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Riser Control Technology for Rectangle Cast Iron Blocks Applying the Heat Control Method of the Heater

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〈Abstract〉

In this study, a device was used to conduct heat to the riser by combining a cylindrical heater with the riser to maintain the molten metal above a certain temperature while continuously compensating for the shrinkage phenomenon that occurs as the molten metal solidifies in the product area. A cylindrical heater is coupled to the riser portion of the upper part of the upper mold, and a heater portion mold is formed between the riser and the cylindrical heater. The cylindrical heater is connected to a controller to control the temperature and a power supply. The cylindrical heater conducts a heat source to the molten metal located on the riser and can continuously compensate for the shrinkage of the cast product by heating the molten metal located on the riser or maintaining it at a constant temperature. The block without a riser had a large shrinkage cavity at the top, and the top became concave due to shrinkage. There is no shrinkage in the block with the Ø100 mm riser. Blocks that did not apply heaters to the Ø50 mm riser experienced shrinkage around the riser and also at the bottom. There is no shrinkage in the block with the Ø50 mm riser to which the heater was applied.

Keywords : Riser, Iron, Heat Control, Casting, Simulation

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1. Introduction

Cast iron is used to shape products and give weight to mechanical devices. It is mainly used in pump cases, various housing parts, bells, mortars, and structures and floors of heavy machines subject to large vibrations. The tensile strength is somewhat low, but the compressive strength is high [1-3]. When Mg is added to gray cast iron, the graphite phase is shaped into spheres rather than flakes, which is called ductile iron (or spheroidal graphite cast iron). In the case of gray cast iron, because the graphite phase is a thin flake, it easily breaks under tensile force, but spheroidal graphite cast iron has high ductility because the graphite phase is transformed into a sphere and the ferrite is connected to each other. Additionally, it can have mechanical properties equivalent to steel [4-6].

In factories that spheroidal graphite cast iron, the volume of the riser is indiscriminately increased in order to minimize defects in the cast product. While molten metal flows into the mold and solidifies, shrinkage occurs, and the molten metal located in the riser compensates for this shrinkage. Therefore, the molten metal located in the riser must solidify more slowly than the molten metal located in the product area. In this way, molten metal can be supplied from the riser to reduce shrinkage occurring in the product area. Therefore, the volume of the riser must be larger than the product area. However, if the volume of the riser is larger than the product area, the recovery rate is lower, which makes the material input cost significantly higher compared to the castings production volume. In addition, the time it takes for the castings to solidify is longer, and the time it takes to remove the riser after it has solidified to room temperature is also longer. In addition, there are many of problems such as defects that may occur when removing the riser, and the labor costs required also affect sales, resulting in economic losses [7-9]. As a way to solve these problems, research is being conducted at foundries on ways to minimize the volume of the riser.

In this study, improve the recovery rate with a sand casting process is proposed. The heater as heat source was provided to the riser, attempting to reduce its size. Also, an optimal gating system for casting housing casting was designed. To minimise the volume of the riser, a riser heating method was developed, which uses a heater to induce delay in the solidification of the molten metal. A casting simulation was then conducted to investigate the effects of size of the riser. The conditions obtained from the simulation result were applied to the experiment. The cast rectangular blocks were cut to check for shrinkage porosities. Brinell hardness test for the casted block and the tensile test for casted block were performed as part of the analysis of physical properties.

2. Design

Ductile iron has a specific gravity of 7.8 which is higher than other metals, so the cross-section area of the sprue is the largest and that of the gate was the smallest was used. As the molten metal is flowed to the gate after passing through the runner, flow rate and pressure become increased.

Fig. 1 shows the gating system for casting the rectangle block. The diameter of the sprue is Ø40 mm and the length is 230 mm. The cross-section of the runner is 21 × 45 mm, while the cross-section of the gate was 21 × 30 mm. The size of the rectangular block is 220 × 150 × 100 mm in length, width and height. The weight of the sprue, runner, and pouring cup is 2.06 kg, 1.00 kg, and 0.79 kg, respectively, and the weight of the gating system is 3.85 kg. The weight of the rectangular block is 25.94 kg.

