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OBTAINING CASTINGS IN LOW-PRESSURE CASTING USING MULTIPLE METAL WIRES

The possibility of using two metal wires for casting into a double mold on the installation of the U95A model was considered, and the influence of pouring each casting into a double mold from a separate metal wire on the quality of filling of the contours of the casting surface was studied. The research results were compared with the results of casting a double mold from a single metal wire. We used standard methods for determining the speed of mold filling, the quality of the surface of castings, and the filling capacity of the mold from several metal wires. To conduct a study on filling multi-seat forms from several metal wires, a double chill of the part "filter housing" was used, consisting of two side parts of the upper rod and a rotary pallet. To conduct the experiment, a new tray, and a new cover for the crucible of the filling device were developed for the existing equipment. The main parameter for conducting research was the fill rate. The estimated speed of filling the form was controlled during the research by the time of filling the form cavity. Improved system of metal supply to the casting at the low-pressure casting unit of the U95A model when filling multi-seat forms from several metal wires, which allows to increase the productivity of the installation without significant changes in its design or its modernization. The conducted research allowed us to determine the possibility of using two metal wires installed in the furnace lid, showed better filling of the contours of the casting surface due to a decrease in the rate of metal entering the mold, simplification and reduction of the length of the gating system. Reducing the speed helps to fill the form more smoothly without disconnecting the flow of liquid metal. No leaks of compressed air were detected, and the rate of pressure increase in the furnace crucible remained the same as when using a single metal wire.

Key words: *low-pressure casting, metal wire, multi-seat forms, surface quality.*

The current process of obtaining castings by low-pressure casting, despite its advantages (automatic controlled filling of the mold cavity, increasing as well as obtaining dense castings by feeding castings under pressure) does not satisfy the growing requirements for increasing productivity, especially in the conditions of mass and large-scale production of castings [1].

One of the ways to control the low-pressure casting process is to use multi- seat forms that are filled from several metal wires [2, 3], since several parts can be produced in the same time.

Filling the mold from several metal wires in low-pressure casting is widely used in the production of parts from aluminum and magnesium alloys [4, 5]. Filling through several metal wires makes it possible, especially when receiving large-sized castings, to reduce the filling time at a given filling speed.

Filling multi-seat forms from several metal wires makes it possible to dramatically increase the productivity of low-pressure casting plants, simplifies the gating system and, thus, provides significant savings in materials [6].

Figure 1 shows a pallet with two gate holes for a central supply of metal to the casting.

AK7 chosen as the material for the experiment [7] was melted in in a 0.4-ton induction crucible furnace with the typical industrial frequency.

The studies were carried out at the machine of U95A model developed by NIISL Company and modernized by the State Enterprise "Engineering Production Scientific Center of Casting under Pressure". The general view of the U95A model unit is given in figure 2.

After casting, the special equipment takes out the cast piece from the cavity of the casting mold. The cast piece is cooled in the air, and after that it undergoes heat treatment [7].

Before the experiments we were based on the assumption that when the casting device is clamped to the bottom with the metal wires, there would emerge the gaps, through which the metal could pour out when filling the cavity of the mold.

However, the experiments have shown that if the furnace is adjusted precisely at the metal wire-bottom point of holding back, no leakage is observed in course of all the experiments. Now, it is obvious that two or more metal wires can be fixed if they are symmetrical about the longitudinal axis of the bottom.

Figure 1. The Bottom with Two Gate Holes

It has also been established that the thermal conditions in the upper part of both metal wires were almost the same, therefore, the values of the residues in both metal wires were the same.

The greater leaks in compressed air within the crucible for a low-pressure die casting unit were not registered when using two metal wires as compared with one metal wire practice and the rate which the pressure in the crucible increased with remained the same as in the case of one metal wire.

The installation of two feeding tubes almost did not affect the temperature drop of the liquid alloy in the crucible while from a technological point of view, two feeding tubes application has been proved by the experiments as the one capable of ensuring better filling of the contours of the casting piece surface due to the lower rate, which the metal enters the mold with and simplified and shortened in length gate system.

Moreover, at other things being equal, it is the decrease in the rate that contributes to a smoother filling of the mold avoiding exfoliation of the liquid metal flow.

