

# Study of Relationship Between Atmospheric Humidity and Gas Porosity on Aluminium Alloys Casting

Dr. Sandeep Phogat & Mr. Avinash Dholiwal

*Assistant Professor, Mechanical Engineering Department, Amity University, Haryana, India.*

**Abstract:** Hydrogen gas naturally diffuses into liquid Aluminium. As the Aluminium solidifies, dissolved hydrogen will come out of solution and make bubbles, which appear as gas pits in casting. The quantity of bubbles is mainly determined by the amount of dissolved hydrogen in the melt at the casting. These gas pits have negative effect on the mechanical properties of the metal cast. Therefore, to remove these gas pits from cast we perform degassing process before casting. Degassing of molten Aluminium alloys is a foundry operation aimed to remove Hydrogen gas dissolved in the metal. Generally, in industries, rotary degassing method is used for degassing. In the rotary degassing method, an inert or chemically inactive gas such as Argon, Nitrogen, or mixed gas, is purged in molten metal to remove dissolved hydrogen gas. Atmospheric humidity also has great effect on degassing process, which needs to be standardized. In Al metal casting industry, the main reason for porosity is evolution of dissolved hydrogen gas during solidification of molten metal. Moisture in the atmosphere is the most prominent reason for the hydrogen generation in molten metal. Therefore, the atmospheric moisture (humidity) is an important parameter in the metal casting processes. In this study, I measure atmospheric humidity periodically in the metal foundry to monitor the moisture content. Average humidity content which includes relative humidity and absolute humidity in the atmosphere of metal foundry was collected for seven months regularly. These results indicate that humidity content is highest in the month of September, whereas lowest in the month of January. Here in present study we have tried to correlate the relationship between atmospheric humidity and porosity in cast metal after degassing.

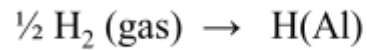
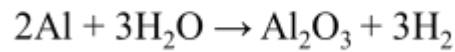
**Keywords:** Humidity, Porosity, Aluminium Alloys, Casting, Degassing.

**Introduction:** Aluminium is the most plentiful metallic substance on the earth's outer surface, of which it contributes approximately eight percentage [1]. Mostly Aluminium present as composite/compound, some of its natural ores being bauxite, Cryolite, Corundum, Alunite, and some silicates like Kaolin, Feldspar, and Mica. Bauxite is an iron-bearing material. Aluminium hydroxide is the elementary primary material from which the metal Aluminium is extracted [2].

Al is extracted from Bauxite with the help of chemical treatment, which produce Alumina  $Al_2O_3$  (Aluminium oxide). The ore is powdered, mixed in NaOH (sodium hydroxide) solution and then heated by water vapor under high pressure to dissolve Aluminium oxide. The impurities are removed by settling and filtration later. Then after cooling the mixture get agitated and crystal of hydrated Aluminium oxide appeared. These Aluminium oxide crystals are removed then dehydrated in large mixing Kilns. The final material, Aluminium oxide is a solid and crystalline white substance looking like a purified sugar crystals [2], [3].

## Humidity variation in ambient atmosphere:

In Al metal casting industry, the main reason for porosity is evolution of dissolved hydrogen gas during solidification of molten metal. Moisture in the atmosphere is the most prominent reason for the hydrogen generation in molten metal, as given in the following equations-



Therefore, the atmospheric moisture (humidity) is an important parameter in the metal casting processes. We measure atmospheric humidity periodically in the metal foundry to monitor the moisture content. Average humidity content which includes relative humidity and absolute humidity in the atmosphere of metal foundry was collected for seven months regularly, as shown in table 4.1 and figure 4.1. These results indicate that humidity content is highest in the month of September, whereas lowest in the month of January.

**Table 1 Data of humidity variation over August to February**

Sr. No.	Months	Relative humidity	Temperature	Absolute humidity
1.	August	58.7	34.3	22
2.	September	53.5	36.8	23
3.	October	41.6	32.4	14
4.	November	32.9	28.2	9
5.	December	34.7	24.5	8
6.	January	46.0	17	7
7.	February	51.0	19	8

### Measuring Hydrogen Concentration in metal samples:

Since the porosity of the cast metal is due to evolution of dissolve hydrogen, therefore first we measure the amount of hydrogen in the metal.[26]The measuring of hydrogen concentration in molten alloys allows the foundry to assess the molten quality before the casting operation. There are several methods available to foundry man to assess hydrogen concentration. These methods are;

1. Reduce pressure test
2. Quantitative reduce pressure test
3. Density measurements
4. Initial bubble test
5. Recirculation gas test

