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Review of Integrating Gantry Mounted Degassing Machine

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A B S T R A C T

Degassing is a critical procedure in the processing of molten aluminum, essential for achieving superior castings. During the melting phase, aluminum tends to absorb hydrogen, especially when moisture is present, which can lead to gas porosity, shrinkage, and diminished mechanical properties in the final product. Effective degassing is important for reducing hydrogen content, improving casting quality, and decreasing scrap rates. Various common degassing techniques include the use of Hexachloroethane tablets, the introduction of inert gases like nitrogen or argon through lance tubes, and the application of inert gas (argon/nitrogen) through a rotary degassing mechanism. Among these, rotary degassing is considered the most efficient, utilizing a rotating shaft to circulate inert gas and effectively remove hydrogen from the melt. To meet varying production demands, different types of rotary degassing equipment are available, including fixed, mobile, hoistable, and gantry models. These technologies play a crucial role in ensuring reliable removal of hydrogen gas and enhancing the overall mechanical properties of aluminum castings. Depending on the operational conditions, we suggest suitable machinery types that aid in process improvement. The gantry degassing machines, in particular, provide numerous benefits in industrial applications, such as removing dissolved gases from molten metals and other substances. They are also beneficial for large-scale machining and handling, offering flexibility and efficiency across different manufacturing processes.

Keywords: Degassing, Rotary Degassing, Gantry Degassing machine, Inert gas etc.

1. Introduction

Molten aluminum is directed into the degassing chamber, where an inert gas such as argon or nitrogen is introduced. A rotating rotor or porous plugs distribute the gas throughout the aluminum, forming bubbles that rise to the surface. These bubbles capture hydrogen and other contaminants, which are subsequently eliminated by a skimming mechanism. The purified aluminum is then moved to the casting furnace. Degassing is a crucial step in the alloy casting process. It can enhance the quality of finished products, minimize the likelihood of blowholes, slag inclusion, and shrinkage, and lower refining expenses. Typically, the degassing machine is positioned between the holding furnace and the casting machine. A rotary degasser features a graphite rotor connected to a graphite shaft. The rotor is submerged in the molten aluminum. Inert gas (generally nitrogen or argon) is piped through the hollow shaft. The spinning rotor disintegrates the gas into small bubbles, spreading them evenly throughout the molten metal. Various types of Degassing Machines are utilized in Aluminum Foundries to eliminate hydrogen and impurities from molten aluminum. These include Fixed Degassing Units, Mobile Degassing Units, Hoistable Degassing Units, and Gantry Degassing Units. Our project focuses on the Gantry Degassing Machine. In contemporary metal casting and refining practices, obtaining high-quality molten metal is vital to guarantee robust, defect-free end products. An essential procedure in metal treatment is degassing, which removes dissolved hydrogen and other impurities from molten metal, especially aluminum and various non-ferrous alloys.

2. Literature Review

2.1 (Bhaskar M.Reddy et.al , 2021)

In non-ferrous foundry, casting defects like microporosity and pin-hole porosity are due to expel of dissolved gases like hydrogen during solidification of castings from liquid stage to solid stage. These porosity defects significantly affect the strength and pressure tightness of the aluminum components. For a sound casting, the amount of dissolved gases present in the molten aluminum metal should be less. Degassing is a perfect process for removing dissolved gases from molten aluminum metal and its alloys. . In this research, degassing of LM13, LM25, LM28, L99, and L155 was performed by passing nitrogen gas into rotary degassing chamber at different treatment time. The amount of H_2 ml/100 g available in the aluminum alloys was measured after degassing by hydrogen gas analyzer and compared with the minimal value. Nitrogen degassing reduced the quantity of H_2 ml/100 g less than the minimal value and made the aluminum alloys defect free [1].

2.2 (Hongyu Chen et.al , 2023)

With the development of membrane separation technology, some traditional separation and purification methods have been replaced by membrane technology. Compared to traditional method, the membrane method has the advantages of small footprint, low energy consumption, safe operation and high removal rate. At present, membrane degassing has become a crucial step in ultra-pure water production for semiconductor industries, and it is also used in ink bubble removal and various wastewater treatment. This paper summarizes the advantages of membrane degassing compared with other gas-liquid separation methods, and introduces polymeric membrane materials used for degassing and their merits and drawbacks. The greatest challenge encountered in membrane degassing is the resistance to wetting phenomenon. This paper provides solutions to wetting phenomenon, which increases the possibility of widespread application of membrane degassing technology and the adaptability of membrane degassing technology to more demanding use scenarios. Finally, the application scenarios of membrane degassing technology are summarized and future perspectives are provided. Gas-liquid separation processes the separation of gas from liquid has long been the subject of investigation in the industrial production [2].

