SUMMARY

to the dissertation for the degree of Doctor of Philosophy (PhD) in educational program 8D07203 – Metallurgy

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Studying and developing the technology of manufacturing complex high-precision castings by the lost foam casting method

Relevance of the study

The production of the own high-precision castings is for any country a task of strategic importance, because it ensures economic independence and determines the basis for the development of national mechanical engineering. According to the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, the share of imported foundry products in Kazakhstan is about 80% now. Meanwhile, our country has both sufficient raw material resources and basic means for manufacturing foundry products for various purposes, including high-precision castings.

Recently, much attention has been paid to the technology of producing castings with the use of the lost foam casting (LFC) method, and in Kazakhstan this technology has begun spreading. The process of introducing the LFC method was one of the first to begin at the Parkhomenko KMZ LLP in Karaganda, and this process showed that the scope of LFC could cover almost completely the traditional sand molding; this is especially true in single and small-scale production.

However, despite the promising nature of the LFC method, preference is still given to sand-clay molding (SCL) and cold-hardening mixtures (CHM), since the LFC method is associated with a number of problems, in particular, a high cost of the model material (casting polystyrene), carburization of the casting surface, etc. The solution to these and the other related problems determines the relevance of this work.

Object of the study: the model material when using the LFC method, the technology of manufacturing castings with the LFC method using the new model materials.

Subject of the study: properties of the model material, their effect on the technological parameters of the LFC process.

Objectives of the study: to develop a technology of manufacturing high-precision castings with the use of the LFC method with the new model materials.

Tasks of the study

- to justify and to determine the composition of the model material based on foundry and construction polystyrene foam;
- to determine the composition of non-stick paint for a new model composition of lubricants;

- to study the effect of the model composition on the quality of the resulting casting (the amount of burnt marks, roughness, the amount of carburization of the casting, the number of casting defects, etc.);

- to study and to model the solidification process of the casting obtained with the use of a new model composition;

- to study the casting process using the developed technology (the new composition of the model, the new design of the flask);

- to study the properties of refractory filling sands;

- to develop the design of a vacuum flask for the sale of fuels and materials with a new model composition.

Practical importance

1. A complex composition of the model material using construction polystyrene has been developed. The cost of the casting process has been reduced due to the use of waste from cheaper construction polystyrene foam.

2. Technological modes for the production of LF castings using new model compositions have been proposed.

3. A new design of the flask has been developed, which makes it possible to reduce the amount of defects when pouring the mold; the quality of the casting mold has improved.

4. A non-stick paint composition has been developed for a new model composition.

5. There has been reduced the burden on the environment due to the possibility of using construction polystyrene foam waste (expanded polystyrene foam is practically not recyclable).

Scientific novelty

- the dependence of the size of polystyrene foam granules effect on the burnout rate has been determined;

- there have been derived the equations for the dependence of casting surface roughness on the content of construction polystyrene foam and the thickness of the non-stick coating;

- the dependence of the model gas permeability, roughness and burn-in value of the casting on the thickness of the non-stick paint layer on the model has been determined;

- the effect of the composition of the model on the roughness, the amount of burnt on the casting and the depth of the carburization layer has been determined.

Propositions to be defended

- the equations for the dependence of surface roughness on the content of construction polystyrene foam and the thickness of the non-stick coating;

- the design of the vacuumized flask;

- the dependence of the model gas permeability, roughness and burn value of the casting on the thickness of the anti-stick paint layer on the model;

- technological modes for the production of manufacturing LF castings with the use of complex polystyrene foam models.

The dissertation structure and volume

The dissertation consists of an introduction, six chapters, a list of references of 120 titles and 3 appendices; it is presented on 92 pages and includes 46 figures, 35 tables.

The work approbation

Based on the research results, 24 scientific papers were published, among them:

- 1 article was published in a journal included in the Scopus database (METALURGIJA, Croatia, percentile 34);
- 10 articles in journals recommended by RK CQASHE (Foundry Production, No. 10, 2012 (Moscow, Russia), Foundry Production, No. 7, 2015 (Moscow, Russia), Foundry Production, No. 10, 2016 (Moscow, Russia), University Proceedings, No. 3, 2017 (Kazakhstan), Foundry Production, No. 7, 2017 (Moscow, Russia), Bulletin of G.N. Nosov Magnitogorsk State Technical University, V.15, No. 4, 2017 (Magnitogorsk, Russia), Bulletin of Serikbaev East Kazakhstan State Technical University, No. 4 , 2017 (Kazakhstan), Bulletin of South Ural State University, 33, 2019 (Chelyabinsk, Russia), Foundry, No. 3, 2021 (Moscow, Russia), University Proceedings, No. 31, 2023 (Kazakhstan));
- 1 articles in journals of RSCI (Bulletin of Irkutsk State Technical University, V.23, No. 5, 2019. (Irkutsk, Russia));
- 1 patent of the Republic of Kazakhstan, 1 patent of the Republic of Kazakhstan for a utility model and 1 Eurasian patent;
- participation at 9 conferences of various levels.

Based on the results of the research, the following were obtained:

- an act of carrying out industrial tests at the Parkhomenko KMZ LLP;
- a technological flow chart approved and accepted for use by the Parkhomenko KMZ LLP;
- an act of implementation at the Parkhomenko KMZ LLP.

The place of performing the work

The work has been performed at the Department of Nanotechnology and Metallurgy of Abylkas Saginov Karaganda Technical University NJSC and at the production site of the Parkhomenko KMZ LLP (Karaganda); the equipment of the Peter the Great St. Petersburg Polytechnic University (St. Petersburg, Russia) has also been used for studies.