Competitiveness increase of technological business processes of casting production on the basis of AlpHaset process

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Abstract. The most important task of the transition from a raw material model of the domestic economy to a model of high-tech development is the use of modern innovative technologies in high-tech industries. It is necessary to use effective and most appropriate modern unstable business conditions for enterprises to manage their production business processes to increase the competitiveness of Russian enterprises. In the modern innovation sphere, there are many contradictions. On the one hand, Russia acts on the world market as a state with high scientific and technical potential, and on the other, it is simultaneously characterized as a technologically backward country. The annual review of the World Economic Forum states that Russia continues to move slowly down the competitiveness rating of the countries of the world. According to the World Economic Forum report, Russia is in only eight of the ten countries in terms of the quality of state institutions and the ability to generate technological innovations. Analysis of the state of the innovation sphere in Russia indicates extremely low rates.

1. Introduction

In the XXI century intensified the process of reducing the number of design, technology bureaus, design and engineering organizations. In general, an analysis of the current state of the scientific, technical and innovation sphere in Russia indicates that the main obstacles to the development of industry are its deep technological and organizational backwardness, which leads to low labor productivity, the loss of a significant part of the domestic sales market with unclear prospects in foreign markets. The low level of remuneration is the reason for the withdrawal of active and promising workers from scientific and design organizations. The composition of the qualified personnel of research institutes and design bureaus decreased more than three times [1].

To increase the efficiency of foundry, the creation and implementation of new production processes in molding, core, chipping, treatment, embossing and other areas is of great importance. Currently, more than 70% of the total number of castings is made in sandy-clay forms. However, despite the versatility of this method, the dimensional accuracy and surface roughness parameters of castings obtained in sand-clay forms, in many cases do not meet modern requirements. That process option will be the most optimal, which provides the lowest amount of reduced costs per production unit.

The efficiency of the foundry depends on solving the problems of its mechanization and automation, using analysis and the correct calculation of all production costs by places of origin, types of costs and products. This problem is especially relevant for foundries of machine-tool factories, where more than 40% of workers are engaged in manual labor.

By the beginning of the XXI century, production volumes in the foundry industry of Russia fell sharply. The main reasons for this process are:

- A sharp decline in production in the 1990s in engineering, shipbuilding, machine tool, and other industries led to a decrease in demand for castings - their production in Russia fell from 25.8 million tons in 1985 to 7.68 million in 2008, and this caused not only an increase in cost, but also a decrease in the quality of products.
- The transition to market relations in the context of globalization required increasing flexibility, production efficiency, its susceptibility to changes in demand and technological innovations, and increasing the competitiveness of its activities.
- The intensification of economic communications of the domestic market with the global one (domestic producers were unable to adapt to international competition); breaking cooperation ties with the countries of the former CIS.
- The use of obsolete technologies and high wear and tear of equipment, the low level of technological innovation in production business processes.

In addition, large industrial enterprises created in the USSR, as a rule, also contained a huge staff of workers, vast areas of production infrastructure, many auxiliary enterprises and social facilities. Similar enterprises in the West and East Asia, cost an order of magnitude less employees number with higher automation and better organizational debugging, instead of auxiliary production they used the services of subcontractors, and instead of direct social support they preferred to pay higher salaries. To reorganize and modernize production, it took a lot of time - so, almost all of Russian metallurgy was modernized in the 2000s. At enterprises, automation was strengthened, the number of employees was reduced many times. Modernization of production was carried out on the basis that the invested funds were compensated by the opportunity to earn due to the guaranteed demand for their products on the foreign market. But many manufacturing industries did not have such an opportunity - the demand for their products depended too much on the availability of technological innovations and the economic efficiency of production. To date, foundries exist both in the form of independent foundries, and in the form of sections of engineering industries and metallurgical complexes [2].

For these reasons, first of all, the structure of foundries has changed - the bulk of the castings began to produce production with a capacity of less than 10000 thousand tons. castings per year. The distribution of foundries and plants in Russia by capacity is shown in figure 1 [3].

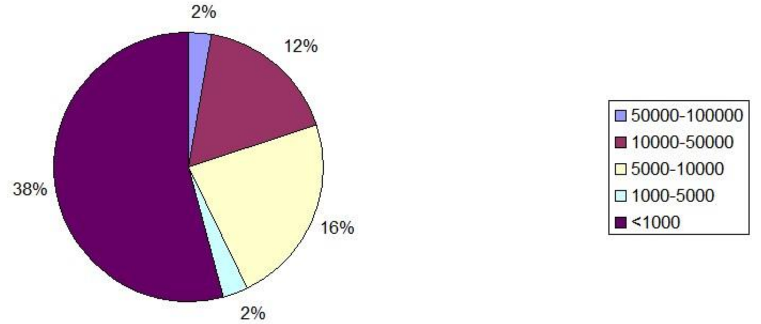

Figure 1. Distribution of foundries and plants by capacity (1000 tons/year) and its percentage.