2.3 (Jayesh . B. Patel et.al , 2021)

The degassing of aluminum alloy melts is a crucial step in the production of high- quality casting products, as the presence of dissolved hydrogen and oxide bi-films is detrimental to the mechanical properties. Current rotary degassing techniques are effective, but they lack efficiency because of the high gas flow and long processing times required. This study aims to solve this problem by presenting an innovative rotor-stator degassing technology, that combines controlled inert gas injection with intensive melt shearing. It has been applied to the liquid metal treatment of an aluminum cast alloy to evaluate the effect on melt cleanliness, casting integrity and mechanical properties. The optimum conditions for an efficient bubble dispersion have been obtained by water modelling. The melt quality during and after degassing has been assessed by in-situ measurement of hydrogen concentration and by reduced pressure test sampling for oxide bi-films and porosity content evaluation. This new technology is faster, requires less gas flow consumption and produces higher melt quality than the existing degassing techniques, due to a characteristic combination of distributive and dispersive mixing flow. In addition, re-gassing is minimized, maintaining a high melt quality for longer time after processing. This results in castings with less defects and better mechanical properties. The improved degassing efficiency of this technology makes it an excellent alternative in industry to increase melt quality and casting productivity. [3]

3. Concept of Gantry Degassing Machine

1. Degassing: - The process used by a Gantry Degassing Machine involves injecting inert gas into molten aluminum to eliminate hydrogen and contaminants. Eliminate the need for manual handling during the Machine Operation and Degassing procedure. Facilitating the Degassing process to ensure ease and safety. Time efficiency will serve as an additional benefit.

2. Gantry Mounted: - It is installed on a Gantry Structure, assisting in the Degassing process for inline Furnaces through an automated program.

Inert Gas Introduction: - Inert gases like argon or nitrogen are introduced into the molten aluminum using lances or porous plugs.

3. Bubble Formation: - A rotating rotor disperses the inert gas into tiny bubbles. These bubbles possess a high surface area to volume ratio, aiding in the diffusion of hydrogen into the bubbles.

4. Bubble Rise: - The bubbles ascend to the surface of the aluminum, transporting hydrogen and impurities with them.

3.1 Components Details

3.1.1. Gantry Framework:

Serves as the support structure for the machine, enabling it to traverse along a track or rails to reach various furnaces. It can be a fixed, mobile, or hoist-mounted type, making it ideal for inline furnaces positioned at the same elevation.

Rotor/Impeller Assembly: A rotating element that is submerged into the molten metal bath. It is engineered to maximize the surface area relative to volume for effective gas extraction. This may include specially crafted shafts, rotors, baffles, and tools for uniform degassing.

3.1.2. Gas Delivery System:

Supplies a precise amount of inert gas (such as argon or nitrogen). The gas is injected into the molten metal through the rotor shaft or alternative injection points. It may feature adjustable gas flow rates for purging or processing with argon or nitrogen.

Control Mechanism: Regulates the degassing process, covering rotor speed, gas flow, and other variables. It can operate fully automatically and can be programmed to conduct degassing at designated furnaces. A control panel may be included for monitoring and adjustments.

3.1.3. Flux Injector (Optional):

Certain models might offer a flux injection feature to assist in degassing and refining the metal. Fluxes can aid in eliminating impurities and enhancing metal quality.

3.1.4. Additional Elements:

Mechanical: Powder-coated machine casing, variable RPM options, and tailored for particular metal capacities. Electrical: 3 Phase, 420 VAC, 50Hz, with a 24V DC control panel and a variable frequency electric motor. Drag Chain: Employed to guide N2 gas and electrical wiring at the top portion of the sliding unit.

3.1.5. Gantry Mounted:

We have used MS Gantry Structure which includes Square Columns and I Beam. We have used 2 Main Square Columns and one Supporting Square Column which is having 3856mm Length of each. We have placed one I Beam with 13784mm Length.

Fig. Gantry Structure [10]

3.1.6. Graphite Rotor & Shaft

Take Graphite Shaft, Rotor & Baffle Plate and make the assembly. A graphite rotary shaft is a type of rotating component made primarily from graphite or graphite composites, used in various industrial applications due to its excellent self-lubricating properties, thermal resistance, and chemical stability.

