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GREAT DIE CASTING

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Contents

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An Investment Casting Foundry Experience in Improving Degassing and Grain Refining in Molten Aluminum Alloys.

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Abstract

The requirements to degas, flux and grain refine molten aluminum alloys for investment casting are well established. The evolution of casting buyer requirements; now requiring larger castings or more complicated geometries than the previous generation, continually require better and more consistent melt treatments for the molten aluminum. Fortunately, several recent technological advancements have allowed degassing, flux and grain refining to be higher performing and more environmentally-friendly than were historically achievable.

This paper will report on the efforts of Atlantic Casting & Engineering (ACE) in Clifton, NJ to implement an improved aluminum alloy treatment process to keep up with the demands of industry. In addition to the process of implementation, this paper will document the rationale and evaluation process for implementing the process improvements. Finally, the paper will discuss the economic, technical and environmental benefits achieved upon complete implementation of the new treatment process.

Keywords: Degassing aluminum alloys, grain refining aluminum alloys, thermal analysis of aluminum alloys, case study, automated treatment of molten aluminum

Introduction

The subject foundry, Atlantic Casting & Engineering, is privately-owned and has been in business for over 80 years. The foundry manufactures high-precision and geometrically complex cast parts, primarily for the aerospace market, but also serves the military, electronics, transportation, medical and various other marketplaces. The operation features two different mold making processes, handling parts up to a 30" cube, and pours approximately 7000 lbs. of aluminum per day. The operation includes various paste and liquid wax injection machines, ranging from 5 to 100 tons. The investment shell area features both automated and manual dipping processes, followed by autoclave dewaxing.

Seven electric melting furnaces are used to process approximately 7000 lbs. of metal per day, with up to 15 different aluminum alloys. Finally, the post-casting operation boasts a variety of equipment for finishing, heat treat, and straightening of castings, and a full CNC machine shop.

Incumbent Melt Treatment ProcedureThe foundry melts and pours an array of aluminum alloys including 201, A203, A205, C355, A356 and F357. These melts are melted and prepared in one of six electricresistant crucible furnaces ranging in size from 1200 lbs. to 250 lbs. in capacity. All foundry elemental additions are made into the furnace directly rather than in the hand ladle prior to pouring.

The historical method for treating aluminum in the subject foundry entailed adding metallic-form TiBor (5%Ti, 1%B) pucks into the melt at a rate of .25% the weight of aluminum to be treated. The additions were made prior to the degassing process, which utilized an iron-cross or gear shaped rotary impellor connected to a simple pneumatic drive degassing unit that is raised, lowered and transported via an overhead hoist. High purity argon was the purge gas used during the 30-minute rotary degassing cycles.

In addition to rotary degassing, hexachloroethane degassing pills were used to provide both cleaning and additional degassing of each melt. The hexachloroethane degassing pill treatments were 10 minutes each and were added at a rate of 0.15% the weight of aluminum to be treated.

Only elemental spectroscopy of the Titanium (Ti) levels was historically used to evaluate grain refinement, with a typical target level of 0.15% (+/-0.02%) by weight. A standard reduced pressure test (RPT) was performed to assess degassing efficiency by placing a standard sample cup under a vacuum pressure of 27.5 (+/-.5) inches of Hg for 7 minutes.

A picture of the reduced pressure testing apparatus appears in Figure 1.

Figure 1. Picture of the RPT apparatus used to assess degassing efficiency.

Once solidified, the RPT specimens were subjected to the hydrostatic displacement technique, i.e., a ratio of weight in air and a weight in water, to determine the specimen'sspecific gravity. The minimum threshold specific gravity for each alloy poured appears in **Table 1.**

Table 1. Alloys and specific gravity threshold minimums

Alloy	Specific Gravity Specification Minimum
201	2.70
A203	2.70
A205	2.80
C355	2.65
A356	2.65
F357	2.65

Thermal Analysis Testing

It has been established that grain refinement can beneficially affect feeding, fluidity and mechanical properties in aluminum castings.[1,2] Hence, inadequate grain refinement can yield shrink voids in aluminum castings. Moreover, it is established that too much Sr can cause porosity in aluminum-silicon alloys also resulting in porosity in cast aluminum.[3,4]

Accordingly, it was decided to assess the grain refinement and eutectic modification levels to see if an improved practice was possible.

A THERMATEST 5000 NG III thermal analysis (TA) unit was used to assess the grain refinement (or grain fineness) and eutectic modification (or eutectic structure) of the treated melts after they were prepped for pouring. Thermal analysis involves collecting data of temperature versus time of a solidifying melt sample and comparing the curve to a set of known curves algorithmically. A photograph of the subject TA unit is shown in **Figure 2.**

Figure 2. Photograph of the TA unit used in the melt assessment.

The TA algorithm analyzes the sample curve liquidus and computes a score on a scale from 1-9 for evaluating grain fineness (GF). A score of 1 references a curve that compares perfectly with curves exhibiting no grain refining. In contrast, a GF score of 9 is achieved when the sample curve compares with those curves know to have produced "perfect" grain refining of melts with the same alloy composition. A pictorial representation of the subject grain refinement levels is provided in **Figure 3.**

The TA unit is also capable of assessing eutectic modification effectiveness as well. Like with grain refinement, the TA device compares experimentally derived temperature/time curves to known standards and computes a score on a 1-7 scale. The scale for measuring eutectic structure (ES) differs from grain refining in that a score of 7 does not denote perfect modification, but rather a condition in which too much Sr has been added and eutectic shrinkage would be expected. Typically, 356 alloy casters who are intentionally modifying the Si eutectic in their melts target a range of 4 to 5.5 on ES. ES values lower suggest insufficient modification and ES values higher suggest too much Sr modification.

