Methodology for Evaluation of Converting Ar for N_2 for Liquid Metal Degassing – A Case Study

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ABSTRACT

Well-established liquid metal treatments are critical towards the production of high-quality aluminum casting components. The aluminum metalcasting industry in North America is worth ~25B USD and must compete effectively with the rest of the world's aluminum casting producers (~94B USD). Part of the necessary continuous improvement activities of the North American foundry industry is to drive down manufacturing costs while not adversely impacting casting quality. This manuscript is a case study on establishing a sound method of converting costly argon (Ar) used for rotary degassing to nitrogen gas (N_2), not in test foundry lab conditions, but in a live production setting which must process up to 60K lbs. of liquid metal daily, while considering the potential impact of meteorological data (max. daily temp. and dew point) on the metal system performance for all seasons. Once the performance of Ar is understood and successful in the most humid of days with near max. liquid metal throughput, conversion of N_2 can be started and monitored for performance.

Keywords: argon, nitrogen gas, degassing, case study, liquid metal treatment, aluminum, casting

INTRODUCTION

Degassing of aluminum melts is one of the critical processing steps to produce castings compliant with customer specifications. Porosity in aluminum castings represents one of the most deleterious impacts on casting quality. It can compromise mechanical integrity and impair leak tightness capabilities which in turn results in costly scrap loss. Porosity in castings arises from bi-films containing an air pocket of normal atmospheric composition (21% O_2, 78% N_2, 0.94%Ar, 0.04% CO_2 and some trace level of $H_2O_{(v)}$ depending on Dew Point). Dissolved hydrogen (H) that resides in the inter-dendritic liquid will diffuse into these bi-film air pockets to form H_2 gas. H_2 gas will expand, and under an imposed hydrostatic stress (due to solidifying a-Al dendrite contraction) will result in that original bi-film growing into a pore of significantly larger size.[1-3]

The source of H in a still bath of liquid aluminum is shown in Figure 1.[1] During the liquid stage both H_2O vapor and O_2 in the atmosphere can react with liquid Al to fuel Al_2O_3 (dross) formation while a continuous H concentration buildup in the liquid will occur. During the mold filling stage metal turbulence will result in more oxide/bi-film generation and is chemically driven by the same reactions as outlined in Figure 1.

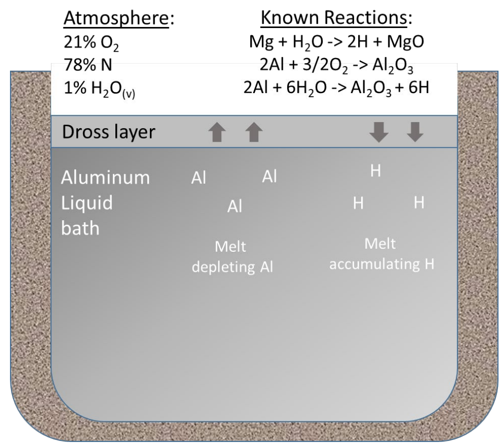

Figure 1. Schematic of the oxide layer that separates liquid aluminum and atmosphere containing H_2O vapor and O_2, the two main methods to form Al_2O_3 and H generation.[1]

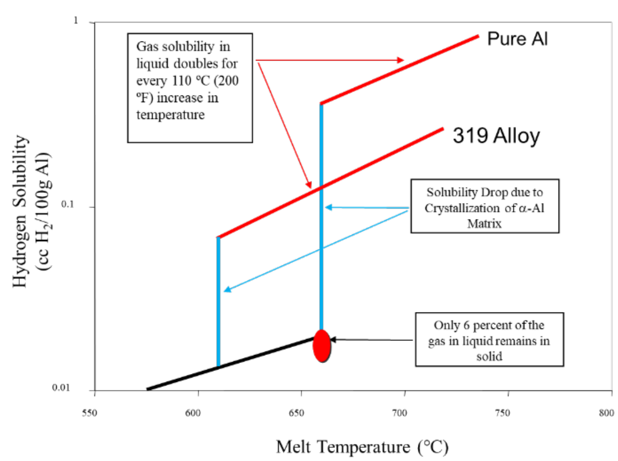

Figure 2. Solubility of H in Aluminum, with 319 alloy and pure Al as examples that reflect differing solubilities.[2]

The solubility of H in liquid aluminum is illustrated in Figure 2. At the Liquidus point the solubility begins to drop significantly, forcing H concentrations within inter-dendritic regions to increase dramatically and provide a feed source for diffusion into bi-film air pockets.

Removal of H from liquid aluminum becomes a critical concern when making high quality aluminum castings. Historically chlorine (Cl_2), nitrogen (N_2) and argon (Ar) have been bubbled in liquid aluminum as a method to reduce H concentrations.[1-3]

Chlorine was highly effective at treating liquid aluminum and was added as hexachloroethane (C_2Cl_6) in the form of plunged tablets or bubbled in as an inert gas mixture with either Ar or N_2.[2] Not only are H concentrations lowered, but Cl_2 based gases also collect oxide material suspended in the bath before exiting at the top of the melt. Chlorine is also effective at removing or lowering magnesium (Mg) concentrations in scrap to make secondary specification aluminum. However, there are health and safety concerns with Cl_2 and it has gradually been banned in some regions in Europe since 1998 (Paris Commission Directive 97/16/EC). It is also currently banned in some states and provinces in North America.