The SRG ratio of the designed gating system was 1 : 0.75 : 0.5. The length of the runner and gate were designed as short as possible to raise recovery rate. As a result of calculations using empirical equation or minimum cross-sectional area equation, the time it takes for molten metal to flow into a rectangular block is expected to be about 9.2 seconds.

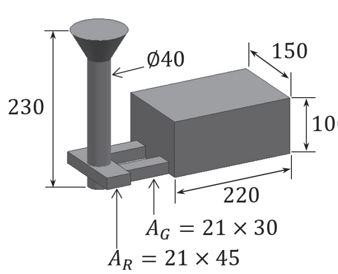

Fig. 1 Gating system design for rectangle casting block

Fig. 2 shows three types of risers applied in the casting block. The sizes of the riser were set none, Ø50 mm, and Ø100 mm. The riser was installed at center top of the block. The height of the riser is 110 mm same as that of the sprue. The volume of Ø50 mm riser is 215,875 mm^3, and weight is 1.70 kg. The volume of Ø100 mm riser is 863,500 mm^3, weight is 6.79 kg. The recovery rate is the ratio of the weight of the rectangular block to the total weight. If there is no riser, the recovery rate is 87%. Ø50 mm riser is 82%, Ø100 mm riser is 71%.

Fig. 3 shows the riser optimization device. The lower mold and upper mold of the cavity of the rectangular block are combined.

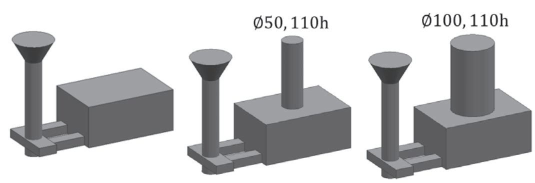

Fig. 2 Three types casting block: without riser, Ø50 mm riser and Ø100 mm riser

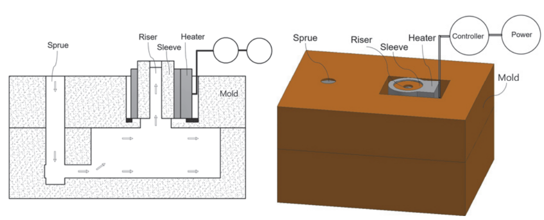

Fig. 3 Rectangle block mold with riser heating device system

A cylindrical heater is installed in the upper mold. A heater mold is combined between the riser and the cylindrical heater, and the cylindrical heater is composed of power supplied from the outside and a controller to control the temperature of the heater. The cylindrical heater can maintain the molten metal at a constant temperature by conducting a heat source to the molten metal located in the riser and heating the molten metal located in the riser, so the riser continuously compensates for the shrinkage phenomenon that occurs while the casting is solidifying.

3. Conditions of Simulation and Experiment

Casting simulation and experiment are conducted under three conditions. These are the conditions without a riser, the condition with a riser of Ø100 mm, and the condition with a heater applied to a riser of Ø50 mm.

Sand casting simulation of MAGMA soft was performed for casting simulation. The temperature of the sand mold was set at 20 ℃. The temperature at which molten metal flows into the mold was set at 1400 ℃. The heater temperature was set to 500 ℃ and the riser position was also maintained at 500 ℃.

Spheroidal graphite cast iron GCD 600 molten metal was prepared to perform the casting experiment. Pig iron, steel scrap and GCD 600 were charged into the induction furnace. The chemical composition and temperature were adjusted using a low frequency induction furnace with a capacity of 2 ton. The molten metal in 1.5 ton ladle was performed for spheroidizing by sandwich construction by using 5 wt.% magnesium ferro-silicon. Fig. 4 shows the riser area being heated by the heater after the heater is installed and the molten metal is poured into the mold. A thermocouple was installed on the riser to predict temperature changes.