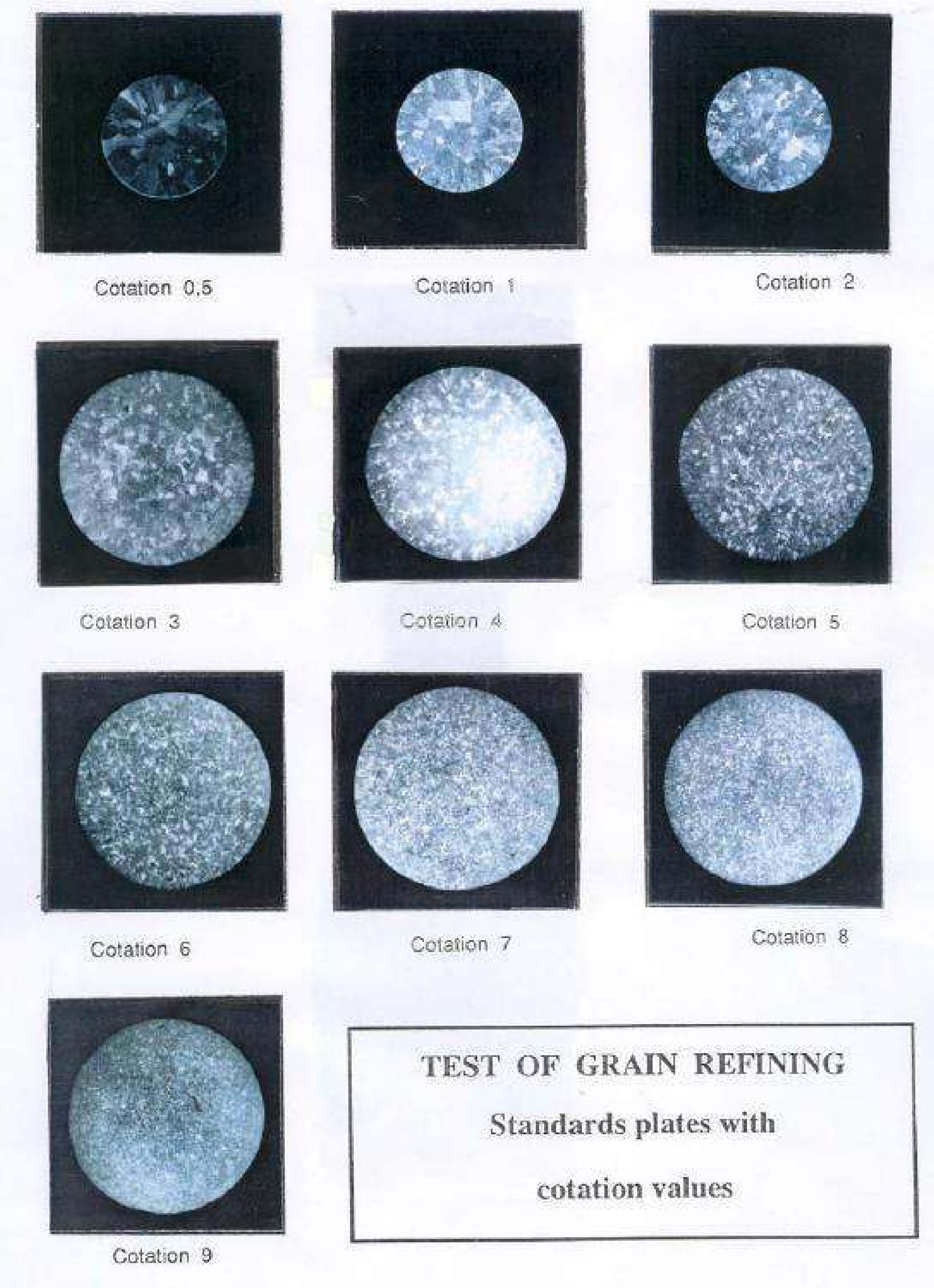


Figure 3. Pictorial representation of the grain refinement levels as measured by the TA.

The results of the TA evaluation of the incumbent process are presented in Table 2. It should be noted that no efforts are typically made to intentionally modify the eutectic silicon so a low level of near 1 was expected for the ES. Fortunately, the level of modification was so low that any effects would be negligible and what modification may have been performed should not prove problematic.

Table 2. Results of TA evaluation with incumbent procedure

Alloy	Grain Fineness (GF)	Eutectic Structure (ES)
355	6.9	2.51
356	6.2	1.27
357	7.5	N/A

The results of the TA analysis clearly show an opportunity for improvement in grain refining as the maximum level of 9.0 was not achieved in any of the three alloy (355, 356, 357) melts benchmarked. Hence, a project to improve the grain refining was initiated.

Salt Form Grain Refining

Before there was grain refining with metallic additives such as TiBor, grain refining was predominantly achieved via salt pucks. The salt pucks would decompose and react at the holding temperatures of molten aluminum to form metallic nuclei in situ. Examples of nuclei created from salts include, but are not limited to, $TiAl_3$, TiB_2 and AlB_2. These examples of nuclei were chosen for the listing as they are the same nuclei formed from metallic TiBor. More information on grain refining can be found in the referenced paper authored by Began and Careil.[5]

Unfortunately, salt form grain refining with pucks fell out of favor since the pucks were buoyant in aluminum requiring that they be plunged with a stainless-steel bell jar. The elemental contamination of Fe from the stainless-steel bell jar would yield both chemistry and mechanical property problems in aluminum so an improved grain refining methodology was required. Metallic form TiBor overcame the buoyancy problems of salt form pucks so despite being costlier and largely less effective than grain refining with salt form pucks, it gained widespread adaptation since, for the moment, it resolved the issue of Fe contamination.

More recently, a novel granular salt flux form grain refiner was developed within the past decade to be an improvement over metallic form TiBor. A recent paper documented the success achieved both technically and financially in converting from metallic form TiBor to the reference salt form grain refiner at Littlestown Foundry in Littlestown, PA.[6]

The salt form grain refiner can be applied without steel tools so it overcomes the Fe contamination issues associated with the pucks. In contrast to the pucks, the granular flux form grain refiner can be integrated with a Metal Treatment Station (MTS) so that only graphite and inert ceramic components contact the aluminum during its application.

The salt form grain refining flux has the additional benefit of being a very strong cleaning flux capable of reacting with oxides to chemically separate them from aluminum.

As previously indicated, the predominant way for reacting the salt form grain refining flux is via a metal treatment station (MTS). In a MTS, a vortex is temporarily created by withdrawing a vortex breaker baffle board and increasing RPM's of the graphite shaft and rotor used in the rotary impellor degassing process. PLC controlled additions of the treatment flux are added into the vortex and mixed to complete reaction prior to the vortex breaker baffle board re-engaging the melt, effectively stopping the vortex. After the vortex has been stopped, the MTS completes a standard rotary degassing process and the treated metal in the ladle or crucible is used for transferring and/or casting.