The rate of mold filling was determined as the average velocity from ratio (1):

$$V_{\text{cp}} = \frac{V_{\text{B}} + V_{\text{E}}}{2}, \quad (1)$$

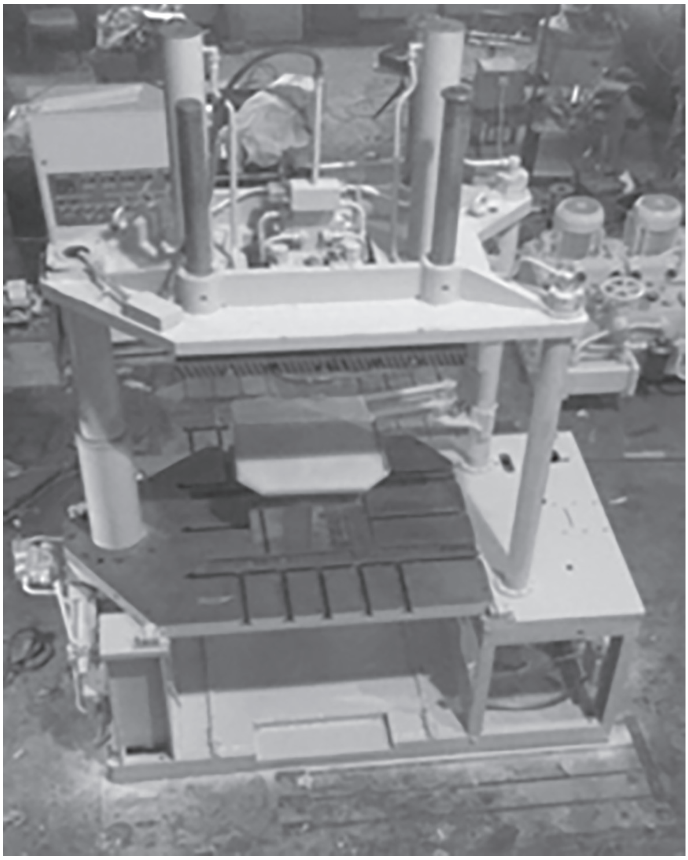

Figure 2. The U95A model machine under Low Pressure

where V_B – filling rate at the beginning of the cycle when crucible is filled with the liquid metal (m/s);

V_E – filling rate at the end of the crucible casting (m/s).

The values of the filling rates at the beginning and at the end of casting into the crucible are determined from ratios (2) and (3):

$$V_{\mathrm{B}} = 4{,}3 \cdot \xi \cdot \sqrt{\frac{P_{\mathrm{B}} - h_{\mathrm{B}}}{\gamma}}, \tag{2}$$

$$V_{\mathrm{E}} = 4{,}3 \cdot \xi \cdot \sqrt{\frac{P_{\mathrm{E}} - h_{\mathrm{E}}}{\gamma}}, \tag{3}$$

where ξ is the coefficient that takes into account the local deposit loss and is equal to 0.7;

P_B – pressure required to fill the mold at the beginning of casting operation into the crucible;

P_E – pressure required to fill the mold at the end of casting operation into the crucible;

h_B – the height of the metal column from its level within the crucible to the mold top at the beginning of casting;

h_E – the height of the metal column from its level within the crucible to the mold top at the end of casting.

The pressure values are as follows:

$$P_{\mathrm{B}} = \frac{h_{\mathrm{B}}}{\xi \cdot K}, \tag{4}$$

$$P_E = \frac{h_E}{\xi \cdot K}, \tag{5}$$

where K – a constant equals 430 kg /m^3 for aluminum alloys;