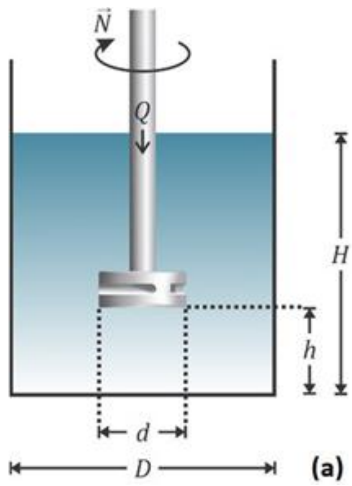

Figure 2: Graphite Rotar & Shaft [11]

3.1.7. Gas (Nitrogen or Argon)

Connect the gas supply from the gas cylinder regulator through gas hose pipe to the input side of the panel mounted on the operation control panel. Set the gas pressure on the bottle to 2 to 4 bar (2 to 4 kg/cm2) and gradually open the flow meter control knob by approximately one turn.

Figure 3: Gas (Nitrogen or Argon) [12]

3.1.7. The Adjustable Baffle Plate

The adjustable baffle plate is an electrically driven device that can move the baffle plate in or out of the melt at any point during the treatment cycle. The absence of baffle plate helps to create the vortex needed for efficient mixing of treatment products. The presence of the baffle plate eliminates the vortex to create the optimum condition for cleaning and degassing.

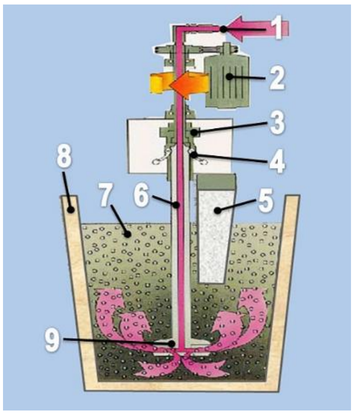

Figure 4: The Adjustable Baffle Plate [13]

4. Observation

Gas porosity in aluminum castings, identifiable by rounded, smooth-walled voids, occurs when trapped gases, such as hydrogen, become solidified within the metal. Detection methods may include visual examinations, X-ray inspections, or ultrasonic assessments.

4.1. Factors Contributing to Gas Porosity:

Trapped Gases: During the casting process, molten aluminum can contain a considerable amount of dissolved gases, especially hydrogen. As the metal cools and solidifies, these gases lose solubility and begin to create bubbles or pores.

Sources of Gases: Air Entrainment: Air might get trapped in the mold cavity or during the pouring process.

Lubricants: Gases can be emitted from lubricants utilized in the casting process.

Moisture: Water present in the mold or on the metal can also lead to gas formation.

Solidification: The cooling process itself can entrap gases if the metal solidifies too rapidly or if there are problems with mold ventilation.

4.2. Features of Gas Porosity:

Shape: Gas porosity often manifests as round or spherical voids.

Location: Gas porosity may be found on the surface or inside the casting.

Appearance: Gas porosity typically showcases smooth, shiny walls.

Size: Porosity can vary from tiny micropores to larger, more noticeable cavities.

4.3. Strategies for Preventing Gas Porosity:

Proper Mold Ventilation: Ensure sufficient venting to allow for the escape of trapped gases during the casting process.

Controlled Pouring: Reduce turbulence and air entrainment while pouring.

De-gassing: Utilize de-gassing methods to extract dissolved gases from molten metal before casting.

Material Selection: Opt for aluminum alloys that have a lower tendency for gas absorption.

Proper Lubrication: Select suitable lubricants that do not emit excessive gases.

Environment: Maintain a clean and dry casting area to avoid contamination and moisture.

4.4. Recommended Actions:

Preventing Gas Porosity:

Proper Mold Ventilation: Ensure sufficient venting to allow for the escape of trapped gases during the casting process.

Controlled Pouring: Reduce turbulence and air entrainment while pouring.

Material Selection: Opt for aluminum alloys that have a lower tendency for gas absorption.

Proper Lubrication: Select suitable lubricants that do not emit excessive gases.

Environment: Maintain a clean and dry casting area to avoid contamination and moisture.

De-gassing: Implement de-gassing methods to remove dissolved gases from molten metal before casting. This de-gassing process is crucial in reducing the hydrogen content in molten aluminum, thereby enhancing the quality of the castings. It effectively removes gas porosity and helps prevent shrinkage porosity in the castings.

