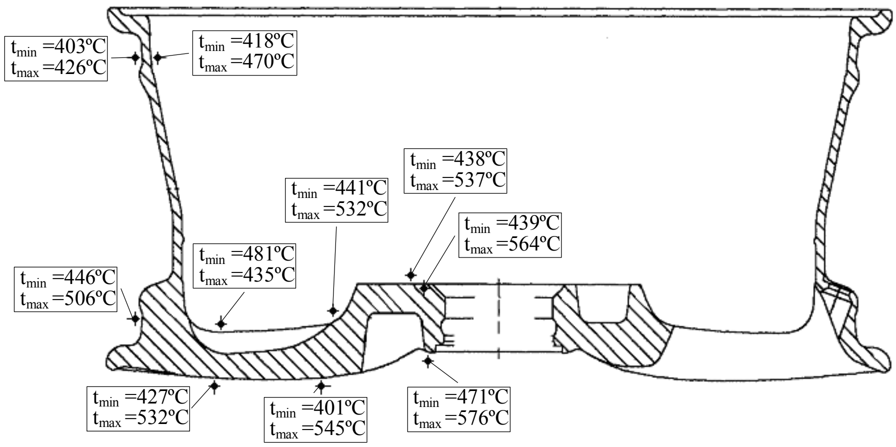

Fig. 4. The temperature distribution of the die cooling air pressure 0,65 MPa during the casting cycle time

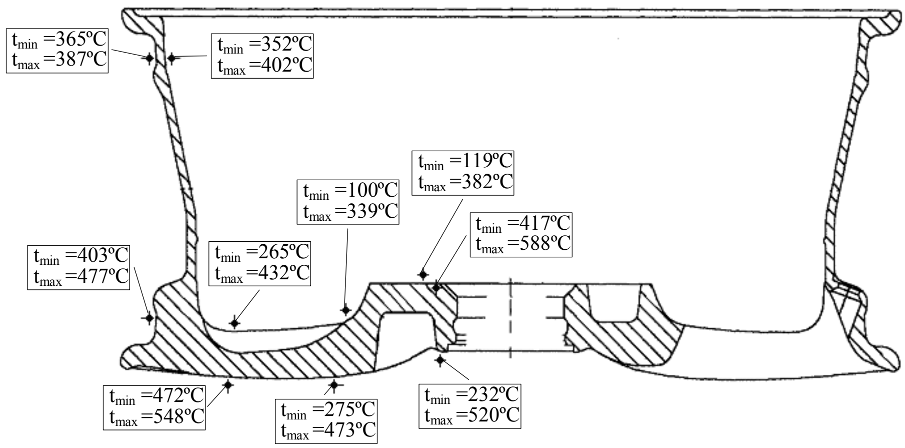

Fig. 5. The temperature distribution of the die cooling with water mist 0.45/0.50 MPa parameters during the casting cycle time