Experimental Procedure

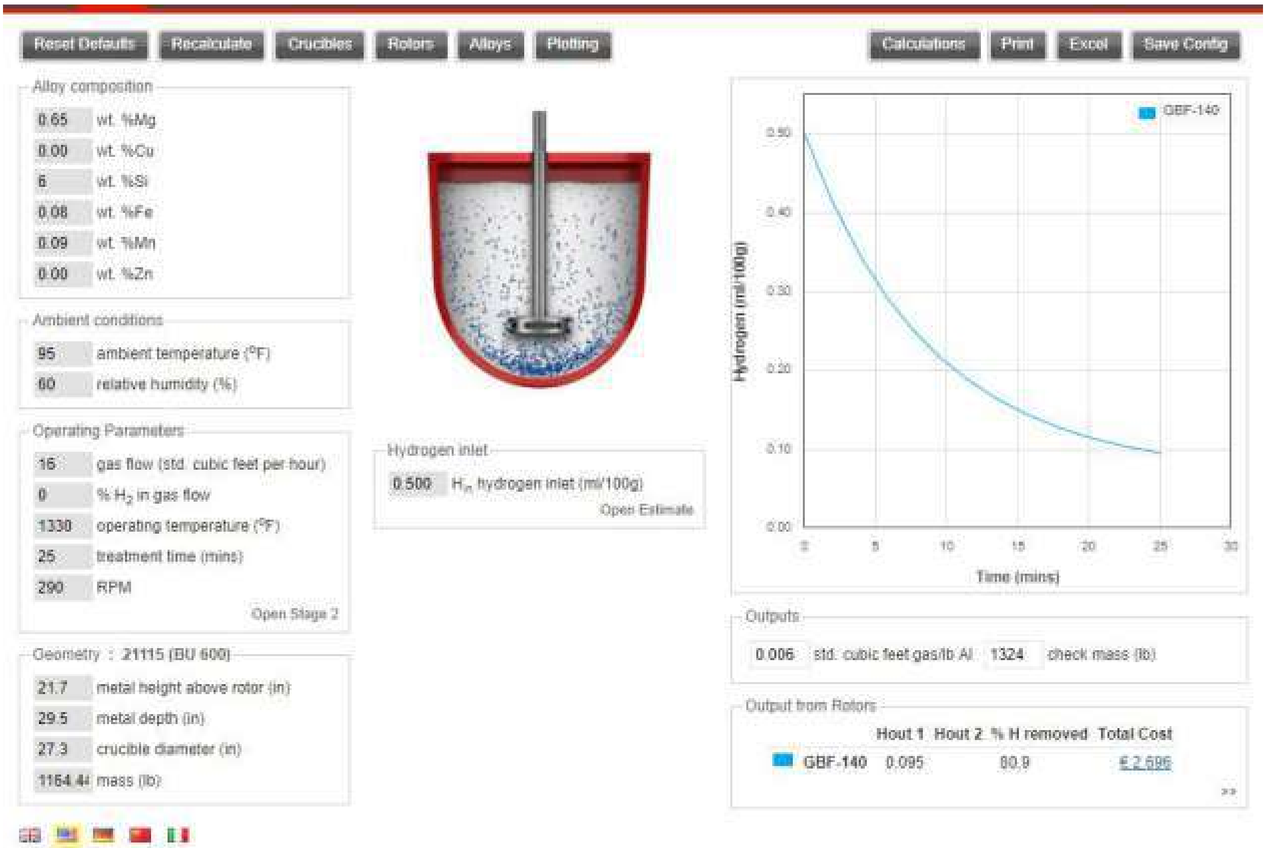
Degas Modeling

To assist with achieving optimized hydrogen removal, a degassing model was utilized to determine a minimum cycle time.[7] The parameters were plugged in using 357 alloy since it is generally the toughest of the aforementioned alloys to degas in terms of cycle time.

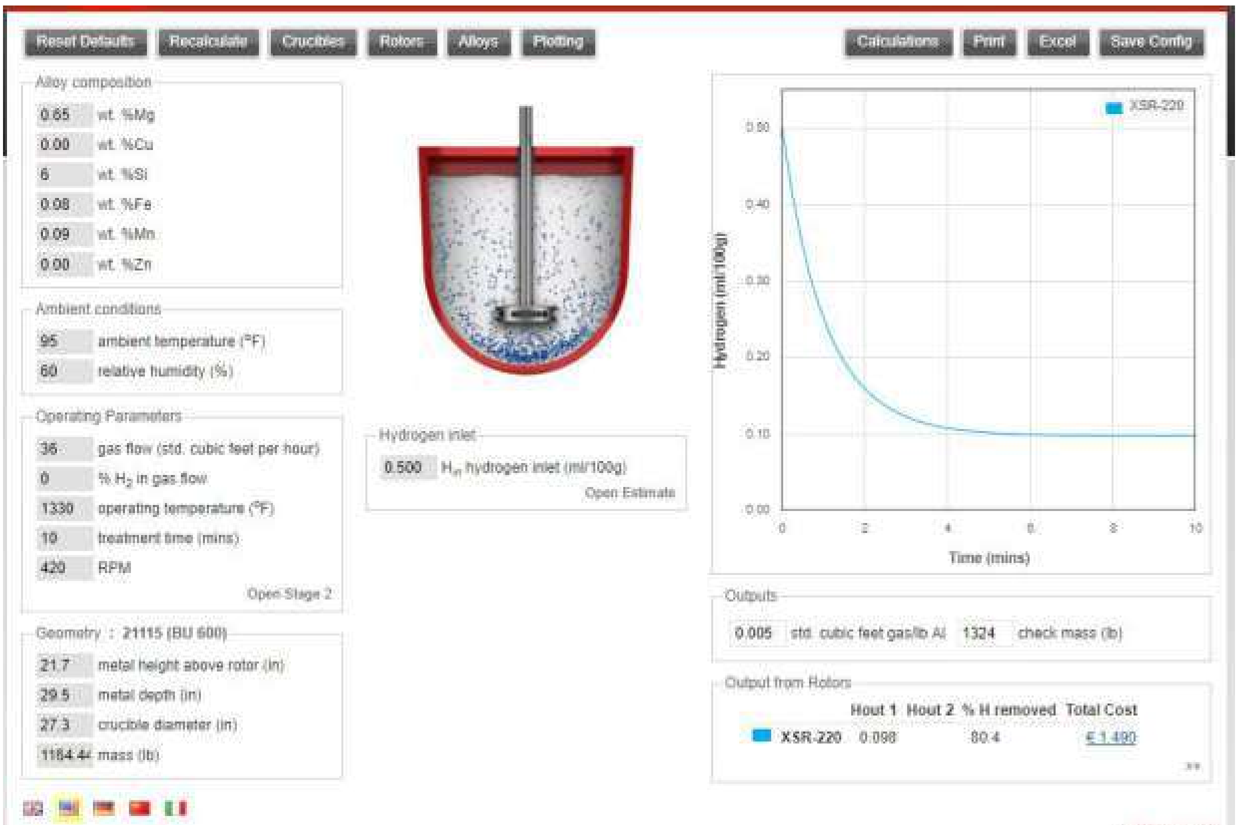
The chosen conditions tended towards the extremes where degassing is most difficult, e.g., high temperature and humidity. The parameters for the new procedure model are presented in **Table 3**. A model was prepared as a best estimation of the incumbent process as well with the only change being the rotor design being run at the traditional rpm, flow rate, etc. The results of the model for both the incumbent procedure and the newly proposed procedure are presented in **Figures 4(a) & 4(b)**, respectively.

Table 3: Parameters for degas modeling

1200 lb Crucible	XSR 220 rotor
357 Alloy	0.50 ml H_2 / 100 g Al starting level
1330º F melt temperature (*)	600 s minimum treatment time (*)
60% relative humidity (*)	95° F ambient temperature (*)



(a) Modelling of incumbent degassing procedure



(b) Modelling of proposed degassing procedure

Figure 4. Results of Degas Modelling 357 in 1200 lb. Furnace.

