AP15473207 "Developing the technology of manufacturing defect-free homogeneous castings by lost foam casting method" – p.m. Kovaleva T.V.

Relevance:

In our country, a number of casting methods are used: sand-clay molding, lost-wax casting, pressure die casting. One of the most widespread and promising methods is gasifiable mold casting (GMC). There is a need to reduce the specific consumption of castings in the production of industrial products. The application of GMC leads to an increase in the geometric and dimensional accuracy of castings, reduces material consumption, and lowers metal costs and production costs. The expenses for machining when producing castings using GMC are reduced by approximately 25% or more due to the elimination of complex processing of internal surfaces; in many cases, machining can be completely avoided or minimized. As a result, cleaning of castings is simplified and done faster. The implementation of the project will allow the commercialization of the results in production, for example, at enterprises such as "Kazakhmys Corporation" LLP, "Parkhomenko KMZ" LLP

Objective of the project: to produce dense and homogeneous castings in terms of composition and structure, with low cost and prospects for further commercialization.

Achieved Results:

For 2022. Optimal casting modes for gasifiable mold casting (GMC) were selected. It was determined that the pouring speed should be within 20-30 seconds. The pouring temperature should be between 1550-1650°C, and the pouring height is 50-100 mm.

An analysis of the current state of GMC casting modes in global practice was conducted. It was found that gasifiable mold casting is one of the promising methods for producing castings. Compared to more traditional methods like sand-clay and sand-resin molding, GMC has several advantages, such as minimal mechanical processing of the finished products and high surface quality of castings.

The essence of the GMC process is the transition of the polystyrene model to a gaseous state during casting with molten metal, followed by solidification of the casting in the shell.

Since the casting process generates gaseous products from the model, which, if improperly vented, can negatively affect the casting quality, particular attention must be paid to the composition of the model, pouring modes, and vacuuming of the shell.

The quality of the casting is influenced by parameters such as pouring method, pouring speed, fluidity, and melt temperature, as well as vacuuming modes of the shell.

A literature review on the state of GMC casting modes and an overview of the factors affecting technological modes and model composition on the structure and properties of castings in GMC were conducted.

The literature analysis confirmed that several parameters significantly affect casting quality. An important parameter is the pouring temperature, which influences the final structure of the solidified casting. Increasing pouring temperature leads to a decrease in casting quality due to increased porosity and primary grain size. Conversely, reducing the pouring temperature reduces melt fluidity, which is also a negative factor. Therefore, it is crucial to find the optimal pouring temperature that balances these parameters.

During the casting process, the model undergoes gasification (burning). The model must have a density that allows it to transition to a gaseous state quickly and completely, without negatively impacting the pouring speed or melt flow. Furthermore, efforts should be made to minimize the model's ash residue to reduce scabbing.

Another factor influencing casting quality is the anti-scaling coating applied to the model to reduce interaction at the "casting-mold" boundary. This coating should have a thickness that ensures minimal interaction between the melt and sand, while its gas permeability should allow even gas venting through the coating to prevent gas defects during casting solidification.

An experimental matrix was developed to achieve the research objectives.

Mathematical planning and analysis of experimental results were carried out using the methodology of V.P. Malyshev.

For 2023. A composite polystyrene model was selected using casting and construction polystyrene granules. The optimal gas permeability and density of the model will be determined to ensure a dense, homogeneous structure of the forming casting.

The composition and application modes of the anti-scaling coating on the polystyrene model were selected to avoid scabbing while maintaining necessary gas permeability. An article was published in a journal indexed in the CQAES database.

Technological modes for manufacturing and using gasifiable models and anti-scaling coatings were selected.

One article was published in a journal with a CiteScore percentile of 64 in the Scopus database.

One patent for a utility model was granted in Kazakhstan.

For 2024. Pouring modes were selected: steel sample pouring temperature, pouring height, and hydrostatic pressure to optimize the speed and completeness of the polystyrene model's combustion.