Argon, a highly inert gas with liquid aluminum, is widely used within aluminum casting manufacturing for the aerospace industry. For automotive applications Ar was used for the Cosworth casting process for Formula 1 engine blocks, and eventually serial production of precision sand molded engine blocks. However, the cost of Ar of the appropriate purity (>99.99%) ranges 2-3 times higher than for the same purity of N_2 over the last 20 years. The cost differential is mainly due to the concentration differences in the regular atmosphere where Ar (0.94%) and N_2 (78%) gas harvesting (via air separation equipment) occurs. Nitrogen gas has a slightly higher tendence to react with liquid aluminum to form aluminum nitrides (AIN), however this reaction occurs at a slow rate and generally doesn't pose problems within typical metal treatment timelines.[1-3]

Rotary degassing is essentially the most efficient method at removing dissolved H and potentially some oxide materials. Rotary degassing, over T-stick bubblers and in-floor porous plugs, provides the optimal cloud distribution of fine bubbles through the liquid aluminum to attract dissolved H. Rotary degassing efficiency is marked by the fact that during an impeller head's rotation large inert gas bubbles are sheared into many small bubbles, and along with an imparted centrifugal force, provides optimal distribution within the working liquid volume. In-floor porous plugs would be considered the next best option towards degassing efficiency, except that without the centrifugal force effect on the bubbles, regions located away from the porous plug take longer to treat. T-stick bubblers would comparatively have the lowest efficiency since the bubbles essentially undergo no shearing and under buoyancy will immediately rise to the top of the liquid bath.

There have been many methods to assess the liquid aluminum quality in terms of pore development prior to casting but the Reduced Pressure Test (RPT) represents the most widely used due to its low equipment cost and apparent robustness for the foundry floor.[1-8] While the impact of dissolved H and oxides contribute to pore formation,[1] the RPT is not able to distinguish the magnitude both are contributing to nucleation and growth of pores. The authors previously published a review of the other equipment devoted to aluminum melt quality but in short, all other systems will analyze and quantify either dissolved H or oxides but cannot measure both.[1,8,9]

Two recent studies were published where degassing with Ar and N_2 were compared in batch crucible conditions where impeller heads used the same rpm and gas flow for both gases,[10,11] and a third publication covered Ar to N_2 using the in-line and covered Alcan Compact Degasser (ACD™).[12] In general, based on RPT readings Ar and N_2 would achieve nearly identical results after initial treatments. Gyarmati et. al[11] however found that after successive treatments N_2 stopped preforming as well as Ar. It was suspected that N_2 was not able to fully remove the bi-film generation that results from the top surface turbulence induced by the rotating shaft of the degassing system. Obzima et. al[10] did not look at successive treatments but focused on degassing duration and found that based on RPT readings a duration of 6 minutes was required for N_2 to perform as well as Ar.

It should be noted that the melt system that will be described in this manuscript will not be identical to the published reports comparing Ar and N_2 degassing performance. The melting system used at Nemak for the Precision Sand Casting Process (PSCP) uses a continuous melting system where most of its liquid metal capacity is N_2 blanket protected, which provides partial protection from the atmosphere, also has three successive rotary degassing systems and a filter box for dispersed oxides. This melting system will be discussed in detail in the next section of this manuscript

EXPERIMENTAL METHODOLOGY

MELTING SYSTEM LAYOUT & DESCRIPTION

The focus of the manuscript will be to establish the method by which a gas type used to treat liquid aluminum is changed while production is running. The melting and casting system that will be described was developed using Ar originally for rotary degassing, and N_2 was used only to provide a protective blanket over most of the melting system.

Figure 3 shows the layout of the melting system in question which also includes melt quality performance data (RPT and Direct H concentration readings). To the left of the figure the metal breakdown system is illustrated. A high-volume melting dry hearth receives charge material in the form of sows, ingots and foundry re-melt (e.g., risers). The 90K lbs. capacity breakdown furnace operates on natural gas burners and represents the largest region of the whole melting system which does not have an N_2 protective blanket.

An N_2 pump draws metal into an N_2 blanketed launder system which eventually will migrate to the first rotary degassing station. The N_2 pump of the breakdown furnace has an open access port which allows for the collection of an RPT sample which will reflect the condition of the liquid aluminum just after rapid melting and before entering the first rotary degassing station.

The gas flow, set with a ball flow meter, and rpm parameters for all three rotary degassers in the system are indicated in Figure 3 and Table 1.

Table 1. Rotary Degassing Gas Flow Settings

Rotary Degassing Parameters	
Process Gas	32-38 psi
Rotation	165-185 rpm
Degas Flow	40-60 schf

Illustrated in Figure 4 is the liquid metal in the first rotary degassing station which contains approximately 816 kgs. (1,798 lbs.) of liquid aluminum. The residence time for degassing is a minimum of 18 minutes. This means that in one-hour 2740 kgs. (6040.6 lbs.) of metal can be treated by the melting system. For a 50 Jobs-per-Hour (JPH) operation, where each casting plus rigging weighs 120lbs., 6000 lbs. is required to maintain 100% hourly uptime.

Figure 5 illustrates the covered portions of the launder system which has a N_2 blanket to deter further H pickup while in-roof heating elements maintain the target temperature of 730C (1346F). The N_2 blanket is sufficient to drop the O_2 level from atmosphere down to approximately 12% (21% in normal atmosphere).