The results of the degas modelling confirmed that in even tough conditions, the new rotor design and unit combination should be able to degas the melt in approximately 6-8 minutes under ideal rotor and baffle plate conditions. A 13-15 minute average cycle should be more than sufficient for when rotor wear, belt wear and perhaps baffle plate wear lead to a slight reduction in degassing performance. The model approximation performed for the incumbent process suggest that 25 minutes are required to degas the same melt in similar conditions; hence, a 30 minute historic degassing time was apropos although experience has shown that when the rotor and/or baffle plate were worn, a repeat cycle was often required.

A dimensional schematic of the MTS degassing unit designed for trials appears in **Figure 5.**

The New Melt Treatment Procedure

After completing the modelling, the new melt treatment procedure was tested against the incumbent procedure. Specifics of the newly evaluated procedure follow:

- Treatments with a Hoist Mount MTS unit and an improved pumping rotor design
- Treatment parameters set according to the degas modeling
- Grain refining and cleaning to be performed via the automatic additions of the grain refining flux
- Argon to remain the purge gas
- Treatment cycle will be automated to 10 mins for 600 lb. crucibles and 15 mins for the 1200 lb. crucibles
- Elimination of TiBor and Hexachloroethane pills

Grain Refining

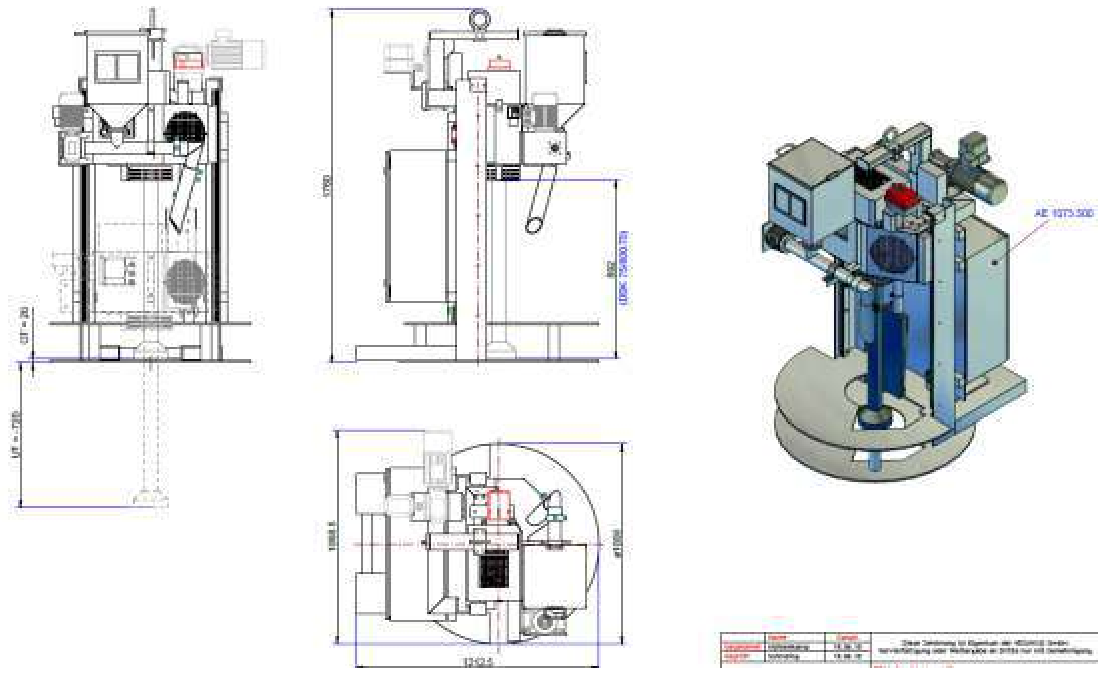


Figure 5. Dimensional Print for the Metal Treatment Station

The unit can be moved into place by either a fork truck or an overhead hoist and operates by being set upon the melt furnace targeted for treatment. The unit employs a retractable carriage that will automatically lower the degassing shaft, rotor and baffle plate into the melt during treatment and automatically withdraw the degassing shaft, rotor and baffle plate at the end of the treatment. The unit is designed to withstand the heat of the melt to be treated and to pass purge gas only during the cycle. The unit is outfitted with a hopper to hold the grain refining flux and an auger drive system to deliver precise amounts of flux each treatment.

Once the MTS unit was onsite, efforts were taken to verify the effectiveness of the vortexing system with respect to grain refinement. Grain refining flux additions of 0.06% the weight of aluminum melt were added via the MTS to both 600 and 1200 lb. melts. The results of the TA testing results are tabulated in Table 4. In every treatment using the grain refining flux, a perfect GF score of 9.0 was achieved.

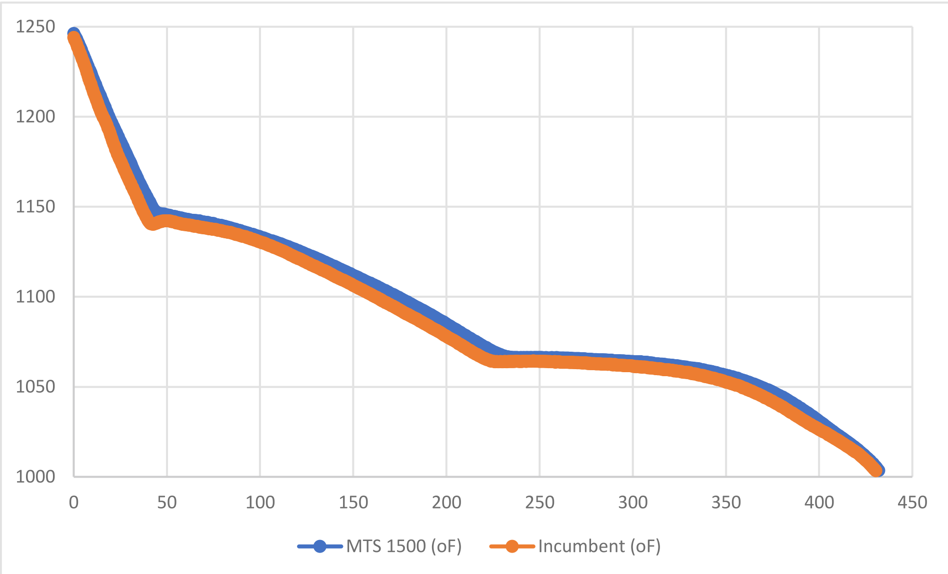
Table 4: Results of TA Evaluation with grain refining flux

Alloy	Grain Fineness (GF)	Eutectic Structure (ES)
355	9.0	1.69
356	9.0	1.00
357	9.0	N/A
355	9.0	2.98
355	9.0	2.06
357	9.0	N/A