The bankruptcy and liquidation of foundries and factories continues. So, from 1985 to the present, the number of foundries and plants has decreased from 2500 to 1200, i.e. 52%, the average load of existing foundries is 42%.

Over the past 5 years, more than 160 foundries have been fully or partially reconstructed. Promising technological processes are widely mastered: melting cast alloys in induction and electric arc furnaces, increasing the share of production of castings from ductile iron, magnesium and aluminum and titanium alloys, manufacturing molds and cores of their cold-hardening mixtures, modeling casting processes using numerical, including 3D technologies [4].

An important role in obtaining high-quality castings is played by methods for producing foundry molds and cores. Promising are the dynamic methods of molds compaction from cold-hardening mixtures [5]. Currently, the manufacture of molds from ASG is 60%, from CTS - 40%. Over the past 5 years, the production of manufacturing forms of their CTS has increased by 11%. The main advantages of HTS technology:

- Low cost of equipment and short terms of its manufacture.
- High strength of produced molds / rods [6].
- HTS can be used in the manufacture of castings of almost any configuration from ferrous and non-ferrous alloys.
- Flexibility in the manufacture of multinomenclature products.

Distinctive casting features on the basis of HTS from casting to the ground:

- No inflows and deviations from linear dimensions.
- It is possible to obtain final surfaces without treatment.
- Minimum allowances (2-3 mm) are given on the machined surfaces
- Foundry pores and sinks are practically absent.
- Casting mass is lower due to smaller allowances and better surface quality.

2. Problem statement

Due to the fact that in Russia there are no enterprises manufacturing automatic molding lines, manufacturing molds using the AlpHaset process, foundries are forced to buy them abroad. This process allows to obtain good quality of the casting surface, in addition, its application provides high productivity and greatly facilitates working conditions, both in the molding area and in the knockout area. In the process of preparing the mixture and filling the forms, the mixture is almost odorless, which makes it possible to manually direct and seal the mixture. The freshly prepared mixture is very fluid and it does not always require a vibrating table to seal it. The cure rate of the mixture is controlled by the type of hardener, while the amount remains constant.

Separation of models and core boxes is easy. Removing from the tool is possible without difficulty, both at the initial stage of curing the mixture, and at a later stage of curing.

During the mixture curing, heat is not generated, therefore, the surface of the models is maintained in good condition for a long time, especially when good model varnishes are applied to it. Advantages arising from the use of the AlpHaset process, such as easy removal from rigging, a significant reduction in model wear, and reduced pollution and model breakdowns make it possible to store core boxes and models as close to their place of use as possible. Thus, the operation of changing models is facilitated, and especially in the manufacture of small series of products, it is easier to maintain and control the molding process.

For Alfaset molding, dust-free quartz sand with an average grain size of 0.22-0.34 mm and a very fine fraction content of less than 2.0% should be used. Failure to do so will increase the consumption of binders. The shape of the sand grains of fresh quartz sand also has a certain effect on the strength characteristics. The best results with AlpHaset molding are achieved on sand with a round and oval particle surface. Sand with an acute-angled shape of sand grains has a large specific area, which leads to a decrease in the strength of the forms [7].

This technology provides the possibility of multi-nomenclature production, quick readjustment of the technological process with the introduction of a new nomenclature, reduction of time for preparation of production, production of single castings and small batches.

The high strength and short hardening cycle of the XTS according to the Alfaset process make it possible in some cases to carry out flaskless molding, drastically reducing the cost of manufacturing equipment.

When concluding a contract for the supply of a line, the company guarantees its performance using the HEXION binder system (ALPHASET TPA 95 resin - ALPHASET ACE hardeners), which allows castings to be obtained with good surface quality and to ensure high efficiency in the process of manufacturing molds and cores with a more environmentally friendly impact during molding filling and knocking out.

ALPHASET TPA 95 resin has proven itself when working on regenerate (the proportion of regenerate can reach 80-90%), allowing to achieve high strength of the mixture at a high curing rate.

At the stage of molding mixture preparation, the hardener is always added before the resin. The amount of hardener is calculated from the amount of resin added and should be 20-22%. Particularly fine-grained and dusty sands may require up to 24% hardener to achieve optimum strength values. When using molding sand that meets the requirements of the developers of this technology, the added amount of resin during molding is 1.2 - 1.6% and in the manufacture of rods 1.3 - 1.8% of the amount of sand.