It was determined that a comprehensive approach to the casting of steel castings is critical for the formation of the most favorable structure (homogeneous, defect-free, with minimal carburization depth). The pouring temperature ranges from 1640-1680°C, pouring speed is 1-2 cm/s, and inoculants made of the same material as the molten metal should have a size of about 120-150 μm. Complete and uniform melting of the inoculants and complete combustion of the polystyrene model were observed, with the removal of combustion products to the casting's shell layer.

Two articles were published in a journal indexed in the CQAES database.

Vacuuming modes of the mold were selected in correlation with gas permeability and gas extraction speed.

It was determined that the most optimal vacuuming mode for removing polystyrene model degradation products is 30-40 kPa. Industrially, it was proven that it is important to place gas channels not only at the bottom of the shell but also on its sidewalls. Casting defects in such shell designs were reduced to 2-3%.

One article was published in a Q2 journal with an impact factor in the Web of Science database.

One monograph was published: Kovalyova T.V. "On the Possibility of Using Composite Models for Producing Castings by Gasifiable Mold Casting." Karaganda: Colibri, 2024. 96 p.

A dissertation titled “Research and Development of Technology for Producing Complex High-Precision Castings by Gasifiable Mold Casting” was defended for the degree of Doctor of Philosophy (PhD) in Metallurgy (Order of the Chairman of the Committee for Quality Assurance in Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan No. 1117, dated November 28, 2024, on conferring the degree).

Within the project, optimal technological modes were developed and implemented for producing “Running Wheel” castings by gasifiable mold casting (GMC). A technological map was prepared, and production trials were conducted, as confirmed by the implementation certificate at “Parkhomenko KMZ” LLP.

The following parameters were established for the "Running Wheel" casting:

• Material: Steel 80GSL;

• Pouring temperature: 1530-1580°C;

• Pouring speed: 0.5 kg/sec;

• Pouring time: 1 min;

• Holding time: 18 hours.

The following were used to make the model:

• Composition: 40% PPS-20, 60% PSW-1L with up to 1.5% inoculants by model mass;

• Coating: 1K02A sand (35%), zircon sand (15%), hydrolyzed alcohol (47%), polyvinyl butyral (3%), applied to a thickness of 1.5 mm;

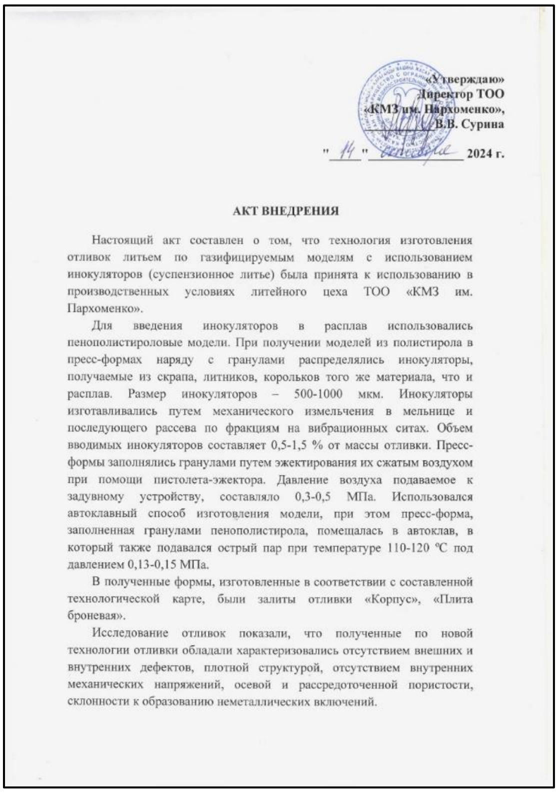
• Shell filler: 1K02 sand (70%) and 1K016 sand (30%).

Experimental results confirmed that using composite polystyrene for steel 35L castings reduces carburization depth, improves surface quality, and increases melt fluidity when the pouring temperature is increased to 1550°C.

Analysis of results showed that using inoculants in GMC reduces overall casting defects to 0.8%, significantly lower than the traditional method (1.4%).

A monograph was published:

• Kovalyova T.V. *“On the Possibility of Using Composite Models for Producing Castings by Gasifiable Mold Casting.” Karaganda: Colibri, 2024. 96 p. ISBN 978-601-08-4513-8.*



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"14" __________ 2024 г.