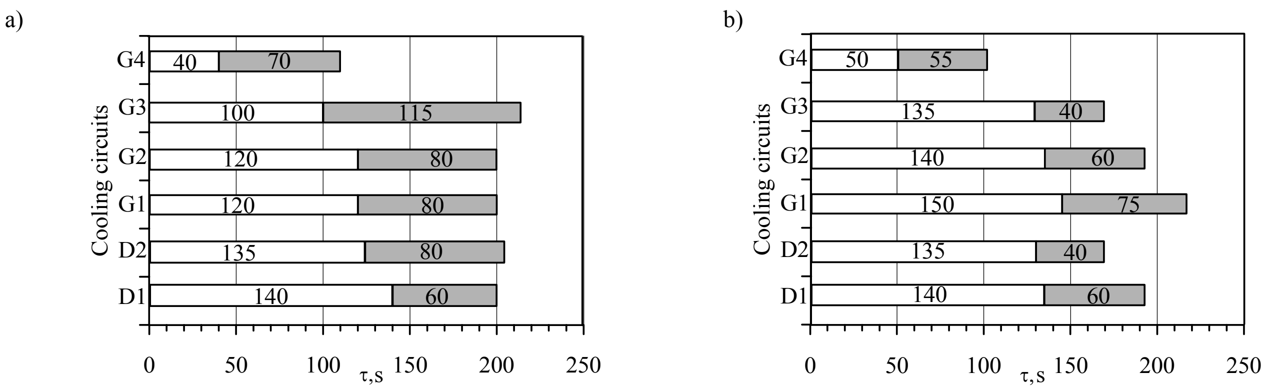

Fig. 6. Steering of cooling circuits: a) air pressure 0.65 MPa, b) water mist 0.45/0.50 MPa parameters; meaning of areas: white – delay time of start (waiting), grey – time of cooling

Overall list of influence of kinds cooling for the summary time of cooling all dies circuit is presented in figure 7. Result from it is that mostly decrease time of cooling dies (by 32%) using water mist with parameters 0,35/0,40 MPa. However then are appearing wheels defects such as misrun casting.

Is accepted, that optimal cooling is equal 0,45/0,50 MPa and then time of casting compared to cooling dies with compressed air is reduce by 28%.

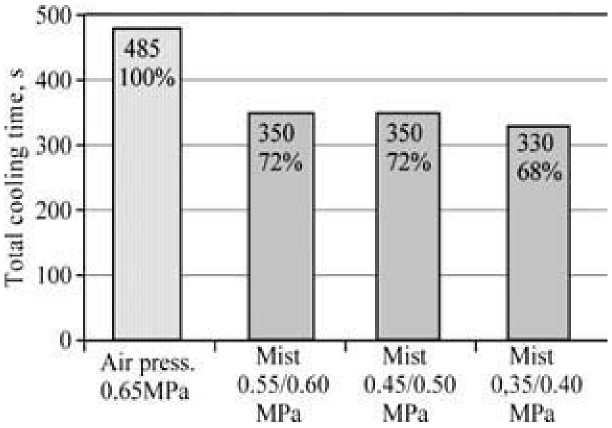

Fig. 7. The summary time of cooling in different conditions of die cooling

Besides reducing casting dies wheels cycle, is coming after refinement of its microstructure that means both α phase and eutectics α + β, what is show as an example in figure 8. Consequence is increase of mechanical properties of wheels in comparison to cooling with air appropriately around: $R_{p0,2}$ = 205 ÷ 280 MPa, R_m = 250 ÷ 310 MPa, A5 = 4 ÷ 5 % and HB = 85 ÷ 97. Carried out simulation of the filling die's cavity process in the Magma program, solidification and self-cooling of car wheel cast proved changes above mentioned cased by different ways of cooling die.

In figure 9 (a, b) is shown simulated distribution of the temperature in car wheel cast after ended process of filling die cooled with air (a) and water mist with parameters 0,45/0,50 MPa (b). Results is, that after ended process of filling the die up with liquid metal cooled with air the distribution of the temperature on the wheel diameter is about 30°C bigger compared with die cooling with water mist. Also accelerated process of crystallization and cooling casting causes decreasing its porosity. In figure 10 (a, b) are presented simulated areas of appearing places with the greatest tendency to the porosity while the die is cooled with air (a) and with water mist (b). The result is wheel lower tendency to the porosity which is castes in the die cooled with water mist. It was confirmed in production conditions.

On figures 11 and 12 (a, b) is shown in a macro scale fragments of the wheel arm (spoke) cast in the die cooled with air (fig. 11 a, b) and with water mist (fig. 12 a, b). Result from above essential reduction of the porosity in the area of the thermal centre of the wheel cast in the die cooled with water mist with 0,45/0,50 MPa parameters

a) b)

Fig. 9. Simulated distribution of temperature in car wheel cast after ended process of filling die cooled with air pressure (a) and water mist with parameters 0.45/0.50 MPa (b)

a) b)

Fig. 10. Simulated areas of appearing places with the greatest tendency of porosity for cooling with air pressure (a) and water mist with parameters 0.45/0.50 MPa (b)

a) b)

