ABSTRACT

dissertation for the degree of Doctor of Philosophy (PhD)
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Development and research of resource-saving technology for the production of thin-walled steel castings by casting in cold-hardening molds

Relevance of the work. Currently, consumers of parts are placing increasingly high demands on products produced by casting: geometric dimensional accuracy, absence of casting defects, homogeneity of structure. A number of parts have structural parts with a thickness of less than 5 mm, that is, such castings can be classified as thin-walled. It is difficult to obtain them by casting them into sandy-clay molds, which can lead to cavities, blockages, adhesions, etc. The use of, for example, lost wax casting generally ensures the production of castings with high geometric accuracy, but significantly increases the cost of casting, complicates the technological process, and reduces productivity. The use of CHM (cold-hardening mixture) to produce thin-walled castings makes it possible to improve the quality of casting while maintaining the relative simplicity of the technological process. However, the disadvantage of CHM is the relatively high cost of the binder (resin). Therefore, reducing the resin content in such a mixture, for example, due to its partial replacement with clay and while maintaining all the advantages of casting in a chemical mixture, is an urgent industrial and scientific task.

The purpose of this dissertation workis to develop a technology for manufacturing defect-free thin-walled castings by casting into cold-hardening molds using combined binders while maintaining the technical and economic advantages of this casting method.

To achieve these goals, the following tasks are proposed:

- analysis of the state of the issue in the field of application of compositions and methods for producing thin-walled castings using molds from cold-hardening mixtures;
- study of the composition and properties of Kazakhstani clays of various mineral compositions to select additives for the complex binder;
- determination of the composition of chemical mixtures for the manufacture of a casting mold in order to obtain castings;
- determination of the influence of technological modes for manufacturing casting molds with a complex binder on the properties of the mold;
- obtaining a pilot batch of samples of defect-free thin-walled castings in industrial conditions, studying the properties of prototypes (for the purpose of developing a technological map).

Object of study – casting mold made from cold-hardening mixtures with a combined binder.

Subject of study – the influence of the composition of CHM with a complex binder and the manufacturing modes of casting molds from them on the quality of thin-walled castings.

Scientific novelty:

- an empirical formula was obtained for determining the thermal conductivity coefficient in molds made of chemically resistant materials of a new composition, which allows you to determine the thermal conductivity coefficient depending on the content of moisture, clay and epoxy resin in the mixture;
- the dependences of the mechanical (strength, hardness) properties of casting molds made of chemical steel with a complex binder on the composition of the mixture and the modes of their production have been identified;
- the dependences of the technological (crumble ability, survivability, gas permeability) properties of casting molds made of chemically resistant materials with a complex binder on the composition of the mixture and the modes of their production have been identified.

Practical significance:

- an optimal composition with a complex CHM binder for the production of thin-walled castings was proposed;
- technological modes for the manufacture of casting molds from CHM with a complex binder for the manufacture of thin-walled castings have been determined;
- the influence of the manufacturing modes of casting molds from CHM with a complex binder on the quality of thin-walled castings was determined.

Research methods:

- mathematical planning of an experiment to determine the optimal composition of binding materials using the method of probabilistic deterministic experiment;
- determination of the casting algorithm in 3D format using the foundry computer modeling system «PoligonSoft»;
- determination of the physical and mechanical properties of samples of forms from CHM and castings obtained with their use;
- methods of metallographic examination of samples of molds from CHM and samples of castings obtained on them;
- methods of quantitative and qualitative analysis of the microstructure of castings using the «Tixomet Pro» program;
- carrying out X-ray phase analysis of samples from CHM;
- virtual modeling of the final element of the process for producing castings using CHM.

Provisions for defense:

- empirical formula for determining the thermal conductivity coefficient in molds made of CHM of a new composition;
- results of modeling the foundry process of obtaining molds from chemical steel («PoligonSoft»);
- results of research on the selection of clay of Kazakhstan origin;
- results of research on developing a new chemical composition;

- results of studies to determine the mechanical and technological properties of forms from a new composition, obtained under various modes;

- results of pilot work on smelting thin-walled castings in molds from the new chemical composition.

The work was carried out at the Department of «Nanotechnology and Metallurgy» of the NJSC «Karaganda Technical University named after Abylkas Saginov»; equipment of the NJSC «KazNRTU named after K. Satpayev», Peter the Great St. Petersburg Polytechnic University was also used for research.

Approbation of work. Based on the research results, 10 articles were published, including:

- 1 article in the international journal «Metallurgija» (Croatia), included in the Scopus database;

- 4 articles in journals recommended by the Committee for Quality Assurance in the Field of Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan («Integrated use of mineral raw materials" No. 1 (2021); «Integrated use of mineral raw materials» No. 1 (2023); «Proceedings of the University» No. 4, 2021; «Proceedings of the University» No. 3 , 2023);

- 1 article in the journal «Foundry», included in the RSCI database;

- received 1 patent for a utility model on a method for producing a cold-hardening mixture;

- 3 theses in international scientific and technical conferences.

Based on the results of industrial tests, the following certificates were obtained:

- act on conducting industrial tests at «KMZ named after Parkhomenko» LLP;

- an act to introduce research on this topic into the educational process of the NJSC «Karaganda Technical University named after Abylkas Saginov»;

- act on conducting industrial tests at «Santekhprom» LLP.

Scope and structure of work. This dissertation consists of the following parts - introduction, 6 main sections, 6 appendices. The dissertation consists of 118 pages of typewritten text, contains 40 figures, 27 tables, and a list of references consisting of 85 titles.