UDC 669.1

OPTIMIZATION OF FOUNDRY PROCESSES USING RHEOLOGICAL MODELS

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Abstract. This study explores the importance of rheological models in sand casting, focusing on their impact on process optimization, product quality, and cost reduction.
Key words: Sand casting, rheological models, molding mixtures, process optimization

Casting is a technological method for producing parts by pouring molten material into a special cavity that replicates the shape of the desired object. Once the material solidifies, it retains the shape of the mold cavity.

Sand casting is currently the most widely used and versatile casting method. It allows for the production of castings from various materials, regardless of their complexity, size, or weight. A key feature of sand molds is their low thermal conductivity and heat capacity, enabling the manufacture of castings with thin wall sections (2.5–5 mm) [1, p. 50].

The molding mixture is a complex, quasi-homogeneous, quasi-isotropic material with rheological properties that include elasticity, viscosity, and plasticity. It is a fundamental component of the casting process, and its properties directly affect the quality of the finished products [2, p. 96].

Given the high demands for precision and process predictability in casting, analyzing existing mathematical rheological models that describe the behavior of molding mixtures during forming is a current and important task.

Rheology is the science that examines the relationship between external forces acting on a material and the resulting deformation. In modern manufacturing, it is essential to accurately predict these properties to optimize technological processes. Rheological models allow for a precise description of molding mixture behavior under load, which helps improve production efficiency, enhance product quality, and reduce manufacturing costs.

Currently, sand-clay molding mixtures are the most common application area for such models. Among the fundamental approaches are:

- the Newtonian model, which describes fluids with constant viscosity, although it does not account for nonlinear effects at high deformation rates;
- Hooke’s model, representing the behavior of an ideal elastic solid;
- the Saint-Venant–Coulomb model, based on the law of dry friction, where deformation occurs only if the shear stress exceeds a certain yield limit [3, p. 602].

The rheological behavior of real materials can be modeled using combinations of these basic models. The most well-known complex models include: (the Kelvin–

Voigt model: a solid body where stress depends on the deformation rate; the Maxwell model: a solid body that flows under constant stress over time; the Prandtl model: a solid that exhibits elastic behavior up to a certain load limit, beyond which immediate, unlimited deformation occurs) [4, p. 123].

A promising direction for further research is the development of hybrid models that combine classical theories with modern numerical methods while considering additional parameters that affect the casting process [5, p. 120].

In conclusion, the development of accurate rheological models is a key tool for analyzing and improving the casting process, particularly for materials with complex behaviors. The integration of new technologies and research methods supports the ongoing development of the foundry industry, ensuring high product quality and resource efficiency.

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