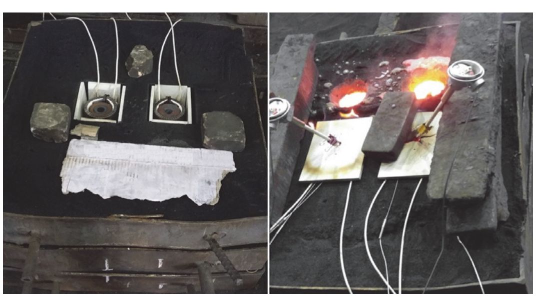

Fig. 4 Heating mold system for control the riser

4. Results

Fig. 5 presents the filling pattern of molten metal in mold cavity. Transparent part

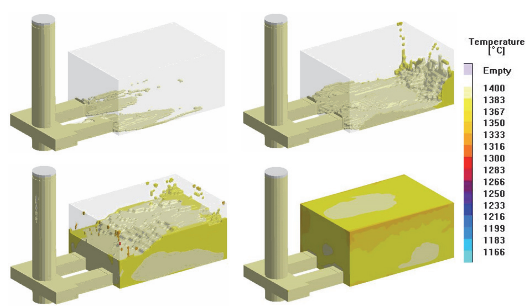

Fig. 5 Casting filling simulation of the rectangle block

displays the condition where the molten metal was not filled into the cavity. After molten metal flows into the sprue, it flows into the block at high speed while passing through the gate. The speed of the molten metal at the gate is approximately 1.6 m/s. Due to the high inflow speed of the molten metal, turbulent flow occurs as it hits the block wall. After the molten metal fills half of the block, the flow becomes somewhat stable. Temperature loss is small while molten metal flows into the block. Since temperature of the liquid phase line of GCD 600 material is 1170 ℃, it flows into the mold in a completely liquid state. The filling time of the molten metal from the equation was 9.2 m/s. The time for molten metal to flow into the block is 9.18s.

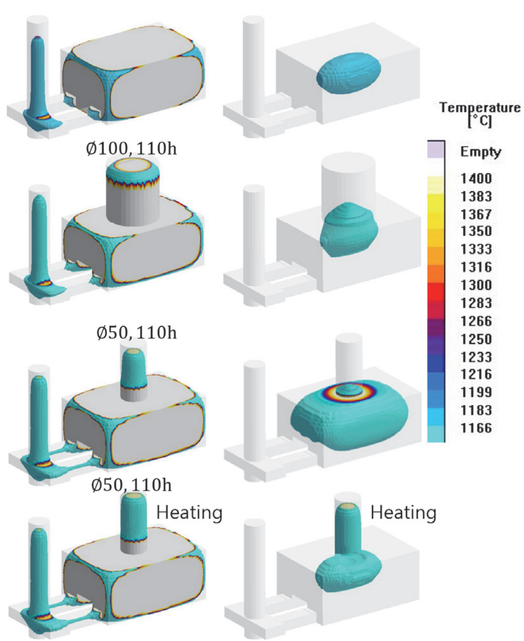

Fig. 6 Solidification simulation of the rectangle block

Fig. 6 is the solidification simulation result. This is the process of solidifying from liquid to solid after the molten metal has completely flowed into the mold cavity. Solidification fraction results of 10% and 100% were shown. In the case of conditions without a riser, solidification begins from the surface of the block and is completed in the center of the block. Shrinkage defects are expected. In the case of the Ø100 mm riser condition, solidification is completed at the boundary between the riser and the block. It is expected that the molten metal located in the riser compensated for the shrinkage of the block. For the Ø50 mm riser, there are conditions with and without a heater. If a heater is not applied, solidification occurs first in the riser than in the block. On the other hand, in the condition where the heater is applied, only the block solidifies while maintaining a constant temperature in the riser area due to the heat source. In the results of 90% solidification, it can be seen that the boundary between the riser and the block remains liquid.

