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## **ENVIRONMENTAL AND LABOR SAFETY ASPECTS OF DEGASIZATION AND PURIFICATION PROCESSES OF NON- FERROUS METAL SOLUTIONS**

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### **Abstract**

This article analyzes the environmental and occupational safety aspects of degassing of non-ferrous metal solutions and purification from non-metallic inclusions. The main risk factors arising from the use of fluxes, inert gases, and filters, the impact on the working environment, and ways to reduce them are indicated. The advantages of modern "green" fluxes, closed degassing systems, and efficient ventilation methods are highlighted, and recommendations are given for the implementation of environmentally friendly and safe technological regimes in non-ferrous metal foundries.

**Keywords:** Non-ferrous metals, degassing, non-metallic additives, flux, inert gas, filter, ecology, occupational safety.

### **Introduction**

Non-ferrous metals and their alloys are widely used in mechanical engineering, aviation, automotive, energy, chemical industry, and many other fields. One of the main factors in the quality of such parts and castings is the effective purification of the solution from gases and non-metallic inclusions before casting. Hydrogen, oxygen, and other gases retained in the solution create pores in the casting; oxides, sulfides, nitrides, and other solid particles, in the form of inclusions, reduce the mechanical properties of the metal, fatigue strength, and reliability. Therefore, the degassing and purification of non-ferrous metal solutions is an integral



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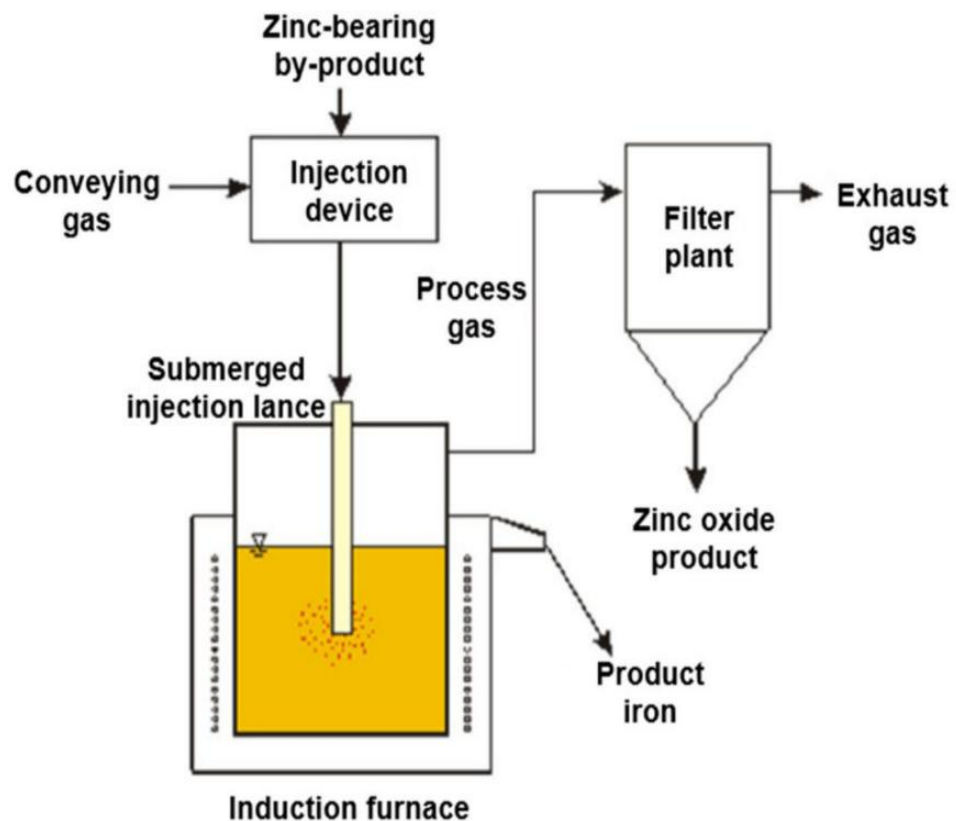
technological stage of every foundry production today. However, these processes are directly related not only to the quality of the metal, but also to the environmental situation and occupational safety. Aggressive components in fluxes, smoke and aerosols released when working with the solution, the risk of working with inert gas cylinders, and a high-temperature environment - all this poses a certain risk to the health of workers and the environment.

The most common methods of degassing and purification of non-ferrous metals before casting are: Blowing with inert gas - removal of hydrogen and other dissolved gases by injecting aluminum, its alloys, as well as argon or nitrogen in some types of bronze into the solution through special tubes. Purification with fluxes - chemical binding of gas and non-metallic inclusions using chloride and fluoride-based salt mixtures (fluxes) and removal of them to the surface of the solution in the form of slag. Filtration - passing the solution through ceramic, foamed ceramics, or special mesh filters in the casting system and capturing solid inclusions present in it. These technologies differ not only in their technological and economic advantages, but also in the amount of waste released into the environment, the degree of dust and gas contamination in the working zone, as well as the possibility of direct exposure of workers to harmful substances. Therefore, it is necessary to evaluate them not only in terms of metal quality, but also in terms of environmental and occupational safety criteria.

