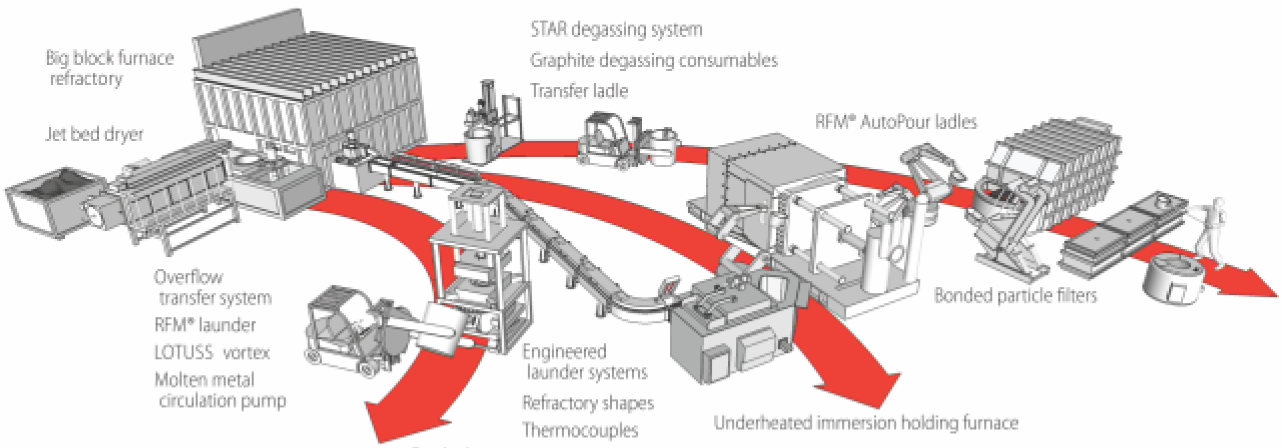
ALUMINIUM GDC TECH
GREAT DIE CASTING

JOURNAL FOR ALUMINIUM CASTING TECHNOLOGY

Volume 42 - October 2020

Bi Monthly

Demand Better Cs



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Note: Some images in some articles may not be clear. Interested readers may contact the author

From Editor's Desk

Dear Readers,

As we release the Journal Issue of October 2020, we are especially happy that we are completing 7 years of publication. It is also quite satisfying to note that all these years we have been able to publish the journal consistently every even month, with a solitary exception of April 2020 due to Lockdown. This of course is possible only due to valuable contribution from various authors from time to time, support from the industry and appreciative readers. The Editorial Board will always remain grateful to them.

From the inception of Journal, the emphasis has always been on the technical content, technical articles in the Journal which can be useful to the Aluminium Casting Industry personnel. There are of course some shortcomings which we are quite aware of. One of them is our inability to get contributors from Academia, Institutes, Faculty Members and Students. We, however hope that in the days to come, we will be able to get some active contribution from this segment as well.

Now, we are all looking at future with some increasing hope, as it appears that we are nearing the end of tunnel which we are forced into over last more than six months. Though we are still quite away from 'Old Normal', there is progressively some improvement in the industrial and social activities over last two months.

So as we move into 8th year of the Journal, we sincerely wish to see some smile back in Aluminium Die Casting Industry in near future.

Anand Joshi

FOSECO

BRAND-NEW INNOVATION FOR THE NON FERROUS SECTOR: THE EXOTHERMIC FEEDER FEEDEX NF1

Author: Arndt Fröscher, Foseco Germany

In aluminium foundries, the use of insulating sleeves in a wide variety of materials has been common practice for many years. FOSECO is now launching an exothermic sleeve material for aluminium casting applications for the first time. The new recipe FEEDEX NF1 was specially developed for the aluminium sector and adapted to the existing requirements there. It ignites quickly, the exothermic reaction takes place slowly and steadily and ensures a considerable improvement in the feeding effect. This results in only low emissions. FEEDEX NF1 feeders are available in numerous different versions and eliminate the need for manual addition of exothermic powders.

INTRODUCTION

The use of insulating feeders is common practice in aluminium foundries. In this segment, many different products are available. In most cases, the products are made of fibres or spheres. In both cases, organic or inorganic binders are being used.

THE CHALLENGE

If the insulating property is not sufficient or if the size of the sleeve is limited, very often so called exothermic powders are applied. These powders start an exothermic reaction when in touch with liquid aluminium and provide their energy to the melt in the feeder to slow down the solidification. Also this technology is common practice.

