METABK 53(4) 601-604 (2014)
UDC – UDK 621.746.744:621.74.04:669.15=111

DEVELOPING TECHNOLOGICAL PROCESS OF OBTAINING GIALITY CASTS

Received – Prispjelo: 2013-11-21
Accepted – Prihvaćeno: 2013-04-20
Preliminary Note – Prethodno priopćenje

The article considers the process of manufacturing castings using sand-resin forms and alloying furnace. Were the optimal technological parameters of manufacturing shell molds for the manufacture of castings of heating equipment. Using the same upon receipt of castings by casting in shell molds furnace alloying and deoxidation of the metal will provide consumers with quality products and have a positive impact on the economy in general engineering.

Key words: foundry, mold, sand, alloying

INTRODUCTION

Mechanical engineering is one of most important fields which permit to realize present day achievement of scientific-technical progress. From the foundry production there begins the manufacturing of machines, mechanisms, various equipment; it's obvious that the quality and stability of cast products defined the work stability of the whole machine building industry and related branches. It is necessary to bear in mind that the efficient effect on organizing a quality regular production is achieved only with a correct selection of technological processes, adequate technical equipping of foundries, a possibility to forecast beforehand how there will effect some factors the cast products.

One of the methods permitting to increase labor productivity in foundry and giving a possibility to obtain quality casts is shell molding. The filler in such casting mixes is quartz sand, and thermal active resin (pulverbakelite) is used as a binder [1].

STATEMENT OF THE AIM OF THE RESEARCH

Using shell molds leads to increasing a molding sand density up to (1,65…1,75)•103 kg/m^3, strength, gas-permeability as compared with sandy-clay molds. As a result the geometrical and dimensional accuracy of the casts increases, metal intensity reduces, metal consumption and cost decrease. Costs for machining in shell molding are reduced by 25 % in connection with excluding a complicated machining of inner surfaces. In a lot of cases machining can be eliminated completely or minimized, so the casts cleaning is simplified and is performed quicker.

At the same time shell sand-and-resin molds possess high strength and gas-permeability, they are not prone to absorb water, to crumble and to resist the solidifying alloy shrinkage. Besides, they easily collapse after a cast forming. This forms favorable conditions for obtaining casts possessing high dimensional accuracy and surface finish. Shell molding ensures a significant e saving of molding materials.

However, it is necessary to develop a technology that is economically expedient in the real production conditions. In this connection the studies aimed to obtaining quality casts are urgent and present a complicated problem: obtaining a quality mold and cast.

METHODOLOGY OF SOLVING THE TASKS OF THE RESEARCH

In this connection optimization of the shell molds producing mode is of great interest: the mix heating temperature effect, the drying oven temperature, as well as the mix persistence time at a certain temperature. When forming a shell the mix is effected by static pressure. The optimal pressure value determining is one of the problems of the studies carried out. The study of the process of forming a hard shell of a sand-and-resin mix (SRM), stressed-and-strained state of the crust and SRM rheological properties was carried out on an experimental plant and devices of an original structure. The study was carried out at LLP "KMZ n.a. Parkhomenko" [2].

The experimental plant is made based on the molding semi-automaton of 51 713 model and consists of a hopper in which there is fed a sand-and-resin mix, a furnace, a plate for a load additional static applying, a table on which there is mounted an electrically heated pattern plate with a model. On the pattern plate there is mounted a filling frame.

On the back of the model equipment there are spring pushers and electric heating units. Here there is a heat transducer with which help there is controlled the plate heating up to the preset temperature.

A. Issagulov, V. Kulikov, D. Issagulova, E. Shcherbakova, A. Kuszhanova, Karaganda State Technical University, Karaganda, Kazakhstan

On the model there was mounted a filling frame (a molding flask) with the height of 100 mm, on the perimeter coinciding with hopper. In the starting position the models were covered with a case of the drying oven. Near it there was a hopper in which there was fed a mechanical mix of sand with pulverbakelite and some additives. The machine can be worked both automatically and manually.