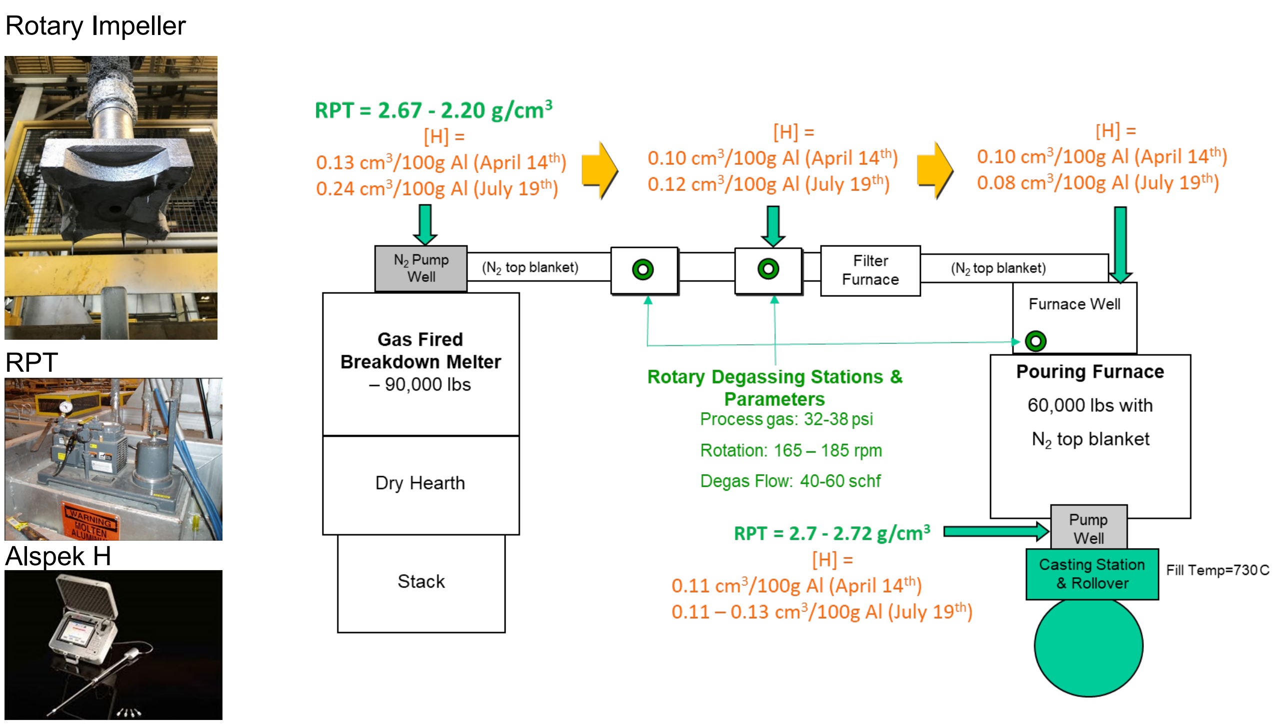

Figure 3. The continuous melting system used to support the production of 20K lbs. worth of parts in an 8-hour period. Three small green circles represent rotary degasser stations. Cited RPT densities (green font) and direct H concentration readings from the Alspek H electrochemical analyzer (orange font).

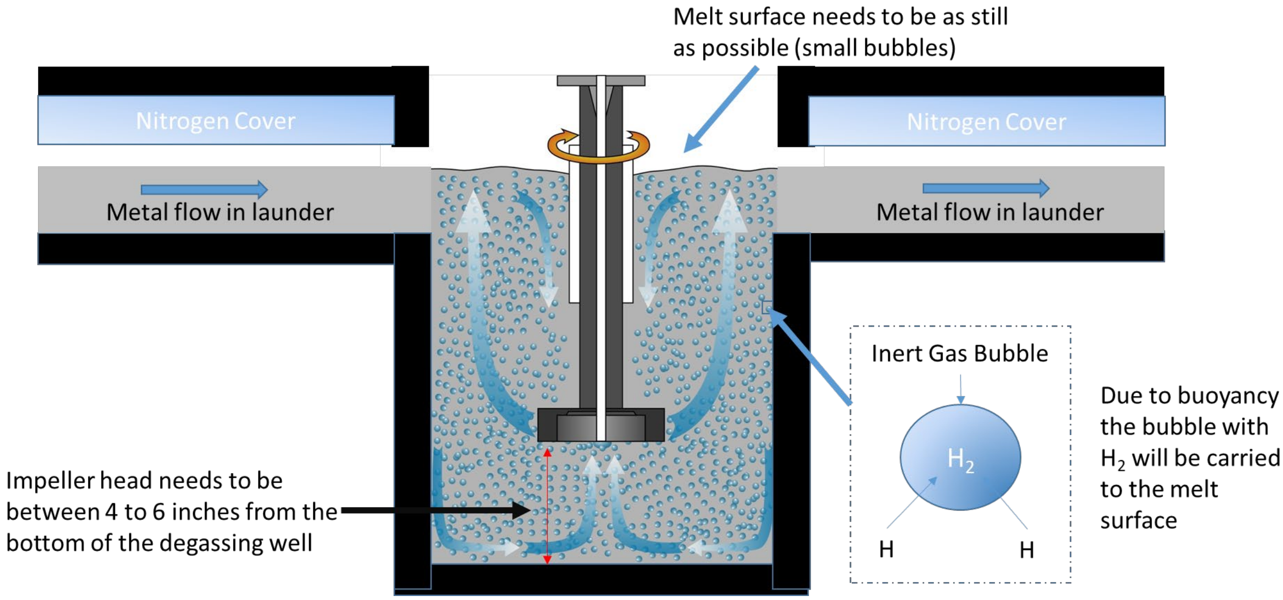

Figure 4. Schematic of the rotary degassing well. Each rotary degassing well in the launder contains 816 Kgs of liquid aluminum and requires a minimum degassing time of 18 minutes (max throughput 2720 kgs/hr).