However, this process contains a number of disadvantages:

First of all, the application of the powder has to be done manually, therefore the amount is often unstable. At big castings with a number of feeders, it is difficult for the operator to apply the powder to all feeders in an acceptable time frame. The exothermic reaction of the powder creates smoke, which (although it is not harmful) should be extracted. As the surface of the feeder must be open to apply the powder, users face limitation during the moulding process.

THE SOLUTION

With the new product line FEEDEX NF1,FOSECO now provides for the first time exothermic feeders for aluminium applications. These products are made of a new developed exothermic recipe and make the application of exothermic powders obsolete. When in contact with liquid aluminium, ignition starts within 30 seconds.

This exothermic reaction goes on slowly and steadily and provides a significantly delayed solidification of the metal in the sleeve and therefore a long lasting feeding performance.

The module extension factor which is between 1.3 and 1.5 for insulating sleeves is between 1.55 and 1.65 for FEDEX NF1.

These facts lead to a number of benefits: First of all, the manual application of exothermic powder becomes obsolete. In addition it is now possible to mould the feeders completely, which leads to reduced emissions. But also at open FEEDEX NF1 sleeves, reduced emissions can be observed. Due to the better feeding performance, sleeve dimensions can be reduced which leads to reduced re-melting costs. Figure 1 shows a typical cooling curve of a FEEDEX NF1 sleeve. The exothermic reaction is clearly visible. The released energy leads to a strongly delayed solidification. FEEDEX NF1 sleeves are available in all common dimensions. In all cases, the combination with a breaker core is possible. The use of breaker cores provides an easy knock-off of the sleeves from the casting and therefore reduces the costs.

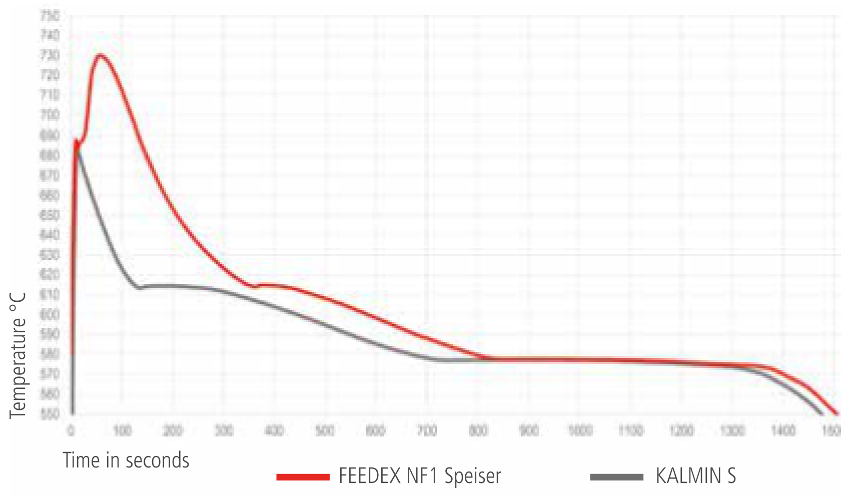
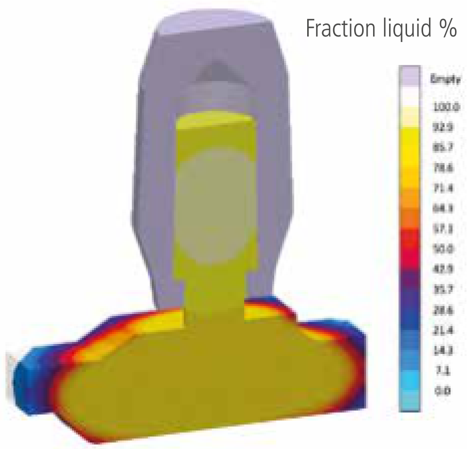


Figure 1: Comparison between cooling curve of an exothermic feeder sleeve FEEDEX NF1 and insulating feeder sleeve KALMIN* S



MAGMA simulation - Fraction liquid in %

Figure 2 shows the risers in the core box. Due to the high strength of the FEEDEX NF1 recipe it is possible to use the feeders on automated moulding lines without any problems. On the opposite, feeders with lower strength can break or deform during the moulding process.
Figure 3 shows the FEEDEX NF1 risers during casting. The exothermic reaction is clearly visible in contrast to the insulating risers. The reaction starts only a few seconds after filling with the melt and continues slowly and evenly. This makes the addition of exothermic powders such as FEEDOL* obsolete.