When turning on the forming machine the furnace was lifted up and from the hopper on the model place there was fed the mix. Besides, on the filling frame with the fed mix there was dropped the plate rendering a static loading on the mix. Then the palate returned in the starting position.

Under the action of the model equipment heat pulverbakelite in the mix layer immediately bordering upon the pattern plate melted and moistened the sand grains.

After receiving a shell the plate returned to the starting position, and the models with the shell were covered by the furnace whose temperature was about 350 °C. The shell thickness was 8…12 mm.

There was determined the dependence of failure and bending strength on the applied static pressure on the mix at the time of the shell forming: with pressure increasing after 0,2…0,25 MPa the strength increases, but the intensity of strngth increase reduces with the further pressure increase. Thus, the optimal pressure which is to be used in shell forming must be recognized 0,18…0,25 MPa.

There was studied the effect of some pressure increase on the mix expediency in the process of forming. It was determined that with increasing pressure by 0,03…0,05 MPa there reduces the shell form roughness without decreasing the technologically needed gas-permeability value. With the further increasing of pressure there is observed reducing gas-permeability less than 100 units and some roughness increase which is caused by the grains extrusion in the shell being formed. The strength properties worsens either due to the binder burning at a more intense SRM heating [3].

In the work there were carried out the experiments to study the molds and casts quality in air-pulse molding. The molding mix was compacted by a pulse head [3]. Before compacting the mix was covered with a polyethylene plate of 5 … 6 mm thickness. It was established that the mix compacting degree achieves the hardness of 90 units.

The essence of the process consists in the mix compacting with an air wave formed at an ultra-fast expansion of a special valve which causes a sharp acceleration of the mix particles. The compacting method depends on the value of pressure maximum over the mix, pressure drop over the mix and in its section, on pressure speed growth over the mix. The time of achieving the air pressure peak is not to exceed 0,01 s. In this connection there was developed a pulse head.

With air-pulse compacting there is no need in special high pressure compressors, neither laying high pressure pipelines; there is sharply simplified machine structures and pneumo-distribution system.

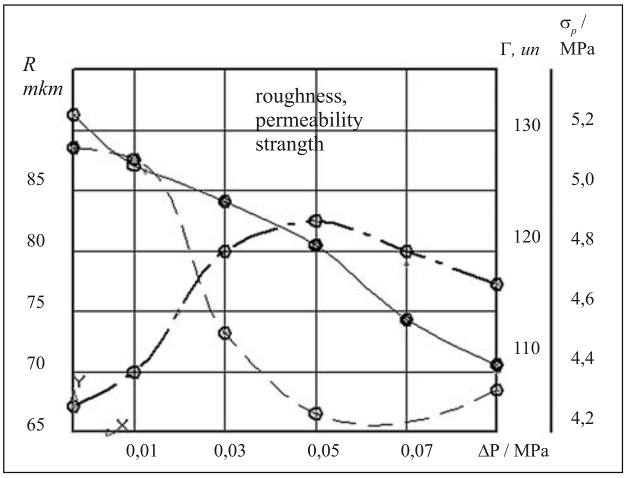

Figure 1 Mold indicators dependence on pressure (ΔP) change value in the process of the shell molding

As a result of implementing pulse molding the cast mass reduces by 10 %, the productivity increases 2,5 times, there are improved the labor sanitary-hygienic conditions.

The heating radiator, boiler sections, milling balls casts produced had a dense fine-grain structure. The surface roughness made Rz 60 … Rz 70.

The plot of the mold roughness dependence on pressure changing in the process of the shell molding is shown in Figure 1. The initial pressure in all cases was 0,2 MPa. The shell persistence time on the plate is 30 s. at 250 °C. The shell sintering takes place in the electric furnace at 350 °C within 180 s. The filler is sand of fractions with the ratio 1K0315-70 % and 1K02-30 %, the binder makes 5 %.

