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Development of New Casting Process for Heat-Resistant Cast Steel

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Regarding the casting of small steel casting, such as the turbine housing (referred to as T/H), molten metal is poured manually in most foundries, compared to cast iron which is poured automatically. So the productivity of steel iron is lower than that of cast iron. The casting technology of cast steel is far behind that of cast iron.

Pressure casting technology is effective in ensuring the fluidity of the cast steel, but the machine required is expensive and difficult to maintain, so it is not suitable for production. Therefore, we developed a new automatic pouring process which pours at a constant temperature and speed to produce a high quality heat-resistant cast steel product at low cost.

Keywords : *heat-resistant cast steel, turbine housing, casting process, automatic pouring machine, constant pouring temperature*

1. Introduction

The number of turbocharger equipped vehicles is increasing in order to reduce vehicle emissions and to increase fuel efficiency. As a result the temperature of exhaust gas is increasing. Therefore the T/H needs to be increasingly heat-resistant, and a higher level of heat-resistant cast steel is required for the T/H.
In general cast steel technology is not as advanced as that of cast iron. So we have developed a new casting process for good quality heat resistant cast steel.

2. Experiment

We made molds of 2mm thickness T/H with the green sand molding process, the shell molding process and the cold box process. We examined the resulting casting quality for fluidity and sand burning of the mold, casting method (gravity casting, low pressure casting) and the casting conditions (pouring temperature and speed). As the result of these studies, a new casting process to obtain low cost high quality heat resistant cast steel product was established.

3. Results and Discussion

Generally, there are two casting methods to ensure the fluidity of cast steel: the vacuum casting method and the pressure casting method. Pressure casting was considered in this paper, as we developed a new low pressure casting machine, which could maintain stable fluidity. In a typical low pressure casting machine as shown in Figure 1, the life of the stalk is too short which is the main disadvantage of this method. Therefore, we devised a new low pressure machine for producing cast steel in which the stalk is made of refractory material (see Figure 1). With this machine we produced 2mm T/H test pieces. We concluded that pressure produced good fluidity results. However, the fluidity is too good, contains the into 0.5mm or less of the small gap between the combination molds, and made a lot of casting fins when mold accuracy is bad even a little. The cost of the low pressure casting machine is high and it is difficult to maintenance. For these reason, it is judged as not suitable for mass production, we addressed to develop the gravity casting process.

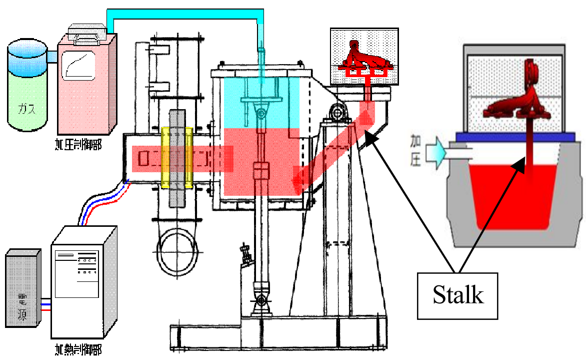

Fig.1 New low pressure casting machine (left), Conventional low pressure casting machine (right)

When casting cast steel by gravity casting manually with foundry ladle, tend to hold high pouring temperature at first mold pouring in order to ensure the molten metal fluidity at last mold since the molten metal temperature drop during pouring.
The high pouring temperature cause sand burning. Furthermore, it causes large variation of pouring temperature and pouring speed. So this makes the quality of cast steel vary and unstable.
Therefore developed the automatic holding pouring furnace with minimal variability in pouring temperature and speed, and then succeed to produce more quality stable cast steel product. Figure 2 shows the results of the pouring temperature and speed of continuous casting the T/H in JIS SCH5 material (equivalent GX40CrSi17) of 1 charge.
The pouring temperature vary 1,524-1,535C, the pouring speed vary 3.1-3.5kg/sec. Both properties are very stable. In addition, it is not necessary to increase the pouring temperature at the first mold, such as when cast manually with foundry ladle, and also it led to prevent the sand burning.

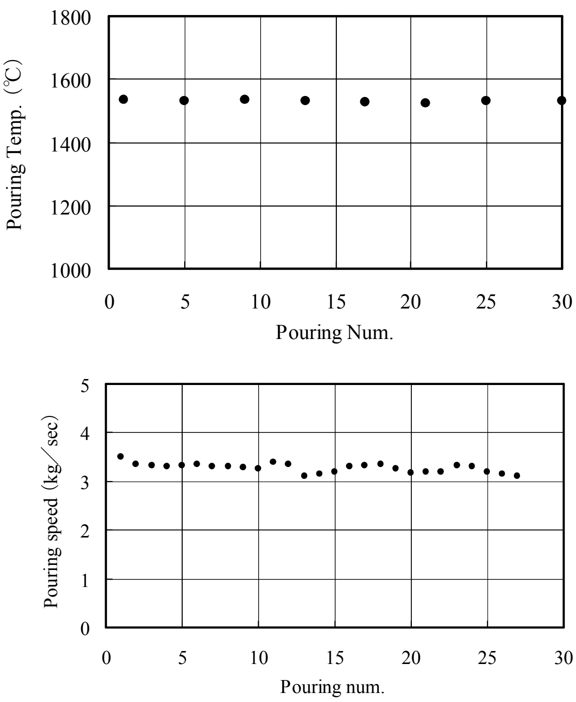

Fig.2 Pouring temperature and speed in the continuous casting

Green sand molds, shell molds and cold box molds were investigated. More burning occurred with the green sand molds than with the other molds.
It was difficult to reduce the mold weight using the cold box molds. So we finally selected the shell molding process which is suitable for producing lightweight molds. As shown in Figure 3, the shell molding process enabled to produce a mold nearer the net shape of shape of the T/H, so this provide 20-30% lightweight mold compare to conventional mold and reduce mold cost.

Fig.3 Steel castings (left) produced using the lightweight shell mold (right)

4. Summary

The developed concept is shown in Figure 4.
We developed an automatic holding pouring furnace with minimal variability in pouring temperature and speed. By utilizing this developed process with the lightweight shell molds, success to produce high quality thin-walled cast steel products at low cost.

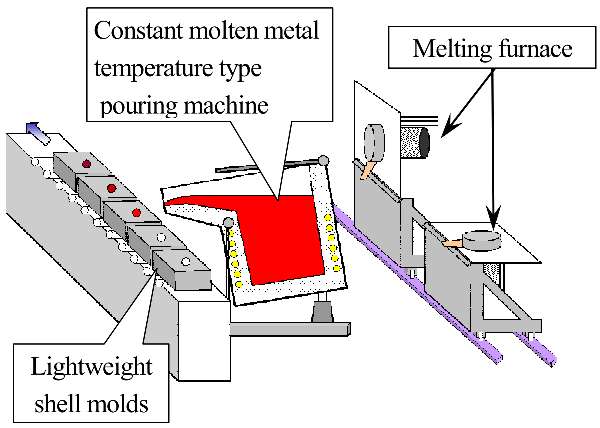

Fig.4 The concept of the newly developed process