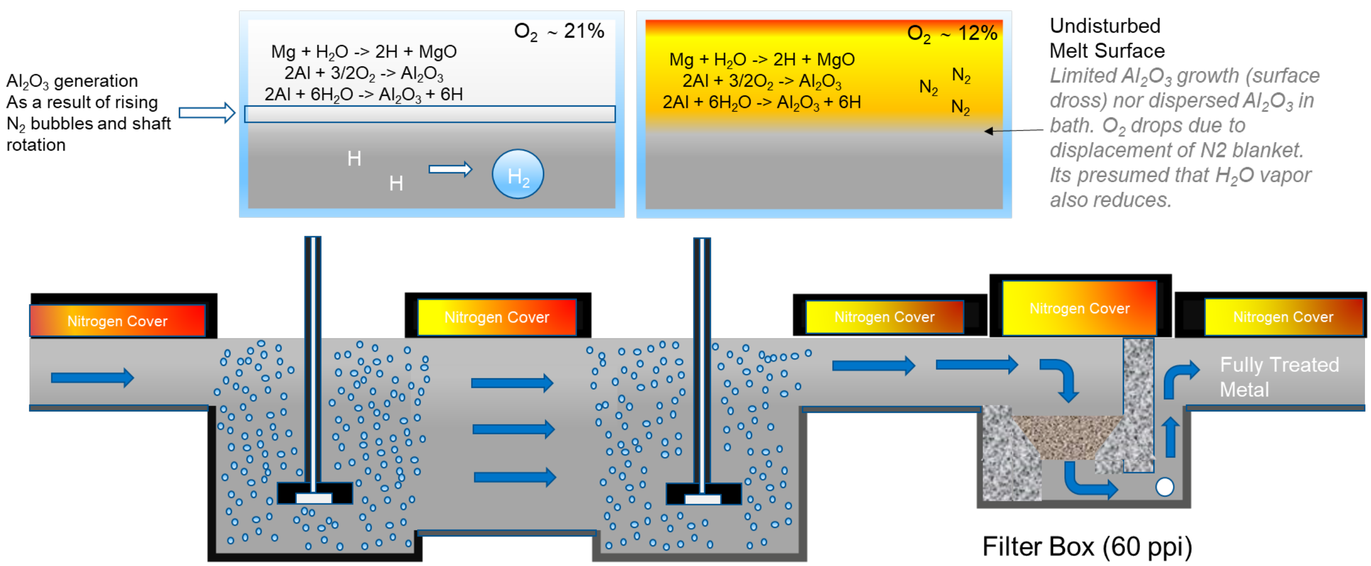

Figure 5. Detailed schematic of the rotary degassing and filter system used to treat the liquid alloy prior to entry into the pouring furnace. The 60 ppi filter is changed 1x per week.

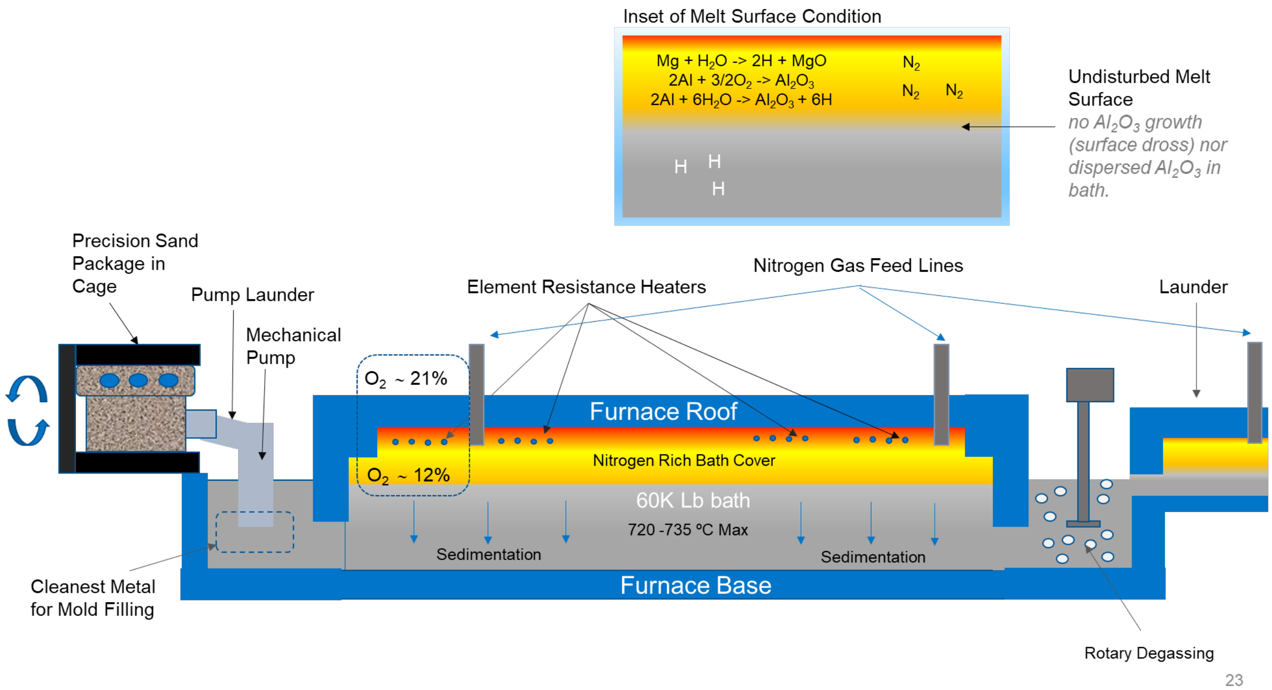

Figure 6. Detailed schematic of the pouring furnace layout.

After the initial degassing residency time is achieved the liquid metal migrates to the secondary degassing well to repeat the process again. After the secondary degassing treatment is completed, the metal is forced through a filter box containing a porous filter (60 ppi) to remove most of the oxide/bi-film material which originates from the metal breakdown and any generated from rotary degassing. From there the liquid aluminum migrates to the back of the main pouring furnace where the last rotary degassing station is placed. The 60K lbs. capacity pouring furnace details are shown in Figure 6 and show a similar protective N_2 blanket setup as used in the launder system.

MELTING SYSTEM PERFORMANCE & BENCHMARKING

In terms of benchmarking the system while Ar is used in rotary degassing, refer to Figure 3 where typical readings from RPT samples taken from the N_2 pump well and the pouring furnace are indicated. The authors also used an Alspek H electrochemical hydrogen sensor as a process spot check since the RPT density values are due to the contributing aspects of dissolved H and oxides to pore nucleation and growth, but their contribution cannot be quantified effectively. The Alspek H data is also listed in Figure 3. From the breakdown furnace the RPT values can vary widely depending on the charge makeup and the local atmosphere conditions (2.20 to 2.67 g/cm^3).

The Alspek H unit used in spring months (i.e., April) indicated a reading of 0.13 cm^3 H_2/100 grams Al, but as the summer months arrived and atmospheric temperature and dew point increased, this value increased to 0.24 cm^3 H_2/100 grams Al. This increase is most likely because there is more available H for uptake due to elevated local atmospheric humidity.

The results of the Alspek H from the secondary degassing station and the casting well are significantly lower in H concentrations due to the progressive impact of degassing and the fact that most of the treated liquid metal is protected by an N_2 blanket. Essentially, the first rotary degassing station performs the most work in treating the liquid, while the N_2 blanket and successive rotary degassing stations maintain H concentrations to below 0.11 cm^3 H_2/100 grams Al.

