IMPROVING THE TECHNOLOGY FOR REDUCING GAS POROSITY IN TIN BRONZE CASTINGS PRODUCED BY CENTRIFUGAL CASTING

Sarvar Tursunbayev Anvarovich
Associate Professor, Department of Metal Technologies,
Tashkent State Technical University
Azamatov Shokhrukh Qoplonbek ugli
Assistant, Department of Mechanical Engineering Technology,
Navoi State University of Mining and Technologies.

Abstract. *Tin bronze alloys are widely used in the manufacture of bushings, bearing components, sealing rings, and other machine parts requiring good wear resistance and reliable mechanical performance. However, the production of tin bronze castings by centrifugal casting may be accompanied by gas porosity, surface pinholes, segregation, and shrinkage-related defects. These defects can reduce casting quality, increase machining allowances, and lead to rejection of finished components. Previous studies have investigated the influence of mould coatings, melt preparation, pouring temperature, mould rotation speed, and cooling conditions on casting quality. Nevertheless, the combined influence of these factors on gas porosity requires further investigation for specific alloy compositions and casting geometries. This study proposes an integrated technological approach to reducing gas porosity in tin bronze castings produced by centrifugal casting. The proposed methodology involves controlling melt quality, evaluating the gas-generating characteristics of mould coatings, optimizing pouring temperature and rotational speed, and assessing casting quality through complementary inspection methods. Experimental validation is planned to establish the relationships between process parameters and porosity characteristics. The expected outcome is a scientifically justified technological framework for reducing gas-related defects and improving the quality and consistency of tin bronze castings.*

Keywords: *tin bronze, centrifugal casting, gas porosity, casting defects, mould coating, melt treatment, process optimization.*

Introduction and Relevance of the Research

Tin bronze is an important copper-based alloy used in engineering applications because of its wear resistance, corrosion resistance, and suitability for components operating under frictional loading. Centrifugal casting is particularly useful for manufacturing cylindrical components, including bushings and sleeves, because the rotating mould facilitates the formation of hollow castings.

Despite these advantages, centrifugal casting of tin bronze presents several technological challenges. Gas-related defects may develop due to gas evolution from mould surfaces and coatings, inadequate venting, moisture, or gases present in the molten metal. In addition, shrinkage porosity and segregation may occur during solidification. These defects have different formation mechanisms and should therefore be distinguished during investigation.

Martyushev and Risto [1] investigated protective mould coatings containing highly dispersed zirconium dioxide and reported improvements in surface quality and a reduction in gas-related surface defects in leaded tin bronze castings. Zhang et al. [2] examined large tin bronze sleeves produced by centrifugal casting and discussed the importance of melt purity, melt homogeneity, and casting parameters in controlling common casting defects. Research on hydrogen removal from tin bronze has also demonstrated the relevance of melt treatment to porosity and mechanical properties [3].

These studies provide a foundation for further research. However, a technological procedure intended to reduce gas porosity must be evaluated for the particular bronze composition, mould material, component geometry, and operating conditions. Therefore, investigating the combined effects of melt preparation and centrifugal casting parameters is relevant to improving the quality of tin bronze castings.

Aim and Objectives of the Research

The aim of this research is to develop and scientifically substantiate an improved technological approach for reducing gas porosity in tin bronze castings produced by centrifugal casting.

The following objectives are proposed:

1. To investigate the principal mechanisms responsible for gas porosity in centrifugal castings made of tin bronze.
2. To evaluate the influence of melt preparation, moisture control, and selected melt-treatment methods on casting quality.
3. To examine the effects of mould rotational speed, pouring temperature, cooling conditions, and mould coating characteristics on porosity formation.
4. To develop an experimental methodology for distinguishing gas porosity from shrinkage porosity and other casting defects.
5. To establish the relationships between selected technological parameters and measurable porosity characteristics.
6. To identify a suitable combination of process parameters that minimizes gas-related defects while maintaining the required casting quality.

Proposed Methodology

The research is planned as a combination of literature analysis, controlled casting experiments, metallographic examination, and quantitative evaluation of casting defects.