Figure 3: Clearly visible exothermic reaction of the FEEDEX NF1 riser

Figure 4. Constant burn-off of the FEEDEX NF1 feeder

CONCLUSION

FEEDEX NF1 is a new recipe for the non- errous sector. The fast, steady and lasting reaction makes it an excellent alternative to conventional insulating feeders. The high strength of the risers makes them suitable for use on automated moulding lines. The improved feeding effect can lead to a reduction of the feeder size and thus to a saving of recycled material. The manual addition of blowhole powders is no longer necessary, which increases process stability.

Figure. 2: Exothermic and insulating risers positioned in the moulding box

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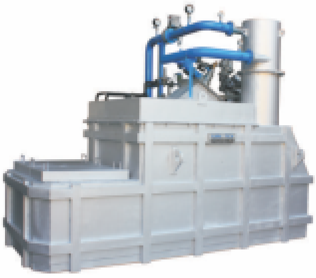
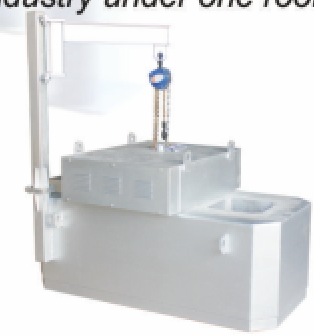


Melting Cum Holding

Electrical Holding (Crucible)



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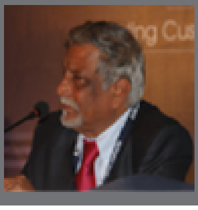

TOOL ENGINEERING - Aluminium Die Casting
Creative, Innovative, Attractive Engineering

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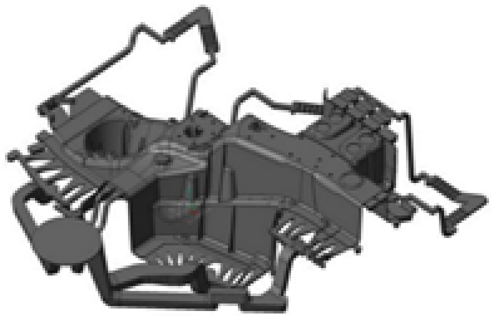
High Pressure (Cold chamber)



Success of good casting is based on:

- Perfectly designed product
- Well-engineered die design
- Best steel used for the Die
- Perfectly heat-treated Die elements
- Robust built Die
- Well prepared Aluminum alloy
- Well-built Die casting machine
- Perfect process engineering practices

Product design validation (DFM):

1) Part profile wall thickness & mass distribution
2) Undercuts & average wall thickness
3) Profile intricacy and internal quality requirements
4) Possibility for fixing the ejection pin for balanced ejection
5) Gate location required to fill and parts final requirement
6) Projected area for locking tonnage selection
7) Mass to select the Plunger diameter to achieve Fill ratio
8) Die placement on the Machine platen
9) Injection centre to Platen relation

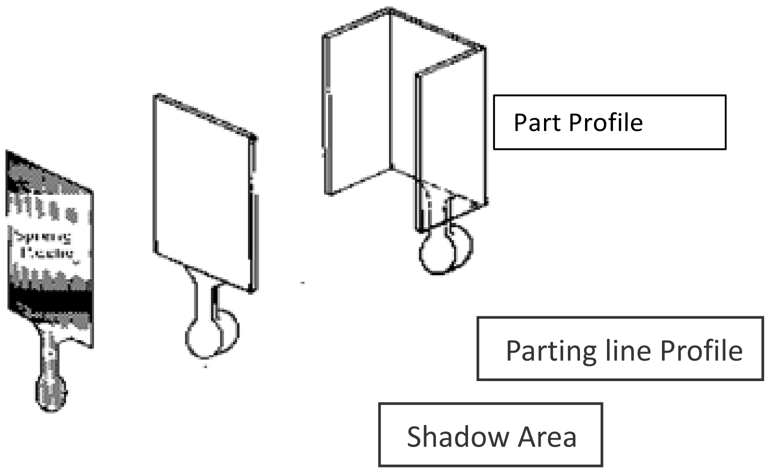
Well-engineered die Design
1. Die design
2. Die material
3. Heat treatment
4. Coatings
5. Operation/maintenance

Draft Angle

Important factor for the stress-free casting removal from the die

- If the profile is longer and slender, it is better to consider enough draft angle up to 3°
- But in some cases, can consider draft angles from 0.5° to 1°
- where the height or length is approximately equal or below 2 times the diameter / height to travel out of the die.
- Thin wall sectioned ribs should be of above 1.5 deg