The expediency and the optimal moment of some pressure increase within the forming was determined in a number of experiments. The mix persistence time under pressure is 30 seconds. The initial pressure used is 0,2 MPa. Pressure increasing took place through the different time intervals. The experiments showed that the moment of increasing pressure affects strongly the mold technological and mechanical characteristics. It is rational to be done at the beginning of forming (in 10…15 seconds). The load increase at the end of forming (25…30 seconds) is not only inexpedient but here there reduces strength as a result of failing the structure of almost formed shell mold (sand grains extrusion from resin). Besides, the larger is ΔP at the late stages of the shell forming, the larger is the mix loss of strength value [4].

EXPERIMENTAL RESEARCHES

Experimental studying of the SRM samples strength dependence on the persistence time on the pattern plate with different pressure values showed that the mix persistence time on the plate increases strength. However, the excessive duration of the thermal action with simultaneous pressure increasing leads to pulverbakelite burning out and, consequently, to the mix loss of strength.

The temperature mode at which there forms the shell, alongside with pressure, also effects gas-permeability and strength. The shells whose forming takes place at a lower temperature have a larger density. With increasing the pattern plate temperature the mix failure strength increases up to a certain limit but gas-permeability reduces.

When defining the dependence of strength on sintering temperature the shell molds formed at the beginning at T = 250 °C on the pattern plate with various load values, then they were kept in the furnace within 90 seconds at different temperatures. The temperature at whose exceeding there takes place the mix loss of strength with increasing pressure on the forming shell, is displaced to the left. It is obvious that this is connected with a higher speed of the mix heating and the resin burning out beginning.

The optimal pressure for obtaining a dense and strong shell is the pressure on the mix consisting of the main and additional loads. The main load on the mix is in the limits from 0,18 to 0,22 MPa. Increasing load in the process of the shell forming up to 0,25 - 0,30 MPa increases failure strength of the sand-resin mix by 0,3 - 0,4 MPa.

Another important component of obtaining a quality cast is obtaining a quality metal. Using out-of-furnace alloying and deoxidization permits to obtain a uniform composition – both chemical and phase. Here there takes place an additional steel purification from the dissolved gases, non-metallic admixtures. In metallurgy and foundry the widely used deoxidization and alloying is an urgent problem whose solution will provide obtaining a quality and efficient, and consequently, competitive production.

Steel deoxidization in the furnace requires a larger consumption of ferroalloys than oxygen removal in the ladle. Introducing alloying elements in the furnace requires a larger consumption due to the increase of waste and to the time duration between ferroalloys introducing and steel discharge from the furnace. Ferroalloys dilution in the ladle is effected by their dispersion and metal temperature in the ladle that are to be optimized in each case.

For example, introducing in the ladle dosed additive of ferrovanadium and ferromolybdenum of 10…20 mm fraction permits them to dissolve in the metal and to obtain the needed chemical composition of steel 0,3 - 0,4% C. 0,3 - 0,4% Mn, 0,2 - 0,4% Si, 0,80 - 1,1% Cr, 0,08 - 0,12% Mo, 0,06 - 0,12% V, Fe by these elements. Fraction increasing increases the chemical liquation in the cast, significant grinding leads to increased waste and, consequently, to great consumption of alloying additives.

It should be taken into account that alongside with gases contained in the metal their certain part in introduced in the mold in the process of pouring. So, gas content in the cast will the higher, the higher is the outflow stream and also depends on the pouring time and temperature. With reducing the temperature of the metal poured the stream discreteness increases and there are introduces more gases from the atmosphere in the mold. Let's take the true metal density corresponding to the limit state, then the amount of the gases introduced with the metal will be:

$$\Gamma = K \cdot \int_0^t \left[\int_0^{\rho_\Sigma} h_{ct} \cdot F_{ct} \cdot d\rho - \int_0^F \rho_{met} \cdot h_{ct} \cdot dF_{met} \right] \cdot dt,$$

where K is a temperature factor, F_{ct} - is a complete area of the stream cross-section, h is the stream height; ρ_{met} is metal density.