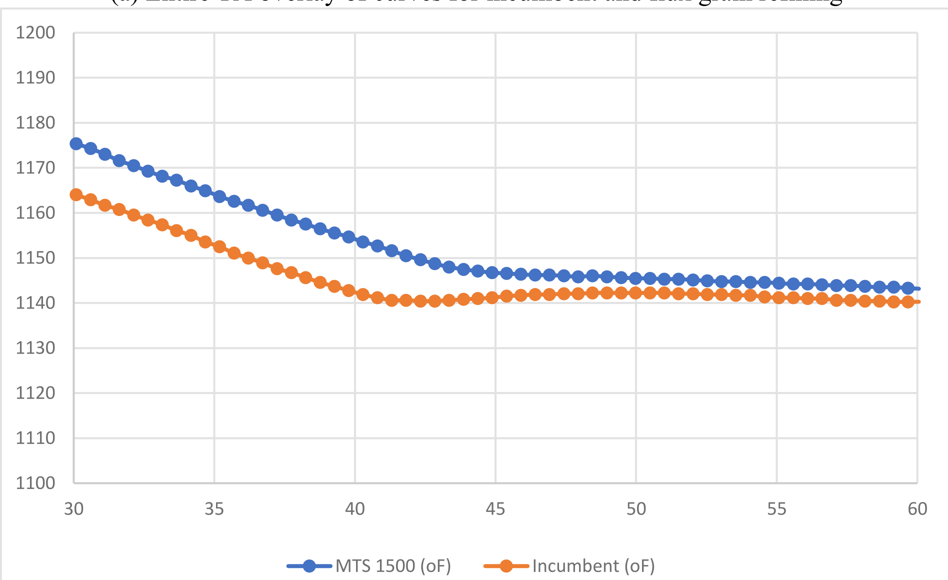
TA curves taken in 356 alloys from the incumbent process (orange) and with the grain refining flux (blue) are overlayed and presented in Figure 6. Figure 6(a) shows the entire TA curve and Figure 6(b) shows a blow up view of the liquidus portion of the curve.

The liquidus is the portion of the curve where the primary aluminum grain changes from liquid to solid. The TA value for the blue (grain refining flux) line was 9 while the TA value for the orange (incumbent with metallic TiBor) line was 6.2. For reference, these TA values match the readings reported in Table 2 and Table 4 respectively, for 356 alloy.

In Figure 6(b) you can clearly see some the orange line go down and then index slightly back up before indexing back down. This phenomena where the cooling curve indexes up before indexing back down is metallurgically referred to undercooling and indicates an opportunity to improve grain refining. In contrast, you do not see any undercooling in the blue (grain refining flux) line which indicates there is no opportunity for improving the grain refining in its melt.



(a) Entire TA overlay of curves for incumbent and flux grain refining



(b) Blowup view of TA curves at liquidus arrest for incumbent and flux grain refining

Figure 6. TA curves taken of both the incumbent and the flux grain refining

Hydrogen Control

Once the effectiveness of grain refining was verified, the evaluation of the hydrogen was completed. The cycle times were lowered from 30 minutes with the incumbent process to a cycle time average of 13 minutes so there was initial concern about matching performance. Fortunately, every cycle tested matched, or exceeded, the threshold specific gravity specification according to the internal RPT protocol. Moreover, a novel in situ hydrogen sensor was used to verify that hydrogen levels were equivalent or better than the incumbent procedure. For more information on the novel hydrogen sensor used to confirm performance, review the content on the work by Fray and co-workers in the referenced paper by Sigworth & Began.[8]

The results of the hydrogen concentrations taken during testing are provided in **Table 5.**

The results are concentrations of hydrogen based on the Nernst equation and were taken from two different dates. In contrast to specific gravity where a higher number is preferred, lower values are preferred with hydrogen concentrations. The great news is that even though the new process showed a little bit better hydrogen concentration levels, even the three measurements taken from the incumbent process were strong (favorable) readings.

Table 5: Results of evaluation for hydrogen concentrations

Alloy	Incumbent [ml/100g]	MTS 1500 April 2018 [ml/100g]	MTS 1500 October 2018 [ml/100g]
355	.10	.07 / .05 / .08	N/A
356	.12	.10	.06
357	.08	.08	.04 / .06 / .06

Environmental and Safety Benefits

There are significant environmental and safety benefits available in the elimination of Hexachloroethane degassing pills. Hexachloroethane pills decompose in aluminum aspirating gaseous chlorine ions. These chlorine ions are recognized as toxic, carcinogenic and highly reactive with many materials. Hexachlorethane pills were actively targeted to be phased out of the foundry industry in the United States starting in 1999 because of the array of detrimental side effects when the chlorine ions are aspirated.

Even when Hexachloroethane pills do not aspirate chlorine ions, they are dangerous to the touch since they can adsorb to the skin causing a depression to the central nervous system according to Wikipedia.[9]

Results

The original evaluation of the new melt treatment was a success so it was implemented, monitored and verified five months later. A tabularized dataset from the adaptation appears in **Table 6.**

Table 6. Tabularized Dataset of Incumbent and New Procedure

Metric	Incumbent	MTS Process	Comments
Chlorine Cost ($/lb.)	$3.20	0	N/A
Chlorine Usage (per/lb of Al)	0.15%	0	N/A
Chlorine $/day	$28.80	0	100% reduction
Ave Cycle Time (mins)	30	13	56.67% reduction
Ave Total Melts/Day	8	8	N/A
Ave Repeat Cycles	2	0	N/A
Ave Approved Melts/Dav	6	8	N/A
Success rate	75%	100%	N/A
Total Degas Time (mins per day)	338	104	69.2% reduction in degassing time
Melt (lbs./day)	6000	7800	30.00% increase metal poured per day
Tibor% Melt/lbs. per Al	25%	0	N/A
COVERAL MTS 1582	0	0.06%	N/A
Grain Refining Cost/Day	$104.55	$20.13	$84.42 or 80.7% reduction in daily spend
Argon Spend/Melt	$11.05	$6.40	

The successful adaptation of the new process brought about the following technical & productivity benefits:

- Perfect grain refinement every treatment measured with the THERMATEST 5000 NG III unit including 7 more tests run 5 months after implementation as part of the verification process
- Not a single failed specific gravity test since implementation! 25% of the treatments with the incumbent process would fail specific gravity testing allowing for 2 more melts treated and poured per day.
- A 69% reduction in degassing time average per day.
- 30% increase in metal poured per day.
- Effective elimination of hexachloroethane pills (without performance implications) leading to improved safety and environment.

Additionally, the following economic benefits were achieved upon adaptation of the new process:

- Elimination of the $28.80 daily spend on Hexachloroethane pills
- Grain refiner savings of $84.42 per day switching from metallic TiBor to the grain refining flux.
- Argon savings approximating $4.65 per melt.

The adaptation was reviewed for potential drawbacks and other implications it may have caused. It was hoped that the mechanical properties, particularly elongation, may go up due to the improved grain refining (as it had in the referenced paper at Littlestown Foundry); however, the mechanical properties tested before and after the new process adaptation remain unchanged statistically. Viewed from another angle, maintaining mechanical properties without using Hexachloroethane pills is a positive as mechanical properties and cleaning of aluminum melts is the predominant reason some foundries cite for not ceasing their use despite the myriad of health issues they can cause.