Locking Tonnage Calculation
Tonnage required= Shadow Area* Specific Pressure*N



Specific Pressure is considered as per the product QA requirements
600 Bar for conventional parts
800 Bar for airtight parts
>1000 Bar for high precision parts with high task load or pressure

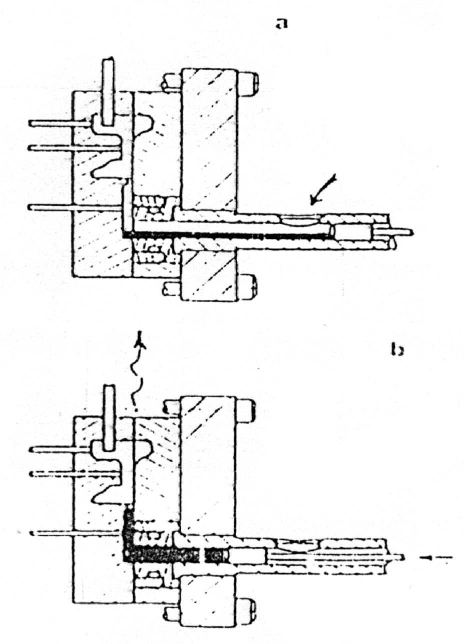
Factor of Safety
N = 1.5 for castings of premium grade with high strength and surface treatments

N = 1.25 for castings requiring high mechanical strength during field function

N = 1.10 for castings for low engineering and high aesthetic performance

Where “N” Denotes the factor of machine safety according to the casting QA needs

Fill ratio of the cold chamber is an important factor for the result of the casting.



Buhler Suggestion

Fill ratio suggestion:

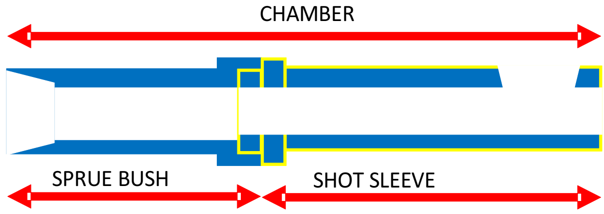
Scientific	70:30:00
Practical	60:40:00
thicker sections	50:50:00

There are likely chances of flash/ non filling/ air trapped high to name some are caused by the improper selection of the fill ratio.

Cold chamber is the cumulative length of the Shot sleeve and the sprue bush.

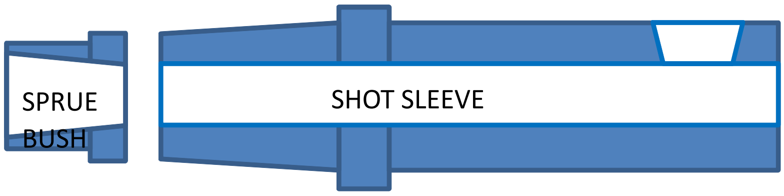
Fill ratio is the cumulative mass of :

cast part+ metal before part +metal after part



Split design pf the cold chamber can have shift in the axis and can shear the plunger. This will not be noticed by the operator but this can be the culprit for casting filling defects.

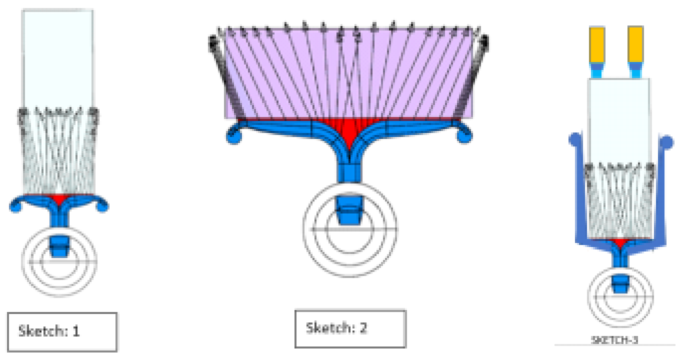
It is suggested to have the design as given in the picture.



This design ensures the free travel as well the alignment of the plunger inside the cold chamber. It is suggested to have the Fitment as **H7 g6** to accommodate the heat expansion of the sleeve as well the plunger.

Runner and Gate guidelines
HPDC-It is better to select the flow in gates such that hot alloy flows shorter distance to reach the complete profile

HPDC :



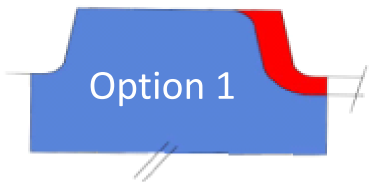
Sketch : 1 & 3
Here the runner design is selected to travel for the longer distance may be for the reason to save the die size as well the HPDC platen suitability in appropriate machine.