АКТ ВНЕДРЕНИЯ

Настоящий акт составлен о том, что технология изготовления отливок литьем по газифицируемым моделям с использованием инокуляторов (суспензионное литье) была принята к использованию в производственных условиях литейного цеха ТОО «КМЗ им. Пархоменко».

Для введения инокуляторов в расплав использовались пенополистироловые модели. При получении моделей из полистирола в пресс-формах наряду с гранулами распределялись инокуляторы, получаемые из скрапа, литников, корольков того же материала, что и расплав. Размер инокуляторов – 500-1000 мкм. Инокуляторы изготавливались путем механического измельчения в мельнице и последующего рассева по фракциям на вибрационных ситах. Объем вводимых инокуляторов составляет 0,5-1,5 % от массы отливки. Пресс-формы заполнялись гранулами путем эжектирования их сжатым воздухом при помощи пистолета-эжектора. Давление воздуха подаваемое к задувному устройству, составляло 0,3-0,5 МПа. Использовался автоклавный способ изготовления модели, при этом пресс-форма, заполненная гранулами пенополистирола, помещалась в автоклав, в который также подавался острый пар при температуре 110-120 °С под давлением 0,13-0,15 МПа.

В полученные формы, изготовленные в соответствии с составленной технологической карте, были залиты отливки «Корпус», «Плита броневая».

Исследование отливок показали, что полученные по новой технологии отливки обладали характеризовались отсутствием внешних и внутренних дефектов, плотной структурой, отсутствием внутренних механических напряжений, осевой и рассредоточенной пористости, склонности к образованию неметаллических включений.

Техническим результатом явилось получение отливок с однородной объемной плотностью по всему сечению модели, имеющих повышенные эксплуатационные свойства (прочность, твердость, износостойкость).

Технология выплавки отливок по данной технологии принята к использованию в производственном процессе.

Акт подписан в рамках выполнения научной работы ИРН AP15473207: «Разработка технологии изготовления бездефектных гомогенных отливок литьем по газифицируемым моделям».

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Figure 1 - Implementation Act

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List of Publications

Kovalyova T.V., Issagulov A.Z. // Research on the Possibility of Using Composite Models in the Technology of Lost Foam Casting// *University Proceedings, No. 2, 2023, pp. 85-88 (*DOI 10.52209/1609-1825_2023_2_85*)*

Tatyana Kovalyova, Yevgeniy Skvortsov, Svetlana Kvon, Michot Gerard, Aristotle Issagulov, Vitaliy Kulikov and Anna Skvortsova // Titanium Carbide and Vibration Effect on the

Structure and Mechanical Properties of Medium-Carbon Alloy Steel //Coatings 2023, 13, 1135. (https://doi.org/10.3390/coatings13071135)

Patent RK for a Utility Model No. 8240 “Method for Producing a Gasifiable Polystyrene Model,” Bulletin No. 37, dated 15.09.2023.

Kovalyova T.V., Issagulov A.Z. // Study of the Depth of Carburization of Steel Castings Obtained by Lost Foam Casting // Foundry Production, No. 3, 2024, pp. 20-22.

Kovalyova T.V., Issagulov A.Z. // Studying the Depth of Carbonifying Castings Obtained by the Lost Foam Casting Method with a Complex Polystyrene Composition // Material and Mechanical Engineering Technology, №1, 2024., p. 9-14 (DOI 10.52209/2706-977X_2024_1_9)

Kovalyova, T.V.; Issagulov, A.; Kovalev, P.; Kulikov, V.; Kvon, S.; Arinova, // Structural Anisotropy Parameters’ Effect on the Low-Temperature Impact Strength of Alloy Steels in Rolled Products // Metals 2023, 13, 1157. (https:// doi.org/10.3390/met13071157), Q2.

Information for Potential Users:

The results obtained can be implemented in the preparatory workshops of machine engineering production. The theoretical and practical outcomes of this work can be used in foundry production, as well as for educational purposes.

Scope of application: foundry workshops of machine engineering plants

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