5. Results and Discussion

A gantry degassing machine employs a gantry framework to transport a degassing unit (such as a rotor) across a molten metal bath, eliminating hydrogen and other non-metallic inclusions to enhance metal quality and maintain consistent outcomes. Here's an overview of the concept and advantages:

Concept: Gantry Structure: The device consists of a gantry or bridge framework that extends over the molten metal bath, enabling the degassing unit to move along the X and Y axes.

Degassing Unit: A degassing unit, typically a rotor, is lowered into the molten metal.

Inert Gas Injection: Inert gas (like nitrogen) is introduced through the rotor shaft, forming small bubbles that mix thoroughly into the molten metal to eliminate impurities.

Automatic Operation: The machinery operates fully automatically and can be programmed for degassing at designated furnaces.

Custom Built: These machines are tailored to specific requirements and designed for continuous operational cycles.

Benefits: Enhanced Metal Quality: Eliminates gas porosity, resulting in cleaner and more uniform metal.

Consistent Results: Ensures repeatable and reliable degassing treatment, yielding high-quality products.

Reduced Treatment Time: Degassing occurs more quickly and efficiently compared to manual techniques.

Lower Costs: Decreased consumption of inert gases and flux, reduced aluminum loss in dross, and lower labor expenses.

Enhanced Safety: Minimizes the need for manual handling of molten metal, thereby improving workplace safety.

Energy Efficiency: Streamlined degassing processes can result in energy reductions.

Less Dross Formation: Decreases aluminum loss in the dross.

Reduced Fumes: In comparison to alternative degassing methods, gantry degassing generates fewer fumes.

Uniform Molten Aluminum: Guarantees consistent temperature and composition throughout the molten metal.

6. Conclusion

As there are different types of Degassing Machines out of which it is found, Gantry Degassing Machine is most suitable Degassing Machine to suggest the end user based on their working conditions and Furnace Alignments. The Gantry Degassing Machine is highly effective for easy maneuverability and degassing when furnaces are aligned in a single line. As a Rotary Degassing machine, it excels at removing hydrogen and impurities from molten aluminum compared to other degassing methods like Tablet Degassing and Lance Degassing. In conclusion, Gantry Degassing Machines designed for degassing and refining molten aluminum are vital for producing high-quality, impurity-free aluminum and suitable for the production floors furnace alignments. The benefits they offer in terms of metal quality, efficiency, and cost-effectiveness, safety work and ease of handling lead to substantial advantages for various industries that depend on aluminum products. Gantry Degassing Machines deliver exceptional results regarding degassing, density index, and time efficiency.

References

1. Bhaskar, M. R (2021). Effect of nitrogen degassing on hydrogen content in aluminum alloys. *Journal of Non-Ferrous Foundry Research*, 10(3), 45-52.

2. Chen, H (2023). Membrane degassing technology: A review on materials, applications, and challenges," *Separation and Purification Technology*, 305, 122312, 2023.

3. Patel, J. B (2021). Innovative rotor-stator degassing technology for aluminum alloy melts," *Materials Processing & Technology*, 15(2), 78-89.

4. Yukse, E (2020). Heavy-duty 5-axis gantry milling machines for aerospace and automotive applications. *International Journal of Machine Tools and Manufactu*re, 85, 102-115.

5. Dhumal (2020). Automation in manufacturing: A case study on gantry-based automated handling systems," *Automation in Manufacturing Journal*, 12(1), 34-42.

6. Krutskikh, V. V (2023). Internet of Things and smart cities: Technological advancements and applications. *Journal of Smart Technologies*, 18(4), 99-112.

7. Koushik, M. M (2018). Design and implementation of gantry automation in manufacturing systems. *Manufacturing Automation Review*, 10(2), 55-67.

8. Yang, H (2019). Development of high-strength and high-ductility die-cast aluminum alloy. *Materials Science & Engineering*, 764, 138191.

9. Wu, S (2012). Ultrasonic vibration-assisted semi-solid slurry preparation and its effect on gas content in Al-Si alloys. *Journal of Materials Processing Technology*, 212(5), 1082-1090.

10. https://www.stonimage.com/single-beam-gantry-crane-p.html

11.https://www.researchgate.net/figure/a-Schematic-representation-of-the-batch-degassing-ladle-indicating-the-rotating-speed_fig1_316987075

12.https://www.thefabricator.com/thefabricator/article/arcwelding/the-economies-of-efficiency-in-gas-delivery

13.https://www.giessereilexikon.com/en/foundry-lexicon/Encyclopedia/show/rotary-degassing4427/?cHash=5929b71f8da1b49a764755b c88f710cb