ALLOY COMPOSITION & RPT THRESHOLD

The alloy used in this study needs to be identified as the RPT threshold will change depending on the alloy concentrations of Si, Cu, Mg. This threshold density will not change during the conversion of Ar to N_2 for rotary degassing. Table 2 shows the composition of the alloy used to produce engine block castings manufactured by the Nemak-Cosworth™ process.[13,14,15]

Table 2. Compositional Limits for Alloy Processed in Melting System in Figs. 3 to 5

Si	Fe	Cu	Mn	Mg	Ni	Zn	Ti
9.0	0.6	3.0	0.4	0.3	0.05	0.7	0.2
8.0	0.2	2.6	0.3	0.2	-	-	-

The threshold value for the measured density in the RPT was reviewed by the authors in a previous publication,[8] however, some details will be reviewed here as they impact the reactivity due to melt processing and degassing with Ar or N_2. The alloy reflected in Table 1 has an absolute density of 2.74 g/cm.[3] This density value was established from using a known pore-free sample in the RPT density scale. The acceptable range to permit a continuation of production is 2.70 to 2.73 g/cm^3 and this range is based on the quality feedback of the casting (compliance to ASTM E155 radiographic standard, tensile, fatigue and leak testing validation). Achieving a value at the pouring furnace of 2.69 g/cm^3 is a buffer where production is alerted to the fact that there is a drop below the regular RPT threshold and that an investigation is required while production continues.

At or below 2.68 g/cm^3 indicates that the processed metal still has sufficient dispersed oxides and H that will contribute to an undesirable level of porosity in the cast component. Production must be completely stopped until 2.70 g/cm^3 is achieved. See the reactivity scale in Table 3.

Table 3. Reactivity Scale for Compliant and Non-compliant RPT Density Readings.

≤ 2.68 grams/cm^3 **Hydrogen or Oxide Content is too high to make acceptable castings. Elevated P ratings as per ASTM E155 possible.**	Stop Production
= 2.69 grams/cm^3 **Hydrogen or Oxide Content has elevated in the pouring furnace, recover melt system to 2.70 grams/cc immediately.**	Run Production
= 2.70 - 2.73 grams/cm^3 **Melt Quality Acceptable to make castings**	
≥ 2.74 grams/cm^3 **Impossible to achieve this value, achieved only with no porosity in the RPT sample.**	Check vacuum on RPT unit (-25 to -27 in Hg) Check scale, water temperature and string condition and test the master RPT sample *(Target 2.70 grams/cc must be achieved for master RPT sample)*

Final Considerations for Experimental Methodology – Ar to N_2 Conversion Process

For the actual process of converting Ar to N_2 in rotary degassers in the production melting system both gases need to be plumbed to each of the rotary degassing stations at the same time (via a T-joint).

This allowed the authors to start N_2 feeding instead of Ar to the rotary degassers and should RPT readings begin to drop, switch back to feeding Ar. This functionality was necessary on the production line since the required throughput for a 50 JPH target requires that 6,000 lbs./hr of liquid aluminum is pushed through the system. Any stagnation in the metal flow due to production stoppages may preferentially support N_2 success, only to discover that during max throughput conditions N_2 cannot handle the capacity and Ar must be reactivated.

The manuscript will review the trend lines for the whole melting system, shown in Figure 3, before the Ar to N_2 conversion takes place. Once the gas conversion has been made, frequent RPT monitoring will be done while ensuring that 50 JPH production rate can be maintained. Should the value of the measured density become too close to the lowest threshold (e.g., 2.69 g/cm^3) or go below that value and its established not to be due to improper degassing or contamination from the charge materials then Ar can be turned back on.

Once N_2 flow begins, using the same set parameters in Table 1, the authors observed the top surface of the degassing well for melt surface turbulence as this may be reflected in gas density differences (N_2: 1.25 kg/m^3, Ar: 1.66 kg/m^3). As mentioned above, however the authors will ultimately monitor and check the RPT response to see what occurs in high throughput conditions after N_2 has commenced.

RESULTS

Figure 7 shows the plot of RPT readings from both the breakdown and the pouring furnace over a several month period when Ar was the feeder gas for all three rotary systems. Also included in the plot are maximum daily temperature and the dew point as recorded from local meteorological reporting. During the day a total of 6 RPT samples are taken from the pouring furnace and another 6 from the breakdown furnace (every 4 hours). The plot seen in Figure 7 covers 220 days of consecutive production (1320 RPT samples from the reverb and 1320 RPT samples from the pouring furnace).

The maximum temperature recorded was the peak temperature of that day. The dew point, defined as the temperature the local atmosphere needs to be to achieve 100% humidity, is documented to assess the level of humidity that potentially could supply a higher amount of $H_2O_{(v)}$ above the open portions of the melt bath and supply an elevated concentration of H. The portion of the launder and pouring furnace which does have the N_2 blanket drops the O_2 concentration by half (see Figures 5 and 6). The drop in $H_2O_{(v)}$ in this N_2 blanket is assumed to be also lowered but not eliminated.