Fig. 7 shows rectangle blocks cast by sand casting. The gating system and riser were cut from the block. A photo of the floor plan of the block was measured. Then, the block was cut in the axial direction and a cross-sectional picture was measured. The block cast without a riser had a large shrinkage cavity at the top, and the top became concave due to shrinkage. There is no shrinkage in the block with the Ø100 mm

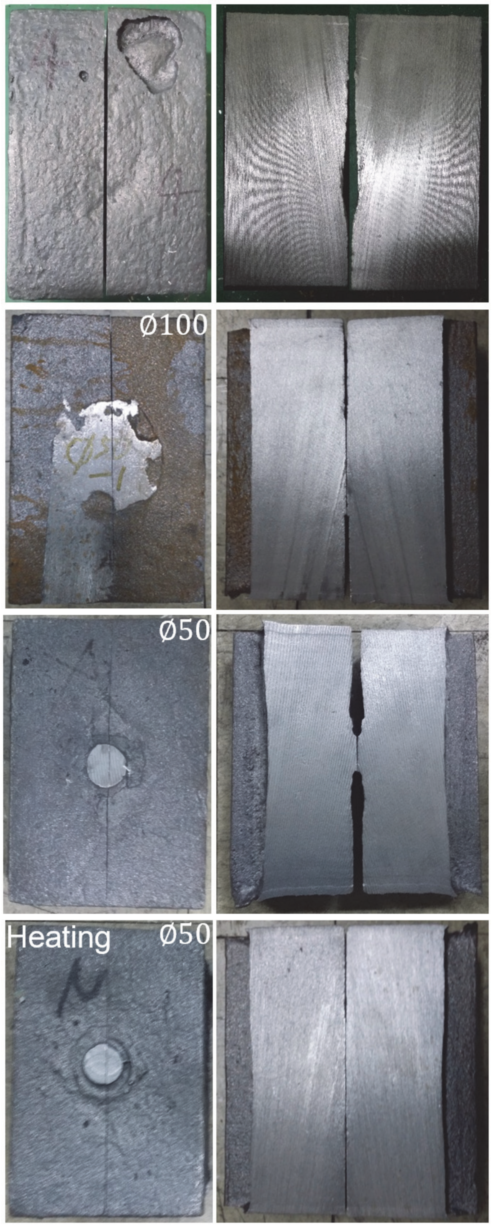

Fig. 7 The rectangle blocks casted by riser effect

Table 1. Mechanical properties of the casted rectangle block

Tensile strength (MPa)	Elongation (%)	Brinell hardness (HB)
520	10	152

riser. Blocks that did not apply heaters to the Ø50 mm riser experienced shrinkage around the riser and also at the bottom. It can be confirmed that there is no shrinkage in the block with the Ø50 mm riser to which the heater was applied.

Table 1 shows the mechanical properties of casted rectangle block. A tensile test specimen and impact test specimens were prepared as per the specifications in ASTM E8M and ASTM 1370. The tensile test was performed three times, and the Brinell hardness test was performed five times. The tensile strength, elongation, and hardness in Table 1 are average values. The tensile strength, elongation, and Brinell hardness were measured as 520 MPa, 10%, and 152 HB, respectively.

5. Conclusions

In this study, a cylindrical heater system that can minimize the volume of the riser was presented. By conducting heat to the molten metal located in the riser and maintaining the molten metal at a constant temperature, the riser can continuously compensate for the shrinkage that occurs while the casting is solidifying. By reducing the volume of unnecessary risers, the recovery rate is improved, the quality of cast products is improved and the defect rate is reduced, the post-process time for riser removal is reduced, and the labor costs required are reduced, thereby improving economic benefits. It is applicable not only to large-volume castings, but also to small-volume castings and thin-thick castings. In particular, when casting multiple small-volume castings at once, a cylindrical heater is installed at the riser position of each casting. This allows you to control the temperature at the same time. The temperature of the heater can be controlled according to the melting point of the material used, regardless of whether it is a ferrous alloy or a non-ferrous metal. Therefore, since the heat source can be supplied to the riser at various temperatures, it can be applied to various fields of the casting process.

Acknowledgments

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