For the considered case:

h_B = 0.56 m; h_E = 0.106 m;

$$P_B = \frac{0{,}56}{0{,}7 \cdot 430} = 1{,}8 \cdot 10^{-3}\frac{kg}{m^3}$$

$$P_E = \frac{0{,}106}{0{,}7 \cdot 430} = 3{,}5 \cdot 10^{-4}\frac{kg}{m^3}$$

$$V_B = 4{,}3 \cdot 0{,}7 \cdot \sqrt{\frac{1{,}8 \cdot 10^{-3}}{0{,}0023} - 0{,}56} = 1{,}4\frac{m}{s}$$

$$V_E = 4{,}3 \cdot 0{,}7 \cdot \sqrt{\frac{3{,}5 \cdot 10^{-4}}{0{,}0023} - 0{,}106} = 0{,}64\frac{m}{s}$$

$$V_{avg} = \frac{1{,}4 + 0{,}64}{2} = 1{,}2\frac{m}{s}$$

The calculated value of the mold filling rate was monitored during the course of study over the time when the mold cavity was being filled and they were 5 seconds at the beginning of casting into the crucible and 10 seconds at the end of casting into the crucible.

The studies have been carried out to know whether the feeding technique influences the casting piece quality: the central feeding (fig. 3) and the side feed into the mold or block mold have been considered.

The central metal feeding technique to fill the double-cavity mold from two metal feeding tubes also improves the risering conditions. At side metal feeding, we failed to obtain a dense metal structure in the massive parts of the casting piece (illustrated in fig. 4). As can be seen from the figures, the shrinkage porosity and the shrinkage cavities have been found both in the central massive parts of the casting piece (fig. 4: 1 *b*) and in the side massive parts of the casting piece (fig. 4: 2 *b* and 3 *b*).

Figure 3. Casting of filter housing part obtained by LowPressure die casting

The indicated shrinkage defects are explained by the fact that when the metal is fed from the side

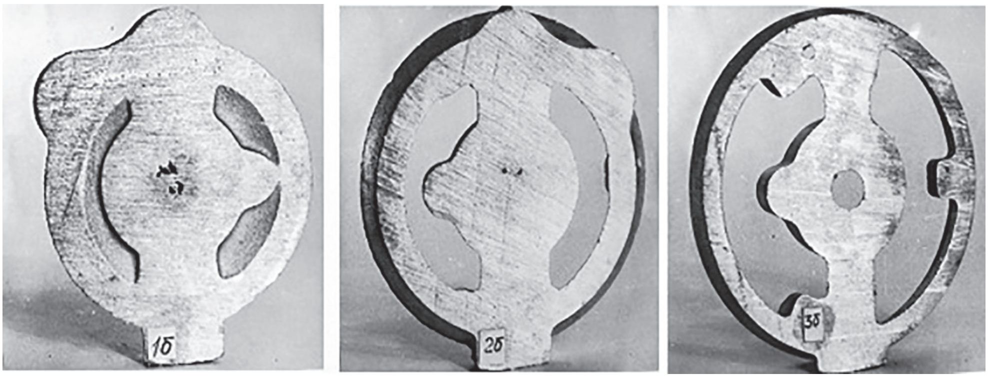

Figure 4. Cross-sections of the castings produced with side metal feeding technique: 1 *b* – 30 mm from the lower end of the casting piece; 2 *b* – 45 mm from the lower end of the casting piece; 3 *b* – 60 mm from the lower end of the casting piece

into the casting piece, it is more significantly cooled in the extended gate system, which leads to a decrease in the efficiency of casting risering during solidification.

The presented sections of the casting piece have been taken as follows:

1) 30 mm from the lower end of the casting piece (fig. 4: 1 *b*);
2) 45 mm from the lower end of the casting piece (fig. 4: 2 *b*);
3) 60 mm from the lower end of the casting (fig. 4: 3 *b*).

Both at the central metal feeding technique to a casting piece and at that when filling a double-cavity mold from two feeding tubes, the flow of the liquid metal touches the mold base only through the gate hole (see Figure 1) and therefore the metal is less cooled, thus a more efficient risering of massive parts casting piece (filter housing part) is achieved.