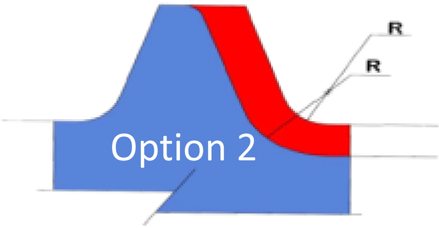
Here the flow distance is longer and alloy may reduce in the temperature as well the velocity. This has to be considered and the runner volume to be enhanced to suite the requirement. To shift the final filling point far away from the casting profile it is suggested to have the chill vent as in the sketch 3

Sketch:2
This is the best lay out to take the liquid alloy with the appropriate velocity as well the temperature. But the die construction n may call for a bigger platen size which may be of a higher tonnage machine. This will have the process cost enhanced hence it is suggested to think of the option as in the sketch 3

Spreader defines the trouble-free flow of the liquid alloy inside the main feeder runners.

It is suggested to have the best flow angle to have the volumetric flow happening from the spreader. Sketch here explains the details

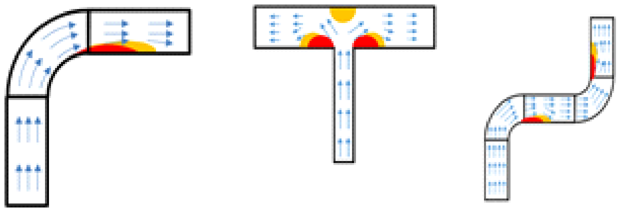


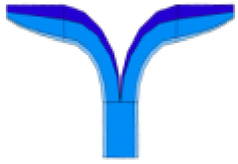


Option 1:
Flow from the sleeve is suddenly restricted. This will cause high velocity by the squeezing of the liquid alloy being forced inside the main feeder runner in the spreader. This will influence to flow defects as well the die erosion.

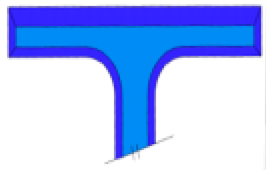
Option 2:
This will have best of flow with the support of the good gradient to reach the sub runners with the appropriate /adequate velocity to fill the part profile

Runner features and guidelines:
`Y' is better than `T' to avoid the vortex shedding

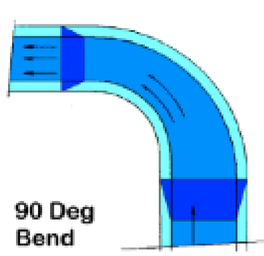




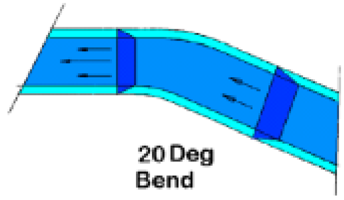
'Y' Junction
Reduces area and increases pressure progressively



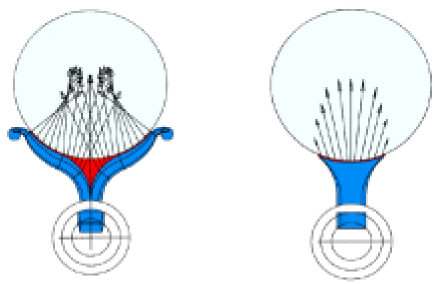
'T' Junction
Increases volume at the junction creating low pressure area at the centre of the gate



30% reduction in runner area - down stream of metal flow – for 90⁰ bend.



10% reduction in runner area- down stream of metal flow – for a 20⁰ bend.



Guide Line to arrive the best shot weight??

Casting Weight is the base (Let us say **A** Kg)

Biscuit weight---8% TO 15% OF **A** (This need not be higher than this)

Runner weight----Minimum 25% **A** (this can be higher as required to match the fill ratio)

Overflow weight---- 8% TO 15% A (This need not be higher than this)

Segmental flow design:

