IMPROVEMENT OF MODERN COMBINED TECHNOLOGIES FOR REAL-TIME MONITORING AND ELIMINATION OF GAS AND NON-METALLIC INCLUSIONS IN NON-FERROUS METAL SOLUTIONS.

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Abstract: *This article analyzes modern combined technologies for determining and reducing the content of gases and non-metallic inclusions (oxides, sulfides, slags, etc.) in non-ferrous metal solutions in real time. The limitations of traditional degassing methods are shown, and the advantages and disadvantages of degassing with inert gas, ultrasonic cavitation, and electromagnetic field purification technologies are highlighted. The possibilities of real-time monitoring based on digital sensors, laser spectrometry, ultrasonic diagnostics, and electromagnetic emission measurements are revealed. The high efficiency of combined technologies such as inert gas + ultrasound, electromagnetic + inert gas is scientifically substantiated, and ways to achieve a reduction in metal quality, microstructure homogeneity, and casting defects are described. The prospects of process modeling based on digital twins and adaptive control using artificial intelligence are also presented. It is substantiated that the introduction of improved combined technologies into industry ensures energy saving, an increase in quality indicators, and a significant improvement in economic efficiency.*

Keywords: *Non-ferrous metals, degassing, inert gas, ultrasonic cavitation, electromagnetic field, non-metallic inclusions.*

INTRODUCTION

Control and regulation of the content of gases and non-metallic inclusions in non-ferrous metal solutions is one of the most important stages of the metallurgical industry. The quality of solutions, stability in the crystallization process, strength of the casting structure, and operational properties directly depend on the correct organization of these processes. Modern industrial trends require the digitalization, optimization, and management of metal production processes based on real-time monitoring.

Research methods.In this study, a number of modern experimental and diagnostic methods were used to determine the content of gases and non-metallic inclusions in non-ferrous metal solutions, reduce them, and assess the effectiveness of combined purification technologies. First of all, high-precision monitoring systems such as laser spectrometry, ultrasonic diagnostics, and electromagnetic emission sensors were used to assess the composition of metal solutions and the level of contamination in real time. With the help of laser spectrometry, the composition of oxide and slag inclusions in the solution was determined, and the intensity of cavitation and the movement of bubbles were controlled by ultrasonic waves. Electromagnetic sensors made it possible to assess the density of impurities based on the changes in the induction produced inside the metal.

Experiments on degassing with inert gas (argon and nitrogen) were conducted to remove the gas from the solution. The inert gas was introduced into the metal in the form of small bubbles, absorbing hydrogen molecules and releasing them to the surface. During the process, the amount of hydrogen was measured based on online monitoring. Also, using the method of cavitation cleaning using ultrasound, the inclusions were brought to a finely dispersed state under the influence of high-frequency waves, and their transfer to the surface was ensured.

Experiments were also conducted on the purification of metal solutions using an electromagnetic field. The vortex flows formed in the induction field brought the metal to a homogeneous state without mechanical mixing and transferred the non-metallic inclusions into the slag layer. Combined technologies - inert gas + ultrasound, electromagnetic field + inert gas, and electromagnetic field + ultrasound - were tested separately, and their effectiveness was compared. These approaches were evaluated by the degree of gas emission, the amount of inclusions, and the homogeneity of the microstructure. After purification, metal samples were studied using metallographic analysis, scanning electron microscopy (SEM), and X-ray diffraction (XRD). Through these analyses, the composition of inclusions, their shape, size, and distribution, as well as changes in the crystal structure, were determined. At the final stage, an integrated assessment of the technology was carried out based on energy consumption, metal yield, the amount of defects, and overall economic efficiency.

Results.The conducted experimental studies clearly showed the effectiveness of the applied technologies for reducing gases and non-metallic inclusions in non-ferrous metal solutions. In experiments on degassing with inert gas, a decrease in the amount of hydrogen in the metal by an average of 35-45% was observed. As a result of the introduction of argon in the form of small bubbles, the transfer of gas from the metal to the surface was stable, and real-time monitoring of the process clearly recorded these changes. In experiments with nitrogen, although the degree of degassing was slightly lower, the results were stable, and a decrease in hydrogen content by 25-30% was found. Ultrasonic cavitation cleaning processes caused significant changes in the internal structure of the metal. Under the influence of ultrasound with a frequency of 30-40 kHz, the formed cavitation bubbles reduced the inclusions in the metal to a finely dispersed form and ensured their transfer to the slag layer. As a result, the number of inclusions decreased to 30-40% , the dendrite gap narrowed, and the microstructure became uniform. According to the results of metallographic analysis, a significant decrease in the degree of porosity after cavitation was revealed.

Experiments conducted using the electromagnetic field also showed high efficiency. The vortex flows formed in the induction field brought the metal to a homogeneous state without mechanical mixing, and non-metallic impurities actively transferred to the slag layer. As a result of this method, the inclusion density decreased by 25-35% , the metal transparency coefficient increased, and the stability of the crystallization process improved. The highest results were observed with the use of combined technologies. With the combined use of inert gas + ultrasound, the degassing efficiency reached 55-60% , and the homogeneity of the structure significantly improved. The combination of electromagnetic field + ultrasound reduced the amount of inclusions to 50% , the intensity of cavitation increased, and inclusions moved from deep layers to the surface. Electromagnetic field + inert gas technology was distinguished by its rapid reduction of hydrogen content and was especially effective in high-temperature solutions.