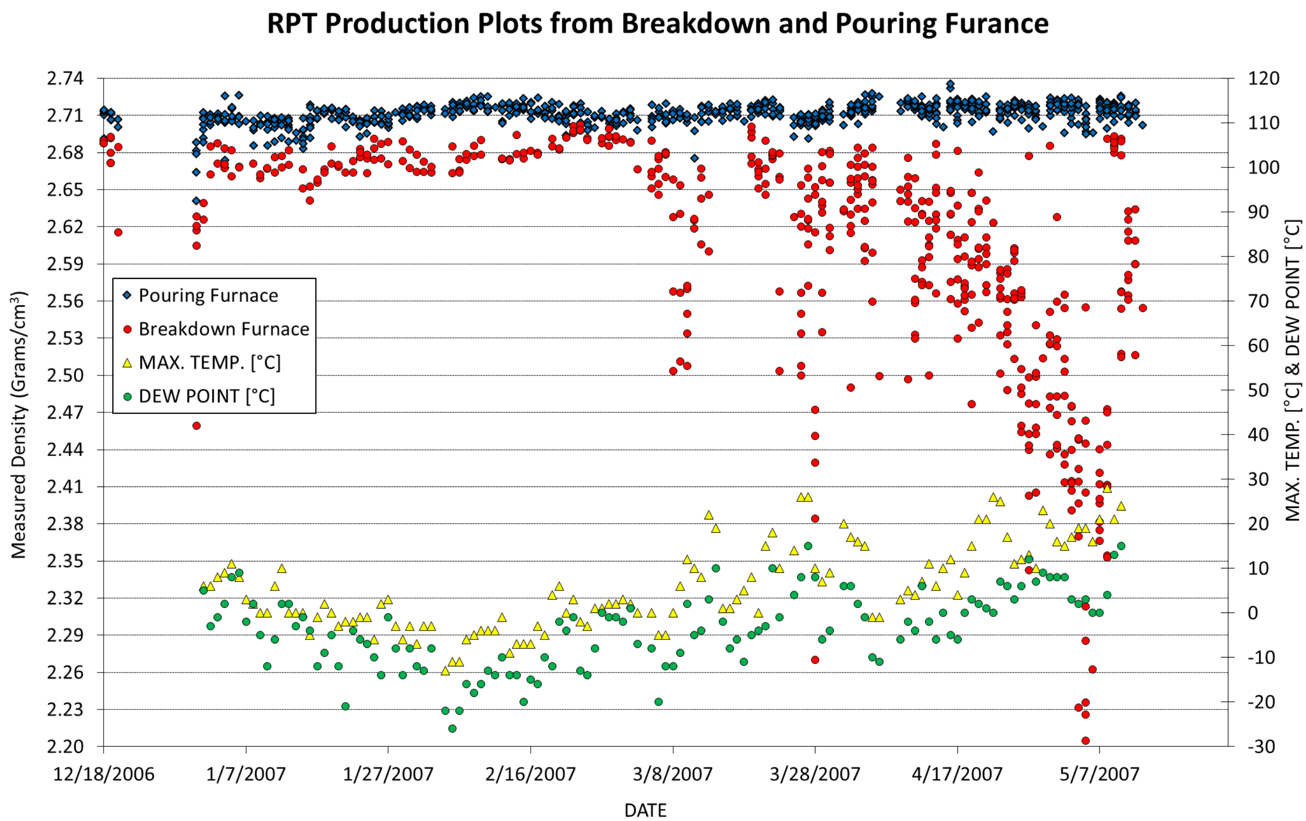

Figure 7. Plot of the melting system and its ability to achieve compliant grade alloy (≥ 2.69 grams/cm3) during early winter months through to the summer months. Outside maximum temperature and dew point are recorded from local metrological sources. Ar was the feeder gas for all three rotary systems.

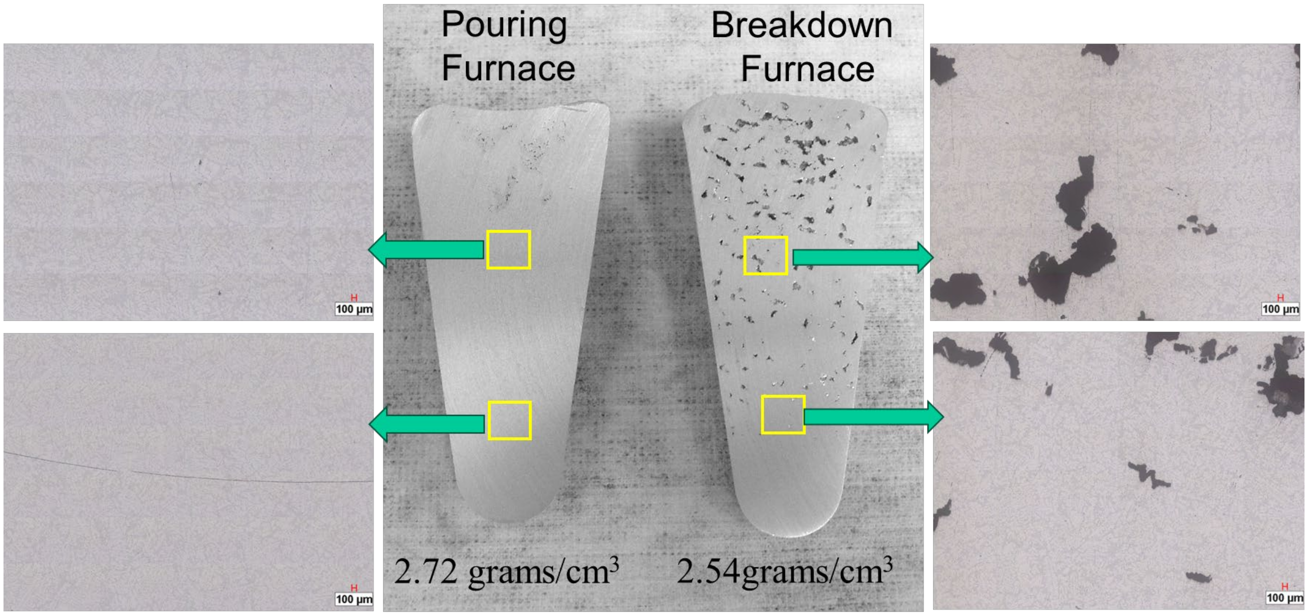

Figure 8. Metallographic examination of breakdown and pouring furnace RPT samples with measured density. The samples are from 3/28/2007 and show the impact of porosity formation after being treated at three rotary degassing stations and a 60 ppi filter.