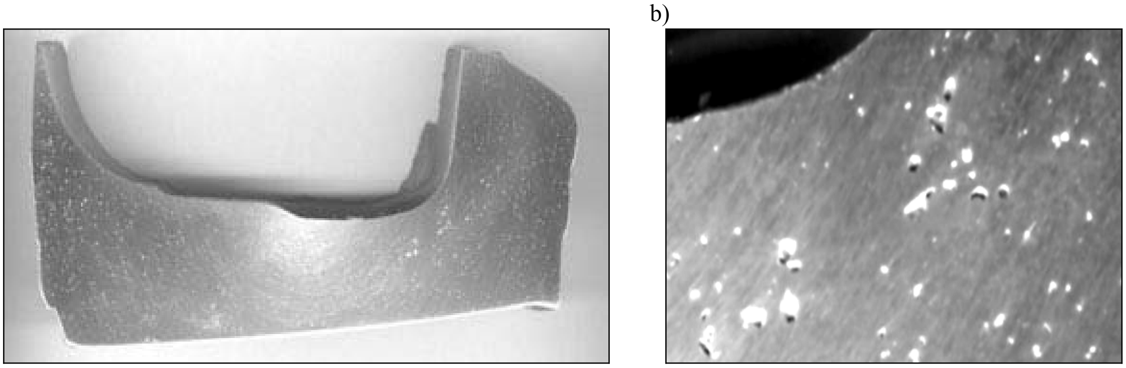

Fig. 11. Porosity of wheel arm (spoke) section casted with air pressure cooling; magnification: a) x 0,5, b) x 3

a) b)

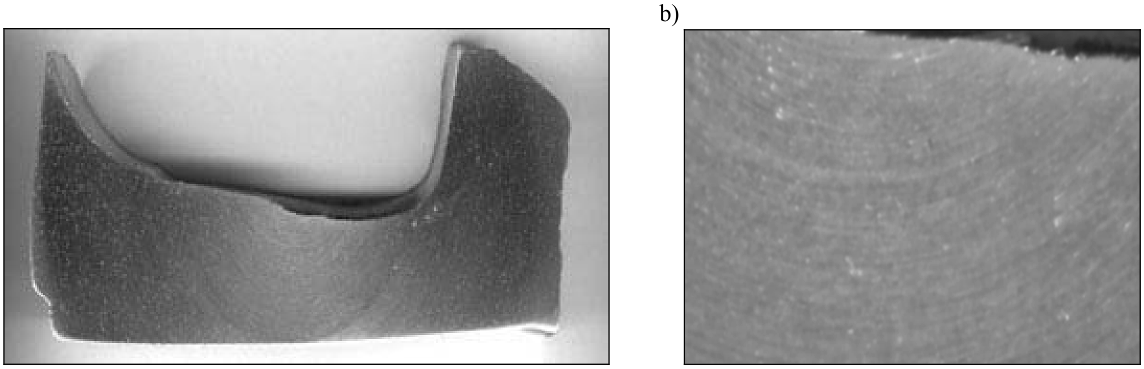

Fig. 12. Porosity of wheel arm section casted with water mist 0,45/0,50 MPa cooling; magnification: a) x 0,5, b) x 3

4. Conclusions

Research are showing that application of water mist to cooling dies causes:

- accelerated the crystallization process of castings and in the consequence decreasing its porosity,
- increasing of cooling rate and lowering the temperature of die during the casting cycle time,
- 28% decreasing the casting cycle time for cooling with use the mist parameters 0,45/0,50 MPa,
- size reduce of microstructure casted wheels and improvement of mechanical properties: $R_{p0,2}$, R_m , A5 and HB.

References

[1] K. Li, M. Cheng, E.Chang, Effect of Pressure on the Feeding Behavior of A356 Alloy in Low-Pressure Casting, AFS Transactions 01-026 (2001) 1-9.

[2] S. Pietrowski, R. Władysiak, Determination and introducing of technological system of water cooling of cocils in the casting of cars wheels from aluminum alloy, Project nr 6T08 080 2004C/06487, 2004-2006 (in Polish).