It's obvious that in the real conditions there should be accounted not the true but apparent density. However, the amount of gases introduced with the metal is controlled using deoxidizers, while the gases taken from the atmosphere by the stream within the pouring are difficult to account.

In this connection to obtain metal without gas inclusions on the whole cast body it is necessary to introduce some deoxidizers in the mold.

To carry out studies of out-of-furnace deoxidization there was used ferromanganese of FM75 grade and ferrosilicon FS75.

Studying the dependence of the component content increase on its fraction showed that the most optimal fraction for the out-of-furnace alloying and deoxidizing steel 0,8 %C, 1 %Mn, 1 %C, 1 %Si, 96,2 %Fe with silicon is ~1 - 2 mm fraction (Figure 2), as the smaller size causes increased waste, and fraction significant increase of ferroalloys introduced does not permit them to dissolve completely in the ladle.

A somewhat different picture is observed with manganese (Figure 3). Large fraction manganese dissolves the worst. A significant jump for steel 80ГСЛ was observed when transferring from fraction 1 mm to fraction 2 mm.

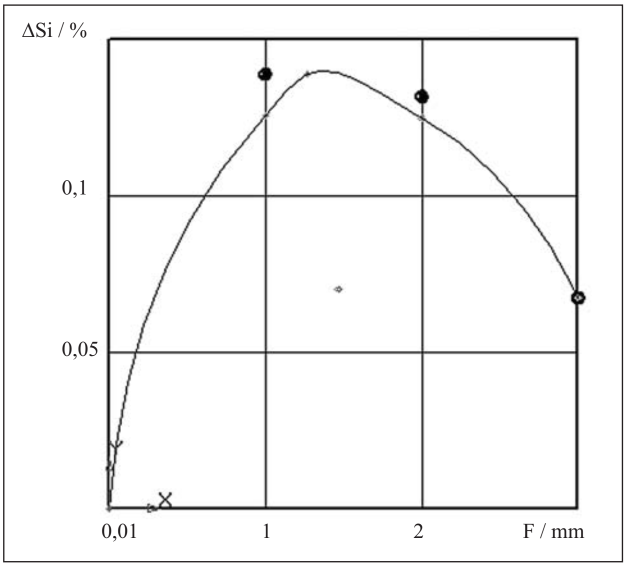

Figure 2 Dependence of silicon content increase on ferroalloys fraction introduced in the ladle

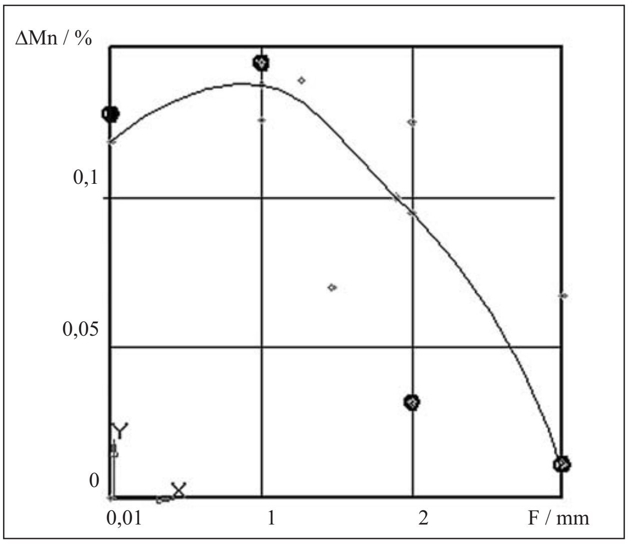

Figure 3 Dependence of manganese content increase on ferroalloys fraction (F) introduced in the ladle

The metal temperature was 1 560 ºC, the metal mass in which there were introduced 400 g of various fractions ferroalloys was 750 kg. Ferroalloys were introduced to the bottom of the ladle. The most expedient is introducing these ferroalloys in the metal stream outflowing from the furnace.