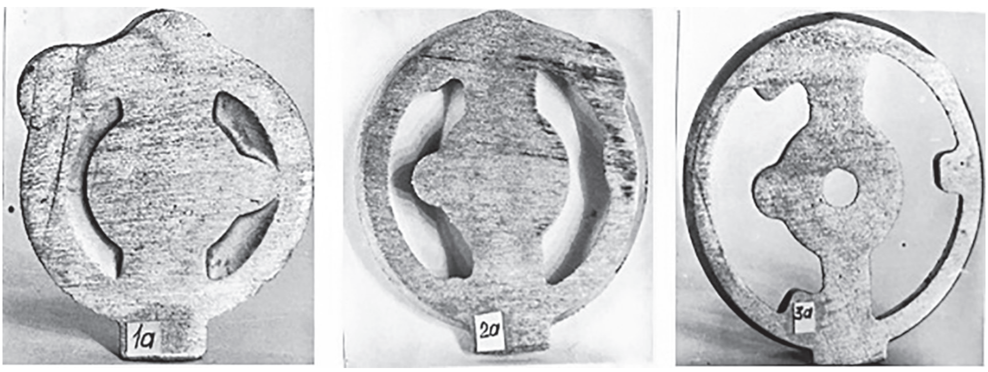

Figure 5. Casting sections produced with central metal feeding: 1 *a* – 30 mm from lower end of the casting; 2 *a* – 45 mm from lower end of the casting; 3 *a* – 60 mm from lower end of the casting

Figure 5: 1 *a*; 2 *a* and 3 *a* show the section cuts at the same distances from the lower end of the casting piece produced by the metal central feeding technique. In this case, a dense structure without shrinkage defects has been obtained.

In addition, the application of a double-cavity block mold for filter housing part casting at U95A machine has reduced the block mold overheating and that of the mold base due to a more uniform distribution of heat transfer from the liquid metal to the mold.

Conclusions:

The reported research has established that in the low-pressure die casting machine of the U95A model, it is possible to practice multi-cavity molds casting from several metal feeding tubes, which is one of the reserves of productivity increase without a significant change in the machine design or its major modernization.

It has been found that with the central metal feeding technique as well as with casting a double-cavity mold from two metal feeding tubes, the flow of liquid metal touches the mold base only at the gate opening and, therefore, it is cooled less, which provides the more efficient feed of the massive parts of the casting piece of filter housing part.

The use of a central metal feeding improves casting feeding conditions, the experiments have shown better fill ability of the casting contours, simplifying and reducing the length of the gate system.

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ОТРИМАННЯ ВИЛИВКІВ ПРИ ЛИТТІ ПІД НИЗЬКИМ ТИСКОМ З ВИКОРИСТАННЯМ ДЕКІЛЬКОХ МЕТАЛОПРОВОДІВ

Розглянуто можливість застосування двох металопроводів при заливці в двомісну форму на установці моделі У95А, а також вивчено вплив заливки кожного виливка в двомісну форму з окремого металопровода на якість заповнюваності контурів поверхні виливки. Результат досліджень порівняли з результатами заливки у двомісну форму з одного металопровода. У роботі застосовували стандартні методики визначення швидкості заповнення форми, якості поверхні виливків, заповнюваності форми з декількох металопроводів. Для проведення дослідження щодо заповнення багатомісних форм з декількох металопроводів, використовувався двомісний кокіль деталі «корпус фільтра», що складається з двох бічних частин: верхнього стержня і поворотного піддону. Для проведення експерименту розроблено до існуючого оснащення новий піддон і нову кришку тигля заливного пристрою. Ос-

новним параметром при проведенні досліджень була швидкість заповнення. Розрахункову величину швидкості заповнення форми контролювали в процесі проведення досліджень часом заповнення порожнини форми. Удосконалено систему підведення металу в виливок на установці лиття під низьким тиском моделі У95А при заливці багатомісних форм з декількох металопроводів, що дозволяє збільшити продуктивність установки без істотної зміни її конструкції чи її модернізації. Проведені дослідження дозволили встановити можливість застосування двох металопроводів, встановлених в кришці печі, що показало кращу заповнюваність контурів поверхні виливки завдяки зменшенню швидкості надходження металу в форму, спрощення та скорочення довжини ливникової системи. Зменшення швидкості сприяє більш плавному заповненню форми без роз›єднання потоку рідкого металу. Виток стисненого повітря не виявлено, швидкість зростання тиску в тиглі печі залишалася такою ж, як і при застосуванні одного металопровода.

Ключові слова: *лиття під низьким тиском, металопровід, багатомісна форма, якість поверхні.*