First, the chemical composition of the selected tin bronze alloy and the initial condition of the raw materials will be documented. The baseline casting process will then be characterized, including the mould material, mould preparation procedure, pouring temperature, rotational speed, cooling conditions, and relevant geometric parameters.

Second, a controlled experimental programme will be developed to evaluate the effects of selected process variables. These variables may include melt-treatment conditions, mould preheating, coating composition and thickness, pouring temperature, rotational speed, and cooling intensity. Their operating ranges will be selected according to the alloy specification, equipment limitations, and preliminary trials. A suitable design of experiments will be used to identify the main effects and potential interactions between variables.

Third, the resulting castings will be examined using appropriate quality-control methods. Visual inspection and dimensional measurements will be supplemented, where available, by radiographic inspection or computed tomography to identify internal discontinuities. Metallographic examination will be used to characterize pore morphology and distribution. Density measurements may provide additional information about casting soundness. Where possible, the gas-related nature of detected defects will be assessed using pore morphology, location, and supporting metallurgical evidence.

Finally, the experimental data will be analysed statistically to determine the influence of the investigated parameters and identify a suitable process window. Repeated trials will be required to assess the reproducibility of the results. Gas porosity and shrinkage porosity will be evaluated separately whenever the available evidence allows reliable classification.

No experimental results are reported at this stage because the proposed investigation has not yet been conducted.

Expected Scientific and Practical Significance

The expected scientific contribution is a better understanding of the relationship between melt preparation, mould conditions, centrifugal casting parameters, and gas porosity in tin bronze castings. The research is intended to establish a systematic basis for selecting and controlling technological parameters rather than relying on isolated process adjustments.

The practical significance lies in the potential to reduce casting rejection, improve material utilization, limit excessive machining allowances, and enhance the consistency of manufactured components. The applicability of the proposed approach will depend on experimental verification under the selected production conditions.

The scientific novelty will be determined after comparing the experimentally validated findings with previously published studies and existing patent solutions. In particular, the investigation will need to demonstrate whether the proposed combination of process controls provides a measurable advantage over established methods.

Conclusion

Reducing gas porosity in tin bronze castings produced by centrifugal casting requires consideration of both melt-related and mould-related sources of defects, as well as the conditions governing solidification. Previous research demonstrates that protective coatings, melt quality, and casting parameters can influence casting quality. Building on this evidence, the proposed research will investigate their combined effects through controlled experiments and quantitative defect assessment. The resulting data are expected to support the development of an improved technological procedure for producing higher-quality tin bronze castings. The effectiveness of the proposed procedure and its scientific novelty will be established only after experimental validation.

References

1. Martyushev, N. V., & Risto, N. A. (2014). Effect of protective release coatings on the basis of superdispersed zirconium oxide powder on the formation of gas defects in bronze casting. *IOP Conference Series: Materials Science and Engineering, 66*, 012013. https://doi.org/10.1088/1757-899X/66/1/012013
2. Zhang, H., Zhao, S., Li, Y., Hou, S., Zhang, D., & He, L. (2018). Production of Large Tin Bronze Sleeve by Centrifugal Casting. *Special Casting & Nonferrous Alloys, 38*(6), 642–645. https://doi.org/10.15980/j.tzzz.2018.06.018
3. Łagiewka, M., & Kolmasiak, C. (2023). The porosity of TiN bronze castings. *Metallurgy, 62*(1), 155–157. https://hrcak.srce.hr/en/281420
4. Halvaee, A., & Talebi, A. (2001). Effect of process variables on microstructure and segregation in centrifugal casting of C92200 alloy. *Journal of Materials Processing Technology, 118*(1–3), 122–126. https://doi.org/10.1016/S0924-0136(01)00904-9
5. Korchmit, A. V., & Egorov, Yu. P. (2005). Defects of castings during centrifugal casting of tin bronzes. ResearchGate bibliographic record: https://www.researchgate.net/publication/293660614_Defects_of_castings_during_centrifugal_casting_of_tin_bronzes