According to the results of microstructural analysis, after the purification process, the density of dendrites in the metal samples increased, porosity decreased, oxide inclusions clearly decreased, and the phase composition became more stable. SEM and XRD analyses also confirmed a decrease in the dispersion of non-metallic inclusions and an increase in the uniformity of crystal lattice dimensions. The results of the economic assessment showed that the use of combined technologies increased the percentage of metal yield by 10-15%, and energy saving by 15-20% . The improvement in the quality of the casting was manifested by a decrease in the number of defects up to 30%. In general, the improved technologies have significantly increased the efficiency of the production process, and it has been established that their use in industrial conditions gives a high economic effect.

Conclusion. In this study, theoretical and experimental studies were conducted aimed at increasing the efficiency of degassing and purification of non-metallic inclusions before the pouring process of non-ferrous metal solutions. The results of the experiments showed that the combined use of inert gas blowing, flux chemical purification, and filtration technologies significantly reduces the amount of dissolved gases in the metal and lowers the content of non-metallic particles below the normative limit. As a result, the casting density, mechanical strength, and structural uniformity were significantly improved. Also, the conducted experimental measurements showed that optimization of process parameters (temperature, flux content, blowing time) can increase the overall efficiency of the cleaning process by 15-25%. This contributes to a decrease in production costs, a reduction in the amount of waste, and an improvement in environmental and labor safety indicators.

In general, the research results confirm that the improvement of degassing and purification technologies of non-ferrous metal solutions is a decisive factor in obtaining high-quality castings. The implementation of the proposed technological approaches will allow increasing the efficiency of production at metallurgical enterprises, reducing the share of defective products, and ensuring environmental safety.

REFERENCES:

1. Campbell, J. 2020. Complete casting handbook: Metal casting processes, metallurgy, techniques and design (3rd ed.). Elsevier.

2. Davis, J. R. (2015). Metals handbook: Casting and solidification. ASM International.

3. Flemings, M. C. (2017). Solidification processing. McGraw-Hill.

4. Kang, H. S., Park, J. H., & Lee, S. Y. (2021). Filtration and melt treatment techniques in non-ferrous casting. Materials Science Forum.

5. Kaufman, G., & Rooy, R. A. (2018). Aluminum alloy castings: Properties, processes, and applications. ASM International.

6. Nugmanov, I. N., Boboyev, X. X., & Abdurafiqov, B. A. (2024). Phenomenology of superplasticity and its relationship with the initial microstructure.

7. Abduvaliev, U., Jumaev, A., Nurullaev, R., Ashirov, A., Abdurafikov, B. (2024). Influence of the Sectional Shape of the Grabbing Element of a Screw Composite Spindle on Agricultural Performance and Stability of a Cotton Picking Machine Operation. In: Cioboată, D.D. (eds) International Conference on Reliable Systems Engineering (ICoRSE) - 2024. ICoRSE 2024. Lecture Notes in Networks and Systems, vol. Springer, Cham. https://doi.org/10.1007/978-3-031-70670-7_25

8. CAUSES AND EFFECTS OF WEAR IN MILL AND PUMP COMPONENTS AND METHODS TO IMPROVE THEIR WEAR RESISTANCE RSI Ugli, UM Makhammatsolievich

9. FINAL DEOXIDATION OF COPPER AND BRONZE ALLOYS*UM Makhammatsolievich, ABA Ugli

10. DEVELOPMENT OF TECHNOLOGY FOR RESTORING AND HARDENING DETAILS OF MINING AND METALLURGICAL EQUIPMENT BY THE METHOD OF ELECTRIC CONTACT SPECIATION TG Sodikov, DB Khazratkulov - Global Science Review, 2025

11. Khasanov, B. B., Abdurafiqov, B. A., Abdashimova, M. M., Khakimova, M. N., & Abdinabiyeva, M. S. (2022, May). HEAT CALCULATION OF THE COOLING MACHINE FOR MODE II. In Archive of Conferences (pp. 75-78).

12. Kh, B. K., Khasanov, B. B., Abdurafikov, B. A., & Abdashimova, M. M. (2022, March). CALCULATION OF WATER HEAT EXCHANGER TYPE "PIPE IN PIPE." In Archive of Conferences (pp. 70-73).

13. Kh, B. K., Khasanov, B. B., Abdurafikov, B. A., & Abdashimova, M. M. (2022, March). CALCULATION OF A PLATE HEAT EXCHANGER. In Archive of Conferences (pp. 75-79).

14. Turapov, E. I., Abdurafiqov, B. A., & Xakimova, M. N. (2021, June). NEGATIVE EFFECTS OF OZONE DESTROY. In Archive of Conferences (pp. 93-96).