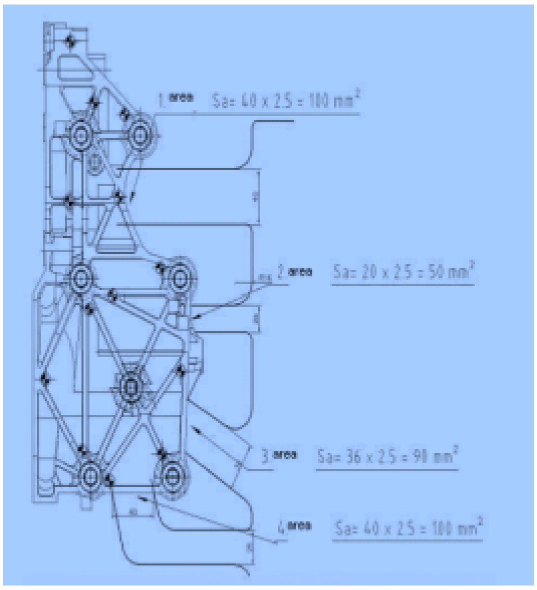
Prepare the lay out for the best flow of the liquid metal into the part profile of the die.

Ensure the number of gates are located to balance the filling.

Maintain the same gate thickness only to have the gate velocity as same in all the gates.

Gate width & the runner width can be to the available space to flow the maximum possible volume of the liquid alloy to fill the part volumetrically.

Then prepare the matrix and study the weight of the segments to be filled by the respective runners. This will guide to decide the runner dimension to match the volumetric filling



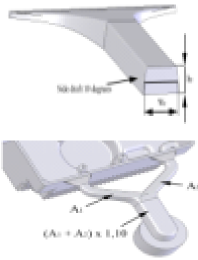
Gate location are to be fixed for shortest travel of the hot alloy in to the profile.

Gate thickness should be the same in all the gates Width can be to the need of the segmental filling

Each gate should fill the weight of the segment covered with in the Fill time specified.

Calculated gate area is for the lowest and can be higher than this and never should be lower than this.

Maintain this in the runner design for the best of flow results:



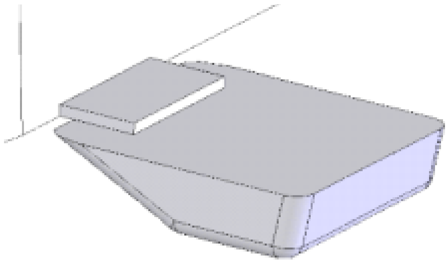
Main Runner height : h_r and with w_r

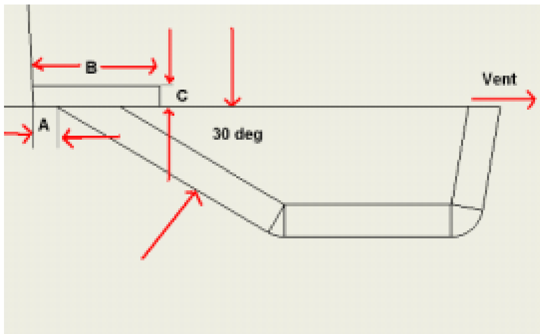
In this example ratio height to average width of 1:2 is used h_r1, w_r=2

Enlarge the runner cross section by 5 – 30 % after each crossing.

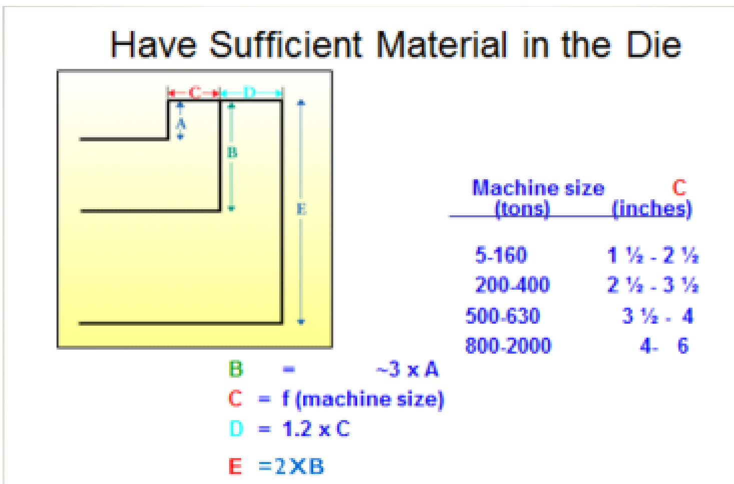
Tapering the runner profile as suggested is to create the flow velocity of the liquid metal as it comes out from the biscuit and the main runner. This is essential because the Plunger velocity with the machine hydraulic do not support this and the flow of alloy back pressure Can only support this.

