Proceedings of the 72nd World Foundry Congress
21-25th May 2016, Nagoya, Japan

Development of Cooling System for Small Core Pin in Aluminum HPDC and Its Applications

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This paper reports the technical aspects of the cooling system in tackling soldering as well as its application in metal saver. As a result of the experiments, no soldering is observed on the small core pin in the Aluminum alloy die casting with using thin walled core pin and greater quantity of cooling water without special die surface treatment.

Keywords: *Aluminum Alloy Die casting, Thin Wall Core Pin, Heat Flow, Surface Temperature, Soldering,*

1. Introduction

To cope with the ever increasing demand for compact engine lay-out, energy efficiency, cost savings, etc., automobile parts and hence die casting die shapes are getting more complex than ever before. Inconsistent part thickness, slender cored holes, deep part shapes have become common features, which in turn needs the use of long and thin core pins and intricately shaped deep insert blocks. Core pin in thick part section often suffers from soldering due to insufficient cooling. Porosity and lower productivity due to longer machine down time caused by core and die polishing and changing broken core pins have become two of the most severe quality and cost concerns, respectively.

In order to address these problems, authors think that thermal approach would provide a better solution to these problems. Thus they have studied [1],[2],[3],[4] the thermal behavior of die castings, heat flow ratio and die surface temperature pattern. And then they have developed the concept of cooling core pin with high pressure water jet with subsequent purging of remaining water enabling real time control of heat flow, and then successfully used the new system in mass production.

2. Thermal behavior of core pin in various thermal conditions

Thermal behaviors of core pin in various conditions were measured. As shown in Fig.1, there are four patterns depending on the casting volume and cooling conditions. In the beginning, just after the metal fills in the cavity, the temperature and heat flux patterns are not so different. However, after reaching the peak value, the thermal behaviors are quite different in each case. In case of low cooling water pressure and large casting volume, counter heat flow (heat flow from core pin to casting) is observed[4]. There's very little heat removal form the cavity to core pin which causes defects such as soldering, shrinkages, and porosities.

The high efficient heat removal form the casting to core pin is achieved with a combination of high flow rate and thin wall of the core pin. That reduces the peak temperature and increases heat flux of the core pin which prevents soldering of core pins. The wall thickness should be no more than 15% of the outer diameter of the pin.

As for example, a core pin with outer diameter of 7mm, the wall thickness will be only 1 mm, which may apparently be thought to cause core pin failure. However, it has been established by computer simulations as well as experiment that the durability of the thin walled core pin against bending force is almost same as that of solid core pin[55].

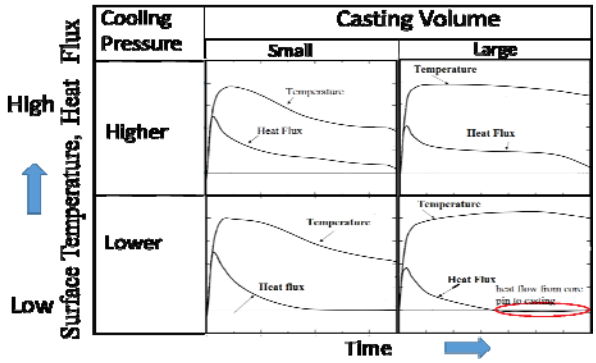


Fig.1 Thermal Behavior of Core pin in various casting conditions

3. Controlling method and its apparatus for preventing defects caused by thermal effects

From the experimental result of thermal behavior of core pin, a new cooling system has been developed as shown in Fig.2. There are four main sections such as “High Pressure Water Supply Unit” capable of supplying large amount of cooling water into small channel of core pin; “Air Purging System” that removes remaining water to control the core pin temperature; ”Water purifier” that purifies the cooling water preventing from scale and; “Water Cooler” to chill the returning water from core pin and dies. In addition to the cooling system, core pin and cooling pipe have also been developed.

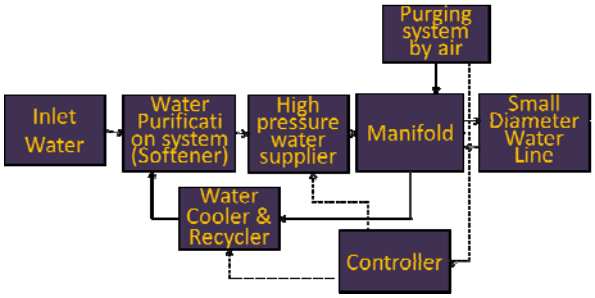


Fig.2 Block diagram of developed cooling system

4. Applications using the Cooling System

The developed apparatus works not only improving soldering but also reducing another defect such as porosity. The typical examples are shown in Fig.3 and Fig .4. As shown in Fig.3, there is no soldering of the core pin after 5000shots by applying this cooling system, and core pin polishing time was extremely reduced to zero which contribute productivity and safety.

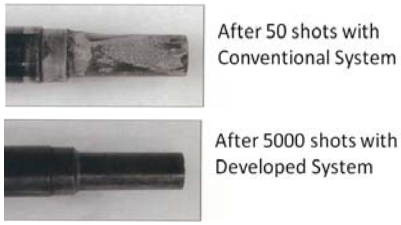
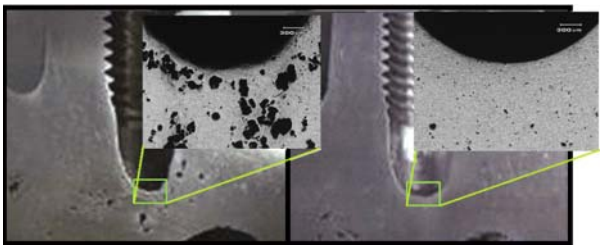


Fig.3 Prevention of soldering using this system

Moreover, with conventional cooling system, shrinkage porosity appeared around core pin due to overheat as shown in Fig.4(a), but when the newly developed cooling system was applied, the shrinkage porosity disappeared as shown in Fig.4(b). Hence, they improves the leakage problem in the machined surface.

Fig.5 shows the result of applying the cooling system to draft angle zero core pin. After 100shots, slight sticking is observed in case of rougher surface (Rmax=3.9micro-meter), however no sticking and no soldering are observed in case of polished pin (Rmax=1.1micro-meter). This shows the possibility of eliminating machining after casting.



a) Conventional Cooling b) Developed Cooling

Fig.4 Reducing porosity near the core pin surface with this system

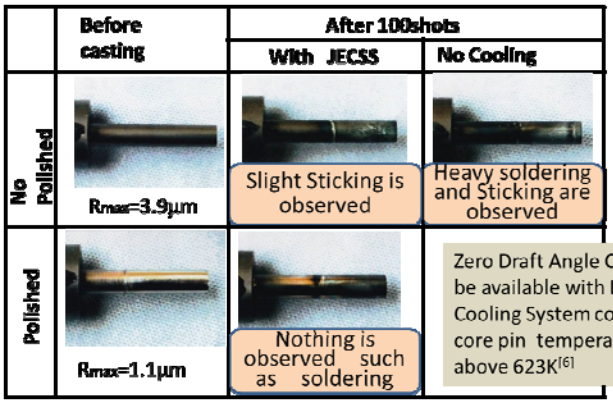


Fig.5 Trial approach of draft angle zero core pin using this system

5. Conclusions

By determining the thermal behavior of core pins, new cooling system has been developed. This system is proved to be effective for small core pin preventing defects caused by thermal problem such as soldering, shrinkage and leakage. Moreover this system contributes to the net-shape manufacturing by HPDC, which eliminate machining to a large extent.

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