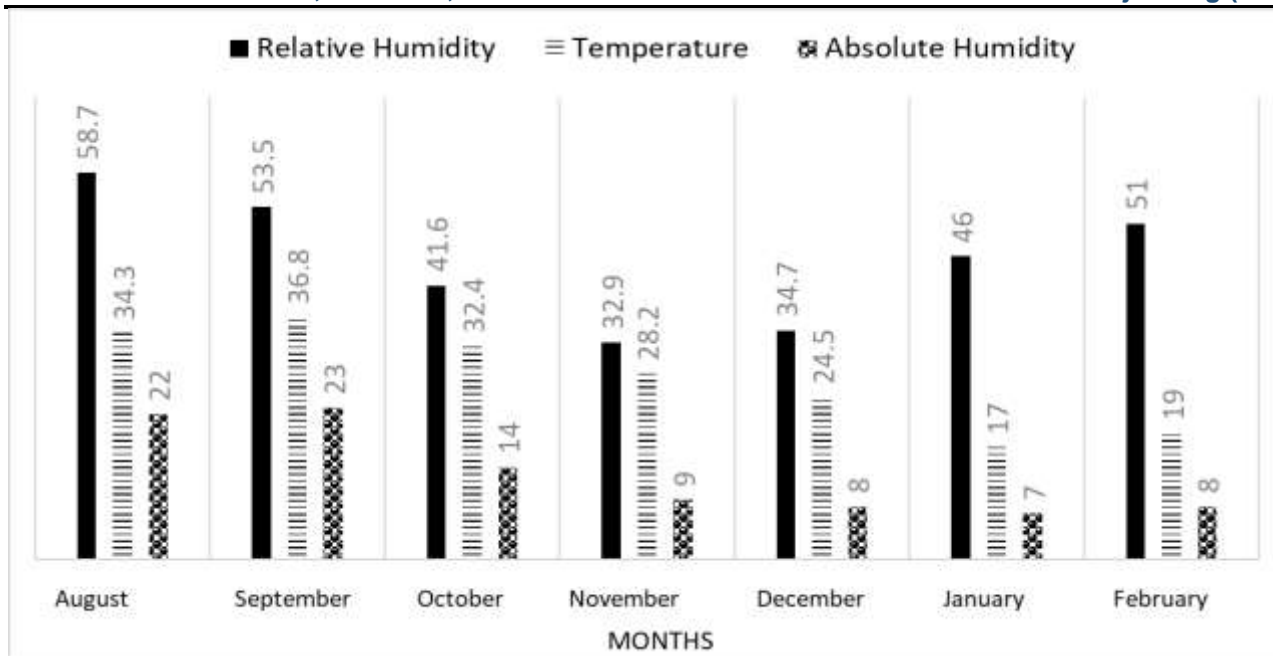


Figure 1: Variation in relative humidity, absolute humidity and temperature.

**Effect of humidity on density index of metal samples:**

It is already established that high moisture (humidity) content in the atmosphere is responsible for the hydrogen generation in the molten Aluminium. Therefore we have calculated density index of various metal samples at different humidity conditions. For our experiment, we have taken 20 minutes degassing period and 10 minutes holding time after degassing condition to see effect of humidity. In table 2, the density index at different humidity condition is tabulated. In figure 2, humidity and density index are also plotted, which indicate that at low humid condition, density index also found to be low. Whereas at high humid condition present, there we found density index is also high. As show in the figure 2, month January is least humid (absolute humidity 7) with lowest destiny index and month August is most humid (absolute humidity 22) with highest density index.