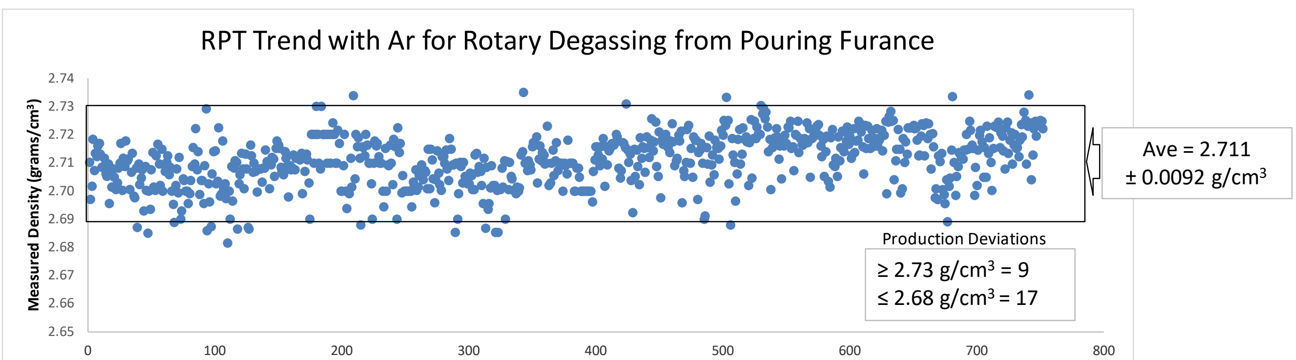

Figure 9. The trend found from 750 RPT (125 days) samples taken from the pouring furnace where all three rotary degassers are using Ar. There were 26 deviations as indicated in the lower right corner.

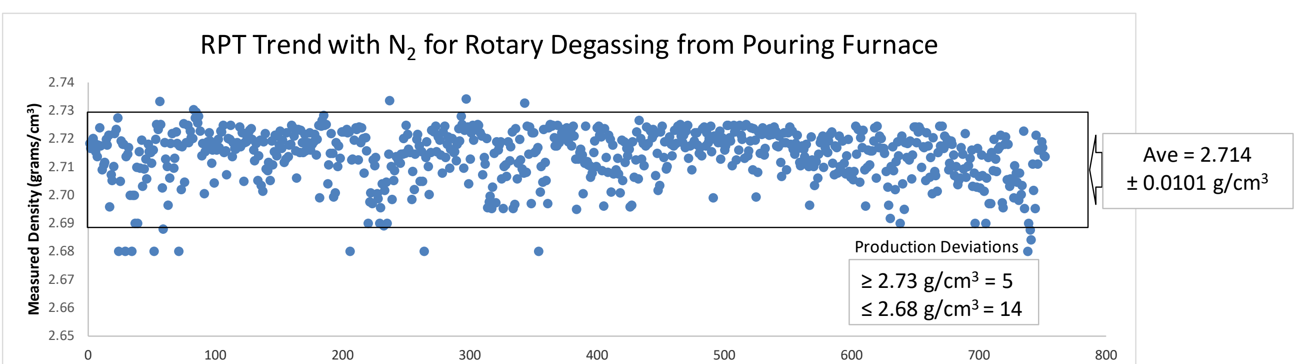

Figure 10. The trend found from 750 RPT (125 days) samples taken from the pouring furnace where all three rotary degassers are using N2. There are 19 deviations as indicated in the lower right corner.

Starting from the left side of Figure 7, data indicates that during the winter and early spring months the RPT difference between the breakdown and the pouring furnace is very small. As the year progresses into the summer months, and the maximum temperature and maximum dew point rise, the RPT in the breakdown furnace drops significantly. The breakdown furnace is the one portion of the whole melting system which does not have a N_2 blanket to deter H or oxide generation. So, when H can be more plentiful due to the elevated concentrations of $H_2O_{(v)}$ in the local atmosphere, the breakdown furnace RPT density measured will drop.

Figure 8 shows the RPT cutaway views and measured densities from the breakdown and pouring furnace on the same date/time. These cutaway images reflect the impact that the three progressive degassing stations, using Ar, and the 60 psi filter box for removing oxides, has on improving liquid metal quality.

After the 220 days of monitoring (121,000 castings with a total amount of metal consumed at 14.6M lbs.) the existing launder system (Figure 5) was sufficient to address the most unfavorable conditions in terms of H uptake, and a portion of the production days saw 50 JPH, meaning that this melting system has robustness for year-round targeting of the RPT at or above 2.69 $g/cm.^3$ From this standpoint, the quality of the data monitored and the inclusion of atmospheric data, the authors can initiate the Ar to N_2 conversion.

Figure 9 shows the trend of the last 750 RPT (125 days) samples taken from the pouring furnace with Ar, and Figure 10 shows the first 750 RPT (125 days) samples after N_2 was fed to the rotary degassers. The statistical behavior in terms of consistency is noted in the average value of the 750 RPT samples, and their calculated standard deviation.

The average values of the 750 RPT samples with Ar supplied to the rotary degassers was 2.711 ± 0.0092 $grams/cm^3$, while 750 RPT samples taken after N_2 was used to supply the rotary degassers was 2.714 ± 0.0101 $grams/cm^3$. These values appear to be similar, with both datasets only having a small percentage of samples that deviated outside the 2.69 to 2.72 $grams/cm^3$ range.

It's important to note that up to half of the sample datasets were seen near or at 50 JPH, which was the maximum production rate. Again, as mentioned if there was a significant population of samples taken when the JPH was much lower, then we have more times of stagnate metal which would potentially add bias to the result. Also, this trial began during the highly humid summer months (July-Sept) so that a significant portion of the RPT samples taken after the conversion occurred during high outside max temperatures and max dew points.

DISCUSSION

This study was conducted so that a proper assessment could be made to convert Ar to N_2 as the gas carrier to rotary degassing system, in a high-volume production environment, potentially realizing approximately 2 to 3x in treatment gas cost savings.

Extensive work was done to fully benchmark the metalcasting line with extensive RPT checks (porosity susceptibility due to oxides and H concentrations) in both the breakdown furnace and the pouring furnace with spot checks performed using an Alspek H analyzer for direct H concentration determination. A production environment was required as lab scale furnace testing would not have been able to evaluate large liquid metal throughput amounts that would occur as detailed in this manuscript. Also, atmospheric data was documented as it is imperative to understand the degassing capacity during the time of year when the humidity is typically the highest.

In short, the launder system, comprising of three rotary degassing stations and a 60 psi filter box, could improve the quality of the melt migrating from the breakdown furnace whether the value was as low as 2.20 $grams/cm^3$ in the highest humidity months, or almost at 2.67 $grams/cm^3$ in the winter months. It may be speculated that the three degassing systems, a 60 psi filter box before the final degassing station, along with the N_2 protective blanket over the majority of the treated system, are robust in summer months and over-designed for the winter months.