Thus, alloying and deoxidization in the ladle will permit to reduce significantly ferroalloys consumption, to obtain a quality metal with a uniform structure and mean chemical composition on the whole cast cross-section and with high mechanical properties satisfying consumers' needs for various conditions of manufacturing and used in different conditions.

Introducing ferrosilicon FC60 showed that it is more rational to introduce it in the ladle while introducing it on the notch chute silicon waste is more significant which proves the incomplete silicon of larger fraction dissolution (Table 1). At the same time highly-dispersed ferroalloys (smaller than 0,3 mm) have a larger waste percent.

In this case it is more expedient to use ferrosilicon of 0,5…1 cm fraction and to introduce them to the ladle bottom. Here there will take place the most complete silicon dissolution in cast iron.

Table 1 **Experimental studies results**

Mass of ferroalloys introduced/ kg	Method of ferroalloys introducing in the ladle	ΔSi/%	Note
0,7	To the notch chute	-0,31	Metal mass 250 kg. Fraction 1…3 cm.
1,0		-0,16	
0,7	In the ladle	-0,14	
1,0		-0,02	

Thus, there were determined the optimal technological parameters of producing shell molds for manufacturing the heating equipment casts. Using the out-of-furnace alloying when obtaining casts by shell molding, and metal deoxidization will permit to present consumers a quality product and will positively affect the mechanical engineering economy on the whole.

CONCLUSIONS

The use of shell molds leads to an increase in the density of sand to (1,65…1,75)•10^3 kg/m^3, strength, permeability, compared with the sandy-clay forms. As a result, the geometric and dimensional accuracy of castings increases metal consumption is reduced, the cost of metal and costs - are reduced.

It is established that the application loads (0,18 ... 0,22 MPa) in the process of hardening sand-resin mixture significantly increases the purity of the inner surface of the mold, increases strength, density, reduces the number of burnt-on casting. Optimal for obtaining a dense and durable shell is the pressure of a mixture consisting of a core (0,18 ... 0,22 MPa) and overhead (up to 0,22 ... 0,30 MPa), which increases the tensile strength of sand and resin to form 0,3 ... 0,4 MPa.

The optimum grain size for the furnace alloying and deoxidation of steel состав 0,8 %C, 1 %Mn, 1 %C, 1 %Si, 96,2 %Fe ferrosilicon is ~ 1 - 2 mm, as smaller size is increased waste, and a significant increase in the fraction of input ferroalloys not allow them to dissolve completely in the ladle.

Alloying and deoxidation in the ladle can significantly reduce the consumption of ferroalloys, allows to obtain high-quality metal with a uniform structure and mean chemical composition across the section of the casting, as well as high mechanical properties that meet consumer demands for various conditions of manufacture and operated under different conditions.

REFERENCES

[1] Sokolov N. A. Lityu v obolochkovie formi. M.: Mashinostroenie, 1969.– 328 p.
[2] Issagulov A.Z., Kulikov V.Yu., Murzazhnov O.S. Izgotovlenie otopitelnich radiatorov litiem v obolochkovie formi // Trudi universiteta, 2004, № 1. – p. 46-48.
[3] Boldin A.N., Davidov N.I., Zhukovskii S.S. i dr. Liteinie formovochnie materiali. Formovochnie, sterzhnevie smesi I pokritiia: Spravochnik. – M.: Mashinostroenie, 2006.
[4] Ponomarev I.N., Sinuhin A.V., Zhukovskii S.S. Sovremennie processi izgotovleniya sterzhnei. Perspektivi dlyu liteinogo proizvodstva Rossii // Liteinoe proisvodstvo, (1997) 4, 8-10.

Note: The responsibile for English language is lecturer from Karaganda State Technical University, Kazakhstan