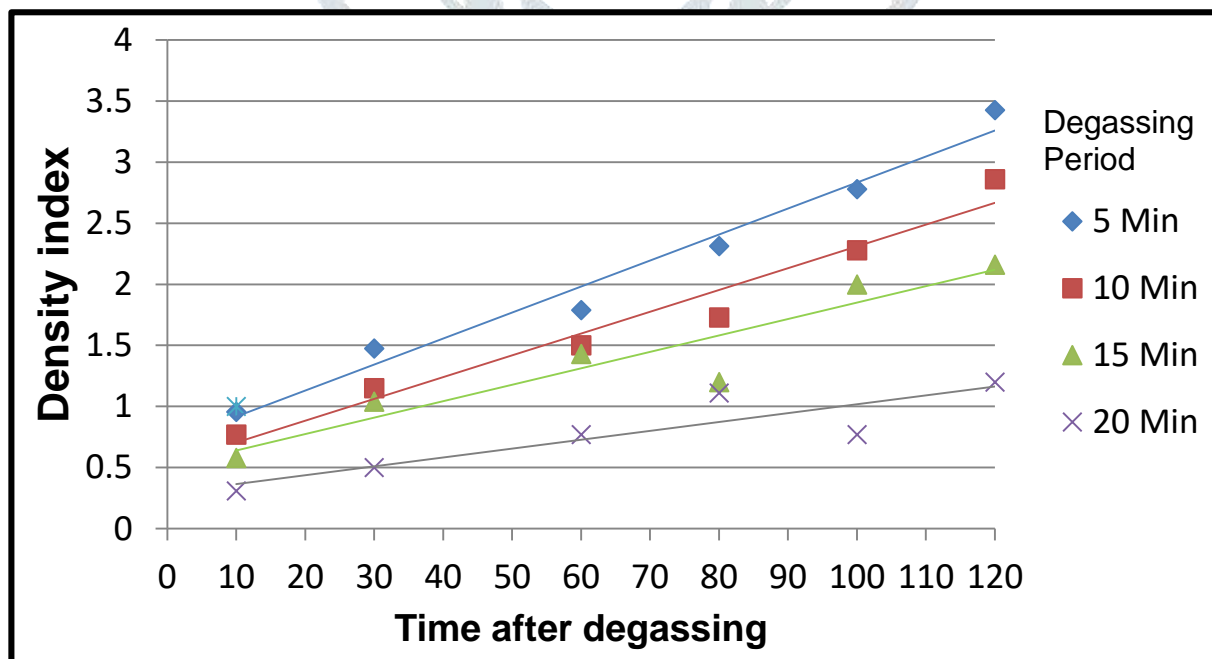
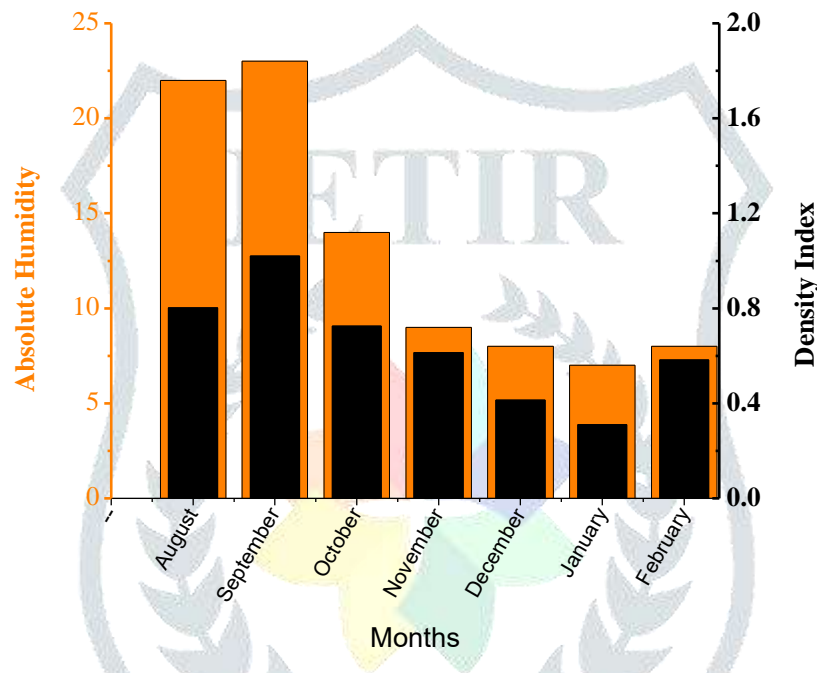


Figure 2: Graph of variation in Density indexes of metal sample 6, at different “Time after degassing” and “Degassing period”

**Table 2: Density index at different humidity condition**

Month	Absolute Humidity	Density Index
August 2018	22	0.802
September 2018	23	1.02
October 2018	14	0.726
November 2018	9	0.614
December 2018	8	0.414
January 2019	7	0.31
February 2019	8	0.583

**Figure 3: Density index at different humidity condition**

Therefore, it could be concluded from the above result that following condition will be favorable to achieve low density index for low gas porosity (GP) defect.

1. High degassing time
2. Low humidity atmospheric condition

So, to keep density index below degassing time and time after degassing should be maintained as per alloy and humidity level.

**Conclusions:** It is concluded that there is relation between humidity and rejection due to gas porosity. We have opted density method to establish the correlation between atmospheric humidity and gas porosity of cast Aluminium/Aluminium alloy. To calculate density index, we used metal samples taken from holding furnace one cooled in pin hole tester (vacuum chamber) and other cooled in atmosphere. Density of each sample is

calculated in different atmospheric humidity condition to find correlation. Increase in humidity increase amount of moisture in air hence more hydrogen is in contact with molten metal. High density index observed in more humid season compare to less humid season which indicates porosity due to hydrogen is more when humidity is high. This work will be establishing the effect of atmospheric humidity on the porosity in metal casting processes and generate useful data for further study. It is also revealed from data that holding melt for long time for same degassing period also increases the density index. Therefore, it can be concluded that, long degassing time and short holding time after degassing results into low density index. The low-density index data indicate low porosity in the cast metal.

**Future Scope:** Daily monitoring of humidity should be done throughout the year. Density index for different alloy should be monitored once in a week. After one year this data can be referred for establishing process standards for controlling rejection due to different humidity levels. Density index at different flow rates of Nitrogen gas must checked for efficient degassing. Turbulence can also introduce gases during the casting processes. This occurs when the molten metal is poured too quickly into the mould. Also placing the casting in a high temperature furnace, which is enclosed in a pressurized container? The casting is heated in an inert gas, which applies isostatic pressure to eliminate the porous elements. Also study on types of gases, which use different types of inert gases.

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