### **Research Methodology**

Fluxes and their environmental impact. A large part of the flux used in the purification of non-ferrous metal solutions is based on chloride (NaCl, KCl, etc.) and fluoride (NaF, CaF<sub>2</sub>, etc.) salts. When such fluxes are dissolved in the solution, various gaseous and aerosol products are released under the influence of high temperatures. As a result, the pouring section may contain: sharp-smelling gases and smoke, finely dispersed flux and slag dust, and chemically aggressive aerosols. These particles pollute the air of the production room, increasing the total amount of harmful substances released into the environment. At the same time, slag and solid waste generated as a result of the flux cleaning process are also an environmental problem. Because they contain salts, oxides, and other chemical components, their disposal at landfills or storage in open areas, like

ordinary industrial waste, can lead to long-term negative environmental consequences. Therefore, when choosing fluxes, along with their effectiveness, their ecological category, the degree of smoke and aerosol emission, and the possibility of further neutralization or utilization of slag should also be taken into account. The ecological aspect of the use of inert gases. Argon and nitrogen are chemically inert gases, which are usually not toxic and do not have a direct toxic effect when added to the atmosphere. At the same time, the large volume of gas used in the inert gas degassing process affects the production economy and the technological energy balance. The production, transportation, and refilling of gas cylinders are associated with a certain amount of energy consumption and consumption of space fuel, which can indirectly affect the carbon footprint and climate. However, inert gas degassing is generally considered a "cleaner" and relatively less environmentally hazardous technology compared to flux-based methods.



**Figure 1.** Scheme of the melt bath injection process



**Filtration technology and waste.** When using ceramic or foam filters, solid non-metallic inclusions are retained through the surface contacting the solution, during which practically no additional gas emission or smoke formation is observed. Therefore, filtration technologies are ecologically preferred over flux methods. However, used filters appear as solid waste containing metal residues, oxides, and other inclusions. It is not advisable to dispose of them as ordinary construction waste; on the contrary, they should be collected according to a special procedure, crushed and processed if necessary, or disposed of at controlled landfills. Thus, the environmental benefits of filter cleaning are maximized.

Non-ferrous metal alloys are typically boiled at 650-750°C (in aluminum alloys), while bronze and some other alloys are boiled at even higher temperatures. Under such conditions, such phenomena as fluctuations on the surface of the solution, splashing of metal droplets, and volatilization of hot slag during metal mixing, flux injection, or inert gas blowing can be observed. This increases the risk of burns, eye injuries, and skin injuries for workers. Therefore, the following are mandatory in production: heat-resistant special clothing, gloves, high-temperature footwear, masks, and goggles that protect the eyes and face, separation of metal baths, buckets, and other hot zones with physical barriers, and the use of devices that minimize the working distance when working on the solution. The use of flux in crushed form, dust, and aerosols that rise into the air during the separation of slag from the solution surface, its crushing, or collecting in containers can damage the respiratory organs, eyes, and skin of workers. At the same time, chemical exposure becomes even more dangerous when working with fluxes containing fluoride components.

I offer several solutions. **Firstly**, "Green" fluxes and low-toxicity reagents recent years, several manufacturers have been offering low-fluorine or fluorine-free fluxes with reduced smoke and aerosol emissions. Such fluxes contribute to: sufficient efficiency in cleaning and degassing the solution; a decrease in the concentration of the harmful substance in the working medium; and facilitating the further detoxification of the slag.

When choosing fluxes at enterprises, not only price and technological efficiency, but also environmental class and impact on occupational safety should become evaluation criteria. **Secondly**, closed system degassing devices, automated rotary



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or closed-type devices, are being widely implemented for inert gas degassing of solutions. Their main advantages are: high efficiency of contact between gas and metal, reducing the required gas consumption; limited processes of erosion and metal splashing, the worker does not directly stand on the solution; the resulting aerosols and smoke remain inside the closed chamber and are expelled through ventilation systems. This allows, at the same time, to improve the quality of the metal, reduce gas consumption, and protect workers from heat and harmful substances. **Thirdly**, Ventilation and gas-dust cleaning systems non-ferrous metal foundries, it is advisable to use local suction devices, filtered cleaning systems, and equipment for neutralizing gas-dust mixtures. Such systems: immediately absorb gases and smoke rising from the solution surface and prevent their spread to the working zone; filter dust and aerosols, reducing the amount of harmful substances released into the environment to the normative level; ensure compliance of the enterprise with environmental requirements. Another **important factor** is the training of employees and increasing the culture of occupational safety. Along with technical solutions, it is also important to increase the knowledge and skills of employees and their responsibility for occupational safety. For this, it is necessary to train: introductory instructions for newly hired employees; periodic training and seminars for existing employees; special instructions on working with gas cylinders, fluxes, filters; algorithms for actions in emergencies (rolling metal, fire, gas leakage). As a result, with the integrated application of technical and organizational measures, the level of environmental and occupational safety of degassing and cleaning processes increases significantly. Thus, improving degassing and cleaning processes, taking into account environmental and occupational safety factors, is not only a factor of social responsibility, but also a factor that increases competitiveness and economic efficiency.

### **Conclusion**

Technologies for degassing non-ferrous metal solutions and purifying them from non-metallic inclusions are an integral part of ensuring casting quality, and it is not enough to evaluate them only from the point of view of metallographic and mechanical indicators. Flux, inert gas, and filter methods each have certain



environmental impacts and occupational safety risks. As indicated in the article, toxic components of fluxes, slag, and filter waste, risk factors when working with inert gas cylinders, as well as a high-temperature environment, can negatively affect the health of workers and the state of the environment. Therefore, it is necessary to use "green" fluxes in foundry workshops, introduce closed and automated degassing devices, apply effective ventilation and gas-dust cleaning systems, regularly train personnel, and maintain a high level of occupational safety culture. In the future, the development of new reagents with low environmental risks, easily processed filter materials, and energy-saving, fully automated technological complexes for the degassing and purification of non-ferrous metal solutions will remain one of the urgent scientific and technical directions.

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