The baffle plate is an additional spend item (approximated at $1500 per annum) so these new costs need to be subtracted from the total savings. Finally, the graphite components for the new system cost more per piece than the historic process components but annualized spend is expected to be less since there are shorter cycle and longer usable life of the newer consumables which are thicker and last longer. However, if (or in our case when) the operators accidentally mishandle these components a slight decrease in savings (and potentially an increase in spend) can result and during the first year an increase of graphite spend is estimated to be nearly $1500.

Finally, the biggest difficulty with the new system is the bulkiness of the new unit, which requires a higher-grade overhead hoist and more caution from the operators because it is nearly ten times larger and heavier than the incumbent unit. However, it is unanimously agreed that the benefits of the new system far outweigh those few difficulties that were introduced with the new unit/procedure.

An approximate payback Table appears in **Figure 7.** After all of the cost savings in reduced argon spend, eliminating chlorine pills and lower grain refining costs are offset by the slight increases in spend on graphite and baffle plates, a payback can be calculated and was determined to be approximately 16.5 months.

Saving	Payback Calculation Component Savings	Comment
Argon	$8,462.38	
Chlorine Pills	$7,488.00	
Grain Refining	$21,949.20	
Baffle Plate	-$1,500.00	
Graphite Shafts/rotors	-$1,459.90	
Sum annualized savings	$34,939.68	
Payback (yrs)	1.37	Yrs
Payback (months)	16.50	Months

Figure 7. Payback Calculation Table

Summary

A novel method for applying a combination salt-form grain refining flux and rotary degassing system was implemented at an investment casting operation in Clinton, NJ to great success. The new treatment method resulted in an improved grain refinement practice that lowered spend, increased productivity, improved hydrogen control, delivered environmental & safety benefits and eliminated waste. The calculated payback on a new MTS unit was calculated to be about 16.5 months.

Acknowledgements

The authors would like to thank Jason Allen of Foseco for preparing the TA curve graphics and Ben Groth of

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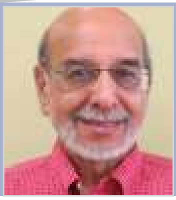

What is CQI 9

Vishwas Kale, Managing Director, Vijayesh Instruments Pvt Ltd, Pune
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Instruments have a vital role in all processes. In metallurgical applications, their importance is already established. Metallurgy is no longer an art, as it was once described. By controlling right from the specifications of the raw materials to the process parameters, a low cost low rejection – prone product may be easily produced.

Temperature is one of the most important factors. However, it is surprising how much it is neglected in quality conscious companies even today. For process standardization, accuracy and repeatability of measurement is required.

HEAT TREATMENT FURNACES

For Heat Treatment, full compliance with CQI-9 is now needed if the company wants to be competitive and preferred supplier

The Automotive Industry Action Group (AIAG) is providing various Continuous Quality Improvement (CQI) information in many fields

Developed in collaboration with volunteers from OEMs, Tier 1 suppliers, heat treat suppliers, and calibration companies that service the heat treat industry, the Special Process: Heat Treat System Assessment (HTSA) 4th edition (CQI-9) is a comprehensive audit covering the most common heat treat processes employed by the automotive industry, intended to provide a common approach to a heat treat management system for automotive production and service part organizations

The CQI-9 (latest version 4) explains requirements for testing of furnace temperature mapping to know uniformity of temperature during process. Casting users and buyers in India and globally are now insisting on it.

Most of the times the actual temperature, the measured and controlled temperatures are different. This happens because of the locations of thermocouples and furnace design. Also the furnace design plays very crucial role. Incorrect calibration of thermocouples and controllers is another issue. For process standardization, accuracy and repeatability of measurement is required. These depend on the thermocouple characteristics, compensating cables, measuring instrument and its calibration and finally the actual method of measurement.

Temperature – Uniformity and Better Control

Uniformity of temperature can be checked by furnace mapping by inserting many thermocouples inside the furnace and collecting data. The mapping is done by flexible bare or mineral insulated (MI) thermocouples put on the job inside furnace. MI thermocouple is suggested as bare thermocouple length gets heated by the temperatures inside the furnace and gives inaccuracy. The data is logged over a period of time and different temperatures. There are procedures as per standards. The thermocouples and instruments are used only after confirming their calibration. For specific furnaces more solutions are possible. For example, a travelling thermocouple along with the job may be used. It will monitor temperature in different zones.

Procedure per CQI 9 version 4

Flexible thermocouples are inserted into the furnace and their sensing tips are located at the jobs where temperature is to be measured. The number of thermocouples is depending on the points to be checked. They are connected to a data logger/scanner. At predetermined temperatures the readings are recorded at regular short intervals.

The thermocouples, data logger/scanner has valid calibration certificate with NABL accreditation. The data is compared with the actual reading obtained from the thermocouples and instruments used with the furnace.

System Accuracy Test (SAT) and Temperature Uniformity Survey (TUS) are carried out. The procedure is based on the furnace dimensions, working temperature, application of furnace, furnace class, instrumentation class, number of sensors to be used etc.

The SAT helps to understand the existing system of temperature measurement and control. The existing system is compared at the working temperature with another thermocouple (master) inserted inside the furnace at the same location of the existing one and another instrument (master) The SAT is done at the actual working conditions.

The TUS is performed to find the temperature pattern at the working temperature inside the furnace with master thermocouples connected to a master instrument for data logging. It is done at the actual process conditions.

The certification involves many points such as number of thermocouples, type of thermocouples, their locations, number of readings, interval of readings, readings before and after stabilization, necessary accuracies of thermocouples uses as master, valid certificates of thermocouples and data logger used as master as well as that of instruments and thermocouples in use at the furnace, process of heat treatment (e.g. hardening, tempering etc.), if conveyer type-then test trials as different speeds. The SAT and TUS results indicate tolerance satisfaction. These may depend on these points. The list is quite long but once understood, very easy to follow.

The mapping test is a very true report of furnace behaviour. The claims of furnace manufacturer are put to test. Though sometimes shocking, it will help to take corrective actions.

CQI 9 Standard

The standard is complex but not difficult to understand. It lays necessary guide lines.

Simply it says, for example: some of them

1) Is there a dedicated and qualified heat treat person on-site?
2) Does the heat treater perform advance quality planning?
3) Are heat treat FMEAs (failure mode and effects analysis) up to date and reflecting current processing?
4) Are heat treat process control plans up to date and reflecting current processing?
5) Are all heat treat related and referenced specifications current and available? For example industry and customer specifications such as SAE, AIAG, ASTM, ISO, EN, JIS etc. and Ford, Fiat etc.
6) Is there a written process specification for all active processes?
7) Has a valid process capability study been performed initially and after process equipment has been relocated or had a major rebuild?
8) Does the heat treater collect and analyse data over time and react to this data?
9) Is management reviewing the heat treat monitoring system every 24 hours?
10) Are internal assessments being completed on an annual basis at a minimum using AAIG HTSA?
11) Is the OEM customer notified when parts are reprocessed? etc.

