ENSURING STABLE CASTING QUALITY UNDER CONDITIONS OF STOCHASTIC DEVIATIONS

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In modern conditions of increasing requirements for the quality of foundry products, the consideration of stochastic characteristics of technological processes is of particular importance. Fluctuations in parameters that arise under the influence of both internal and external factors directly affect the quality of castings.

Reliable quality management is possible only under the condition of quantitative analysis of the regularities of parameter dispersion both in the casting process and in the final properties of the product. The work considered the stochastic features of various stages of foundry production - molding, pouring, crystallization and cooling [1].

It was established that most technological parameters are subject to random fluctuations caused by the instability of regimes, the heterogeneity of materials and the influence of the human factor.

This makes it impossible to use only deterministic methods when assessing quality and requires the use of the mathematical apparatus of probability theory and statistics.

To analyze empirical parameter distributions, universal systems of random variable distribution functions were used - Pearson and Johnson distributions, which are characterized by high flexibility and the ability to describe a wide range of forms. Particular attention is paid to the Johnson distribution of type Sb, which demonstrated the highest accuracy of approximation of data obtained during production and technological observations[2].

The use of this model made it possible to effectively take into account the asymmetry and limited ranges of parameters, which is characteristic of foundry processes.

Numerical experiments performed on the basis of real production data confirmed the feasibility of using Johnson distributions to describe the stochastic behavior of such parameters as metal temperature during pouring, pouring speed, molding compound strength and geometric deviations of castings [3].

Calculation of numerical characteristics, construction of histograms and selection of distribution parameters were carried out using the methods of least squares and maximum likelihood. The analysis showed that it is the Johnson distribution of type Sb that provides the most complete and accurate description of parameter variations, and can also be easily integrated into statistical quality control (SPC) systems.

This creates a basis for automated process control, allows for prompt detection of deviations and taking corrective actions, which contributes to reducing the level of defects and increasing the stability of production.

Additionally, the possibility of applying the proposed approach to classifying foundry processes by the degree of stochasticity [4] is considered. Such classification allows developing flexible management strategies focused on the features of a specific section or type of product.

The isolation of processes with a high level of uncertainty allows focusing efforts on their stabilization and strengthening control. The developed models and approaches can be used within digital production platforms and predictive analytics systems aimed at predicting quality and automatically adjusting parameters in real time [5].

This is especially relevant during the transition to the concepts of smart manufacturing and Industry 4.0, where high adaptability of technological solutions is required.

Thus, the results of the study confirm that stochastic modeling of casting process parameters is a necessary element in building reliable and effective quality management systems. The use of the Johnson distribution of type Sb provides an accurate description of empirical data, which makes it a promising tool in the practice of modern foundry production.

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