Overflows shapes for the best performance:





- The shape and dimensions of an overflow.
- A = Land length (2 – 5 mm);
- B = Overall length of the overflow gate (5 - 8 mm)
- C = Overflow gate height (Al 0,6 – 1,2 mm, Zn 0,3 – 0,8 mm, Ms. 0,8 – 1,5 mm). Vent height is as follows: Al 0,10 – 0,15 mm, Zn 0,06 – 0,10 mm, Ms. 0,1 – 0,15 mm.



Recommendation of a steel mill

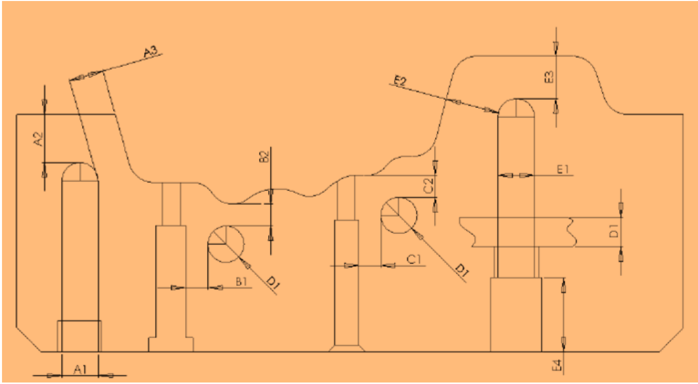
(Suggested to consider at least 70% to 80%)

`A' Cavity depth

`B 'Insert Thickness

Waterlines for the thermal management of the die:

This sketch is of guidelines need to be applied when adding waterlines to the cavity.



PL = Parting Line
WL=Water line

	Percolator (Bubbler)			Core Pins		Ejector Pins		Baffle				Waterline
	A1	A2 – Distance to PL	A3 – Distance to Cavity Surface	B1	B2	C1	C2	E1	E2 – Distance to Cavity Surface	E3 – Distance to Shutoff Surface	E4	D1
Water	¼ NPT	1.00"	0.75"	0.75"	0.75"	0.75"	0.75"	3/8 NPT	0.75"	1.00"	Must reach Intersection W.L	¼ NPT
Oil	1/4 NPT	0.75"	0.5"	0.5"	0.5"	0.5"	0.5"	3/8 NPT	0.5"	0.75"	Must reach Intersection W.L	3/8 NPT

Table 2.2.4 – (PL = Parting Line)

A case study of a runner and the plunger decision for a best forming die to achieve techno commercially viable

Shot weight with Ø 70 mm Plunger: 880 grams

- Fill ratio is 27% of the cold chamber
- Runner weight should be 126 grams

Shot weight with Ø 60 mm Plunger: 559 grams

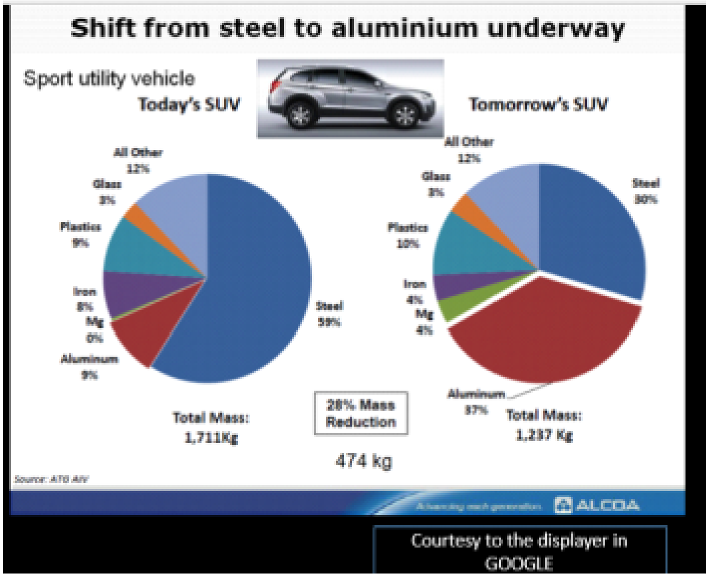
- Fill ratio is 24%
- Runner weight should be 63 grams
- Aluminium alloy saving will be 321 grams per shot
- Saving is higher in the Ø 60 mm Plunger design
- Fill ratio is also Ok for the best filling

Conclusive suggestion is to go for Ø 60 mm Plunger

For best of the filling and economical shot weight. This will be of highest cost benefit decision

What will be the future and for which we have get Knowledge to cater to:

- Weight being the critical subject to be discussed whether Magnesium will have more scope against Aluminium
- Aluminium Structural parts which will have higher section thicknesses will be Cast in Liquid Forging principles against the Squeeze casting, DC & LPDC
- Slurry casting will catch up higher to replace thixo casting as this can be carried out in the same machines with some attachment of peripherals



Tool Design is important

WHY???