Importantly, it has sections and tables to specify

1) Management Responsibility and Quality Planning
2) Floor and Material Handling Responsibility
3) Equipment
4) Requirements for specific heat treatments
5) Process and test equipment requirements
6) Pyrometer needs etc.

All these tests are not only to fulfil customer's needs but also to establish truthfully own manufacturing and testing capabilities.

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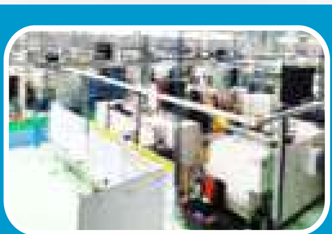

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Aluminium Foundry - GDC/LPDC/PDC

Dr. D. D. Kumbhar
Director Technical (Foundry) Jayashree Group of Industries, Pune.
ddkumbhar1203@gmail.com

- Tools / equipment used in aluminum foundry
- Melting method
- Molten Metal Treatment/Alloys Processes
- Chemical composition of different alloys
- Sand system in Foundry
- Reaction of hydrogen gas on aluminium alloy
- Casting Extraction or casting process
- Uses of Aluminium Metal in Automobile, Engineering, Agriculture, Electrical etc Major properties of the different alloys

Tools to use in Foundry:-

1) Sklener Melting Furnace
2) Crucible (Tilting) Furnace
3) Rotary Furnace
4) Induction furnace (electric)
5) Laddle - for transfer of metal
6) Scraper for cleaning and rabbling
7) Skimmer to be used for dross removing
8) Pouring Pot /Spoon – Tool use for pouring.
9) Clay / Shadu / Asbestos / Mastic / Diecoat
10) Filter/Wiremesh/Tongs/ Handling trolley
11) Casting Cutting Machine
12) Belt sander
13) Files / Rough files/ Round files
14) Tower type furnace

Mold coating for aluminum die casting:

For molds made for aluminium castings the coatings are made as follows. Sodium silicate is used as a binder for coating and the following substances are mixed in water. Graphite Powder Fine Silocell and Clay Asbestos, Vermiculite Soapstone Powder Aluminum etc.

The following benefits are obtained after coating the mold :

1. Control of casting cooling and solidification

so the casting structure gets better. It also creates defect less casting.

2. Thermal shocks of the mold become less.
3. This reduces the amount of metal penetration into the surface of the mold so that you do not get rough casting.
4. The coating acts as an insulator.
5. Increases fluidity of metal.

The right mold to create the best casting in the foundry

The choice of coatings are very important. After coating, the mold is heated to 220 to 250 ° C with the help of a good burner. If warpage found in the mold, the mold should be rejected. Heat the new die for at least 1 hours with the help of a burner gambling bowl. Mold cavity should be light sand blasted and heat until 220 degree for better coating. When coated on a cold mold, the coating goes back and forth and does not apply properly. When the hot mold is coated with a brush, it looks like a crust and the coating was removed. When the coating is lightly applied by spray

gun on the hot mold a thin layer is applied evenly on all the molds. If you need insulated coating, apply several layers to the mold in this way, but these layers should be soft and easy to scratch. While coating, the part should be covered with steel wool for some time and this process should be continued till the layer of suitable thickness is obtained. The coating layer of mold cavity should be about 0.002 to 0.005 inches. The diecoats should be slightly thicker on the Riaer section and the ingates and rest cavity thinner elsewhere so that the heat flows faster. Do not place the coating in the corner of the mold while coating. So the casting corner will not come. The metal core does not have insulin coating. But they spray paint made of graphite and water on it. Graphite works like lubricant. Core prints and and core resting area are not coated. Once the coating is done, there will be no coating on the vent. Make sure and clean all vents.
Even if the coating applied to the mould by the above method is used continuously, the coating that lasts for 24 hours of use is likely to wear out and the casting misrun will come. At this time, the mold should be re-coated. Fine and thin coating is reqd. This is because if the coating is very bad, the old coating is removed with a brush and light sand blasting is followed by re-coating.
The coating applied to the mould and the metal from which the mould is made differs in the rate of diffusion of heat due to which the coating loses and evaporates. This time the mould is cooled and reheated. When the product is delayed for some reason and will start on the same coating after some time, keep the mould slightly warm. Otherwise the mould will have to be re-coated.
The mould does not retain its accuracy if the mould cavity is too large during each blasting or scratching the coating by the wire brush during repair. In this case, even if the mould cavity is too large, it is not suitable for damping. However, for this reason, be as careful as possible when replacing the mould, requiring recoating at least once.Gravity Die Casting **(GDC) Low Pressure Die Casting Method (LPDC), High Pressure Die Casting Method:**

(HPDC)

1. Comparison
2. Advantages and disadvantages of suitable method
3. Limitations of each method.

To the die casting manufacturer, the castings will meet customer expectations (quality). In the same way, they have to choose the right method considering all the cost and safety of their product. The manufacturer has to decide which method can produce the highest quality, cheapest and best quality product. Consider the following important points.

Choosing the right method:
Number of castings, quality, customer expectations, that where the castings will be used. also, what metal and alloy are to be made from and which method to use will be economically viable. etc. only then the right method is chosen. most importantly, the emphasis is on fulfilling the customer's expectations.

Gravity or permanent mould method:

This method is most suitable for small, medium or large production and for those castings whose thickness is not uniform. this is because risers and feeders can be used for thicker areas. Similarly, the weight of the gating and feeding system can be kept higher than the weight of the actual casting. the dies used in this method can be used in a fully automated manner by hand as they are made from the C.i/S.G iron. punches are made of hot die steel.
the time it takes to produce is the time it takes for the metal to cool. fully finished castings (using properly made and well-measured dies) have excellent surface quality and accurate measurements and casting measurements. the yield difference in gravity die casting method is 50 to 60% in normal casting. this increases the cost of smelting the metal as well as the cost of the fetting operation. Sometimes the casting is not as flawless as expected due to the faulty

method for castings and due to oxidation of metals Blow holes are also found due to entanglement/turbulance. This method gives very good physical, chemical and mechanical properties.

Low pressure casting method (low pressure):

Alloys which are cast by gravity method in low pressure method give better results. This is because the casting method has an ideal technique and a close approach. This method has many advantages over manual casting method as the metal is filled under the right pressure controlled speed and under the surface of the metal oxidized. In this low pressure method the molten metal is in a closed pressure vessel and is heated by an electric heating element. It is covered with a ceramic tube. (Silicon carbide)
The cooling action of the casting was in a certain order. Solidification is done in a progressive manner i.e. it gradually cools from the side of the mould to the middle. Casting with thin ribs occurs in this method. Or

1. Made in Gravity Die Casting Method All types of castings are made by low pressure method.
2. The low pressure belt gives a yield of 95 per cent of the metal. So Gravity gives 50 to 60 percent yield.
3. Decrease in metal smelting price - LPDC
4. Fettling price reduction - LPDC
5. Improvement of Metal Structure - LPDC
6. less Porosity - LPDC and
7. Casting surface better and less flow lines in LPDC compared to Gravity method
8. Gravity costs less labour cost. Less manpower required for operation (compared to Gravity) – LPDC
9. Fully automated system improves LPDC work around workers due to greater control and cleanliness as well as relief from high temperatures
10. Proper control of metal temperature (meet temperature) - LPDC
11. Properly supported clay mold of steel

Can also be used in this method as well as clay Cores can be used. LPDC

12. Almost all types of metals and alloys can be used in low pressure methods. The low pressure method is the most common method for castings such as aluminum wheel rims housing etc.
13. Process control is better in the low pressure bar.