The authors will argue that having variable process parameters in liquid metal treatment adopted for seasonal conditions is difficult to do effectively and requires discipline towards monitoring and scheduling changes in processing parameters and then to change them back when the seasons change again. The true cost-saving initiative here is the drop in raw material costs for the gas used while operating a process with needed consistency. Now the specific factors of this Ar to N_2 gas conversion which gave rise to its success will now be discussed in detail.

60 ppi FILTER

It should be noted that the 60 ppi filter was replaced on a weekly basis regardless of whether the filter was still good or not. As reported by Gyarmati et al.[11] degassing with N_2, especially in consecutive treatment regimes, can generate more oxide bi-films compared to Ar, which ultimately will drop RPT readings. The authors were not able to confirm if there was a more rapid collection of bi-film/oxides in the filter after the N_2 conversion due to the frequent scheduled replacement protocols. If filters were left in production for longer periods than a week it is possible the suspected impact of N_2 towards a shortened filter life may have been seen. Should the 60 ppi filter become sufficiently plugged because of oxide/bi-film accumulation the liquid metal height in the launder on the opposite side of the filter box would drop. However, referring to the observation made by Gyarmati et al.[11] it is also possible that without the filter box the Ar and N_2 may not have been possible, particularly in the humid summer months.

N_2 BLANKET

The authors also wish to mention that without the N_2 blanket, which is used post the initial rotary degassing station, it's possible that this conversion may have seen a slight drop in RPT during the most humid of months. The melt configuration outlined in Figure 3 was not designed to operate without the extensive N_2 blanket. The results contained in Figure 3 clearly show that both the RPT and the direct hydrogen concentration measurements significantly changed when the maximum temperature and dew point were high during the summer months. Yet the final melt condition as measured from the casting well of the pouring furnace was within the 2.69 to 2.72 grams/cm^3 threshold.

GAS FLOW & IMPELLER HEAD DESIGN

Finally, gas flow and rotary rotation rate parameters for the rotary degassers, as indicated in Figure 3 and outlined in Table 1, were not required to change once the conversion from Ar to N_2 occurred. As mentioned, this was based on the RPT consistency in performance in the 750 RPT samples before, and the 750 RPT samples after the Ar to N_2 gas change. However, the cited literature did indicate that an Ar and N_2 conversion was possible within a specific time window, and this was based on the same impeller rotation rate and gas flow used in their studies.[10,11,13]

Table 4. Conditions for Ar and N_2 Performance Comparison Where Flow and Impeller Design were Not Changed

Author	**Gyarmati et al.[10]**	**Obzina et al.[11]**	**Present Study**
Impeller Type	**Pump Type** 	**Propeller Type** 	**Propeller Type** 
Working Melt Volume	**50 kgs.**	**200 kgs.**	**816 kgs.**
RPM	**300**	**500**	**165-185**
Gas Flow	**7 l/min**	**10.5 l/min**	**23 l/min**
Distance from bottom	**Not reported**	**150 mm**	**127 mm**
Alloy	**AlSi7Mg0.3**	**AlSi7Mg0.3**	**AlSi9Cu3**
Degassing Residence	**10 minutes**	**6 minutes**	**18 minutes**

The impeller head design used in the present work is known as the propeller type impeller head. Table 4 illustrates the conditions and impeller head designs used in the Ar to N_2 comparative studies cited[10,11] and what was used in the current work of this manuscript. A recent study attempted to compare six different impeller head designs on degassing efficiency and found that the propeller type impeller heads (as in this work) performed better than pump type impeller heads.[16] However, all the impeller head designs achieved target degassing levels, it was degassing efficiency differences which were noted.

From Table 4 we can see that while the present work is using the largest working volume for treatment it requires a sufficiently long residency degassing time of 18 minutes. Gas flow settings in the Ar and N_2 comparative studies[10,11] are much lower, while rpm levels are much higher, than what was used for this study presumably due to the impact of the working volume being much larger in this work and that different impeller head designs were used. The authors based their gas flow and rpm settings based on the minimalization of surface disruptions (caused by sheared bubble size) and degree of vortex generation (controlled by the rpm of the rotating shaft). The authors who published the Ar and N_2 degassing comparison studied did not indicate where their flow and rpm parameters were derived from.[10,11]

FUTURE CONSIDERATIONS FOR COST SAVINGS

If a foundry was to consider making an investment for inert gas self-generation on-site, the cost for the purifying equipment (also called air separation technology) for N_2 is much lower than for Ar. Nitrogen gas represents almost 78% of the regular atmosphere makeup, while Ar at best is less than 1%. Self-generation also reduces shipping (lower CO_2 emissions) and storage costs and is not subject to market fluctuations (because of demand) for the end-user. The cost savings with self-generation equipment on-site can be conservatively 40% or more annually, on top of the cost savings with using N_2 instead of Ar.

LONG TERM PERFORMANCE

Since this conversion in degassing media was made back in 2007, we can report that these changes with the carrier gas remained in place until production stopped in 2020. There were no changes in the P rating using the ASTM E155 standard, nor did any other porosity related quality issues occur.

CONCLUSIONS

A methodical monitoring process was established to assess rotary degassing efficiencies for an aluminum alloy melting system during the drier winter months and humid summer months with Ar as the feeder gas. Once the system was established to be able to perform with Ar during the most demanding time for casting production (50 JPH, RPT for the breakdown furnace near 2.2 grams/cm,[3] high outside daily temperature and dew point), trialing the same monitoring procedure with N_2 as the feeder gas can be performed. In short, presumably due to an extensive N_2 blanket over the treated liquid metal, inclusion of the 60 ppi filter box before the last degassing station, allowed the conversion from Ar to N_2 to rotary degassing to be successful.

Conducting this trial specifically in the drier winter months, or during low JPH conditions where there is a chance for stagnant metal processing, may provide a false sense that the Ar to N_2 conversion of the feeder gas in rotary degassing was possible year-round. This was why this evaluation needed to be conducted in a production environment, having the option to alternate between N_2 and Ar if needed, to fully assess that the conversion could be made for year-round production.

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