One company purchased an IMF automatic molding line for mold sizes of 1200x1000x450 / 450 and a capacity of 20 molds / hour. At the request of the line, the mixture should have the following tensile strength, kg / cm2: after 25-30min-0.8-0.9; after 60min-1.4-1.7; after 120min-2.3-2.7. Strength of 0.8-0.9 is necessary for the high-quality extraction of half-forms from the drawer, if the strength is less, the half-mold can break when it is removed, if the strength is higher, the half-mold can get stuck in the box. Strength of 1.4-1.7 is necessary for the smooth operation of the manipulator during transportation and tilting of half-forms. If the strength is lower, the manipulator may crush the half-mold; if the strength is higher, the spikes of the manipulator may not catch the half-mold, and it may fall or crack with increasing effort to take it. Strength 2,3-2,7 allows to withstand the pressure of the cast metal [8].

In the process of debugging and putting into production of this line using the AlpHaset technology of the process using molding sand of grade 1K20303, it was found that its stability is ensured only with a resin content of 1.8-2.0%, hardener 26-28% of resin and 76 -80% regenerate [9]. This is because the Russian foundry sand does not meet the AlpHaset process requirement. The increased consumption of resin and hardener led to an unplanned increase in the cost of their acquisition, which reduced the effectiveness of the implementation of this process. For this reason, the enterprise turned to the Siberian Federal University of Krasnoyarsk with a request to eliminate this negative phenomenon.

3. Proposed solution

Specialists of the Siberian Federal University decided to study the possibility of using another resin, cheaper and manufactured by the Russian company. Resin Alkaset (Alphabond) NV7 with a hardener Catalit 3B of the Uralchimplast – Hüttenes Albertus enterprise (UCP-HA) was chosen. The development of mold manufacturing technology required the manufacture of a multi-socket core box for the manufacture of "eights" (figure 2). All work was carried out in the molding laboratory of the foundry.

To prepare the mixture, a cup-type foundry mixer was used, a laboratory bowl with a capacity of 6 kg, the components were dosed with measuring cups. Initially, molding sand was mixed with regenerate and resin, then a hardener was added. Stirring was carried out until a homogeneous mass was obtained, then the mixture was placed in a core box and kept for 25-28 minutes.

Figure 2. A core box with a rail for cutting off excess mixture.

At the first stage, the obtained eights were taken out of the box and laid on the laboratory bench, 2 of the total number were tensile tested using a special installation (figure 3).

Figure 3. Installation for testing "eights".

The tests of the remaining eights were carried out at certain intervals of time, according to the requirements for the mechanical properties of the mixture by the developers of the automatic molding line (25-28 minutes, 60-65 minutes, 120-130 minutes). One eight returned to the laboratory and tested after 10 hours, this test allowed us to determine the permissible storage time of the molds before filling it. At the second stage, two eights were tested immediately in the laboratory, and the rest lay on the conveyor belt after the tilter. Thus, they went through the further process of manufacturing molds and at each stage one or two "eights" were removed from the tape and subjected to a tensile test in the molding laboratory. The results of the studies are shown in table 1.

Table 1. Costs for the purchase of fresh materials used in the manufacture of the molding sand.

Composition option	Refractory filler mixtures	Number of kg per 1 t	Price th.rub/t	Binder	Number of kg per 1t	Price th.rub/t	Hardener	Number of kg per 1t	Price th.rub/t	The cost of 1 t Mixture, rub
№ 1	sand 1K_20_303	200,0	2,0	Resin ALPHASET TPA 95	19,0	15,0	ALPHASET ACE	5,0	250	1935
№ 2	sand 1K_20_303	200,0	2,0	Resin Alcazet NB7	19,0	20,0	Catalit 3B	5,0	100	1280

4. Conclusion

Thus, the studies showed the following:

- ALPHASET TPA 95 resin and ALPHASET ACE hardener can be replaced with Alkaset NV7 resin with Catalit 3B hardener with tensile strength after 28 minutes - 0.7-0.8 kg / cm2, after 60 minutes - 1.3-1 , 4 kg / cm2, and after 120 minutes - 2.3-2.6 kg / cm2.
- Costs per 1 ton of molding sand are reduced by 33.85%, which significantly affects the costs per 1 ton of castings. This allows you to increase the competitiveness of manufactured products by increasing the economic efficiency of production business processes.
- The use of these materials allows you to get rid of purchases from foreign manufacturers and support the domestic supplier, which in the difficult conditions of globalization and increasing competition in world markets makes the position of foundries today more stable and competitive.

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