High Pressure Die Casting Method:
The main goal of thin castings and uniformly thick castings is to ensure that the casting solidifies as quickly as possible before it cools down and allows heavy sections to be filled before extraction. Both of these numbers are highly anticipated. Machines for this are very expensive

Being forced to invest more money. For this, the number of castings and the speed of production per hour must be high. Dies used for high pressure die casting are also expensive. The cavities in the die have to be made of high quality steel and good quality using high technology. In the same way, their heat treatment is expected to have a good surface and the accuracy of the measurements are important as well as financially expensive. But strict adherence to all these factors helps to reduce the further cost of casting. Mainly cast finishes, perfect ribs, fin are filled in this method.

Pressure die casting dies (moulds):
Pressure die casting die is the joining of different

ferrous materials in a certain way. This connection is for rapid changes in temperature and works accordingly. This is because the molten metal or alloy is poured under high pressure and cools down immediately. It is essential that the die insert (which forms the shape of the machining casting) is rigorously machined as well as the heat treatment is done in a proper manner, which gives the desired properties to the die insert. A single die is made from parts of ten or more types of steel. Other non-ferrous among them.

It also includes parts of materials and alloys that resist high temperatures.

Die casting dies consist of this part of the cover high and half of the ejector dies (which come together on a common parting line). The cover die part is a fixed (fixed) fitting to the die casting machine. This half contains the spruce that fills the cavity and is aligned with the hot chamber of the cold chamber machine. The injector die half consists of a casting extractor and a runner, most of which is connected to a moving high and then to a clamping mechanism. Die casting is the key to producing the best quality die. The quality and consistency of the die casting is largely dependent on the quality of the die. Along with other important issues like cycle time, dicoat at the right time and proper use of metal or alloy compositions and metal temperature This Things are just as important. But the important points in terms of die (which determine the surface quality and consistency of the casting part) are as follows and need to be carefully considered.
1) Design of die
2) Material of die (metal or alloy)

Die layout:
Since it is important for the casting to come out of the die easily, it is necessary to plan the die accordingly Is. This is because it is the heat balance that controls the quality and soundness of the casting surface. The die should be framed in such a way that the right technical capabilities as well as the fine finish should come together simulteniously in the maximum casting.

1. Single cavity dies (single cavity) have the following four parts.

(A)Die the blocks (chashi inserts) with exact impressions of the casting.
(B)Casting system (ejector)
System)
2. Dies with multiple cavities (multiple cavity dies):

Multi-cavity dies can also be made in such a way that more than one simultaneous casting can be made from a single die. It is used to increase the number of die casts and to reduce the number of die casting machines. This type of die consists of dies with two or more single duplicate cavities. With this die (more than a single cavity die can be made into a casting product, the product can be doubled) to maximize production in less time.

Die storage and maintenance:
Pressure die castings are very expensive.
So their store and maintenance very carefully have to do. Dies that are not in use should be cleaned and reattached and placed on a wooden platform or in a separate box. Die cores, injection pins, loose pieces should be kept with the die so that they remain safe. It would be great if you could keep a die repair information card. Punch the name of the casting on that die and also write it on the box. Do not replace one die with another. Otherwise there is a possibility of some difficulty during production. Before taking the die product, make sure that the die repair / rectification is completed as per the information card. Also clean the die thorougly. Remove the undercut. If there are any cracks in the die, polish it. Create a separate card for each die as follows. File neatly.
serial number, Die code no. and Name Production No. / Date of Amendment / remark by authority

Common Disadvantages of Pressure Die Casting:

A. Filling / shortening of casting

1. Low temperature of metal
2. Low temperature of die
3. Excess wear of the die
4. Shot valve not working properly
5. Low pressure for casting
6. Going to the metal level under the shot sleeve

B. Bar or flash to the casting

1. Formation of layer of thin metal near parting line
2. The bottom part of the die is weakened.
3. Improper use of die
4. Casting pressure is high.
5. The speed of the metal is too high
6. Not locked with die
7. More Pressure of Solidification (Phase III)

Aluminium alloys, Its equivalence and use:

U.K.	ISO	End Uses
LMO	Al 99.5	Electrical, Food, Chemical Plant
LM2	AL-SI10Cufe	Pressure Diecasting
LM4	Al-SI5CU3	Sand, Gravity Diecasting Manifolds, Gear Boxes Etc.
LM5	AL-Mg5 Si1, Mg6	Sand, Gravity, Corrosion Resistant for marine use food plant, Chemical plant
LM6	Al-Si12, AL - SI12FE	Sand Gravity ECT, Motor Housing, Cover Plates Etc, High Strength when heat treated
LM9	AL-SI 10 MG	Low pressure, ETC Motor Housing, Vover Plates Etc, High Strength even Heat Treated
LM12	AL - CU 10 SI 2 MG	Gravity, Sand Cast, Machines Well, Hydrauolic Equipment
LM 13	AL - SI 12 CU, AL - SI 12 CU FE	Sand Chill, Used for Pistons
LM 16	AL - SI 5 CU 1 MG	Sand Chill, Cyclinder Heands valve Bodies, Good Pressure Tightness
LM 20	AL - SI 12 CU, SI 12 CU FE	Pressure Diecasting, Corrosion Resistant Marine Casting, Water Pumps, Meter Cases
LM 21	AL - SI 6 CU 4	Sand, Gravity, Similar TO LM4, Crankcases, Gear Boxes Etc.
LM 22	AL - SI 5 CU 3	Chill Casting, Solution Treated, Good Shock Resistance, Automotive Heavy Duty Parts.
LM 24	AL - SI 8 CU FE	Pressure Diecasting, Engineering Diecasting
LM 25	AL - SI 7 MG	Sand Chill, General Purpose High Strength Alloy With Good Castibilty, Wheels, Cylinder Blocks, Heads
LM 26	AL - SI 5 CU 3 MG	Chill, Used for Pistons
LM 27	AL - SI 7 CU 2 MN 0.5	Sand, Chill, Versatile Alloy, Good Castability, General, Engg.
LM 28	AL - SI 19 CU MG NI	Chill High Performance Pistons
LM 29	AL - SI 23 CU MG NI	Chill High Performance Pistons
LM 30	AL - SI 17 CU 4 MG	Pressure Diecast, Unlined Cylinder Blocks
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