Any development is successful only by implementing it in the field of public utilisation.

How tool making services in this scenario?

Commercial tool making in India has not flourished well but for few players. Actual needs are met by Imports to major volume facing lots of difficulties but compromising on the best timelines adhered by the suppliers.

Available commercial tool rooms are not financially & technically competent to that of the import suppliers.

How Can this be Bridged?

QCD is the only way out. I would say DCQ is the correct word to mention. Cost is the criterion which is enhanced mainly by timeline which will determine the cost as by product.

Simple example!!

If a Foreign Supplier Pays 4$ per hour for the technician, it is said in India we pay lower than 1$per hour. In this case how they can be cheaper is that if they take 4 hours for a job, we take say 20 hours then he is cheaper than us by 5 times.

Prototypes cannot do that in mass numbers. Hence tooling is the solution for getting the result of successive repeated production of the parts manufactured in sheet metal, Plastic & Aluminium.

It is time for us to gear up to the need of the hour.

Reduction of Oxide Inclusions in Aluminum Cylinder Heads through Autonomous Designs of Experiments

Lubos Pavlak and Jörg C. Sturm, MAGMA GmbH, Aachen, Germany

Abstract

Oxide inclusions, which are created during the pouring process of aluminum alloys, are the main cause of leaks in castings. This contribution shows how the integration of autonomous design of experiments (DOEs) into the casting process simulation tool MAGMASOFT® provides the basis for the evaluation and subsequent optimization of process parameters in the melt transport and pouring process, which are responsible for the creation and distribution of oxide inclusions. At the same time, quality criteria describing the creation of oxides during the casting process of cylinder heads was evaluated quantitatively. The utilization of autonomous DOEs creates variations of the gating system and process parameters autonomously. It will be shown that autonomous DOEs are leading to optimized gating designs and process parameters resulting in a significant reduction of oxides in castings. The experiments supported by simulation were accompanied and validated by high-speed video technology and the PREFIL-measurement technology.

Keywords: aluminum casting, cylinder head, oxide inclusions, Design of Experiments, virtual experimentation, autonomous optimization, gating system

Introduction

Oxide inclusions, which are created during the pouring process of aluminum alloys, are deemed the main cause of leaks in thin-walled aluminum castings like cylinder aluminum melts, is not dissolved or re-melted due to its high melting temperature and remains in its solid state inside the casting. Any pouring process leads to turbulence at the melt surface. This leads to a break-up of the oxide skin, which then is entrained into the melt. Oxide skins lead to a material separation within the microstructure, which, depending on their size, can cause a reduction in local mechanical properties, or, especially in thin casting walls, they can cause leaks.

The damaging effects of oxides on the quality of castings can in the real world only be evaluated through experiments, i. e. leak tests on castings, after castings have been produced. The location of oxides, their distribution and the leaks they cause, are difficult to predict and are almost impossible to quantify. Literature[1,2] describes potential causes and mechanisms that create oxides during the melting and pouring processes of aluminum alloys. However, the qualitative and quantitative evaluation of each root cause for the creation of oxides in each step of the production process of cylinder heads has so far not been comprehensively evaluated.

An efficient evaluation of the many different impact factors of the mold filling process on the quality of a cylinder head is only feasible through the utilization of casting process simulation. The simulation of flow phenomena and the mold filling process is an accepted standard procedure in the industry. Different simulation methods have been proposed in the last few years to describe the creation and transport of oxides during the mold filling process[3-7], however, many of these models are only available as 2-dimensional models. Due to their complexity and the computing demands, they are not applicable to the specific conditions of aluminum alloys and are almost useless in foundries due to their extremely long calculation times.

The current version of the simulation software MAGMASOFT® offers an easy to use, meaningful, and quantifying option to evaluate the potential of oxide creation during the mold filling process of complex castings. The complete integration of autonomous DOEs by enabling autonomous optimization technology leads to the development of optimized gating systems and process parameters in a very short time frame, which can even be utilized early in the design process of a casting.

Experimental Melt Quality Evaluation

The melt quality was experimentally evaluated for different process steps. The PREFIL system used for this evaluation is based on the filtration of a liquid aluminum sample, which is passed through a ceramic filter under controlled conditions. The qualitative evaluation is performed on samples, which are extracted near the filter. The number, thickness, and length of oxide particles were evaluated using metallographic methods (Figure 1).

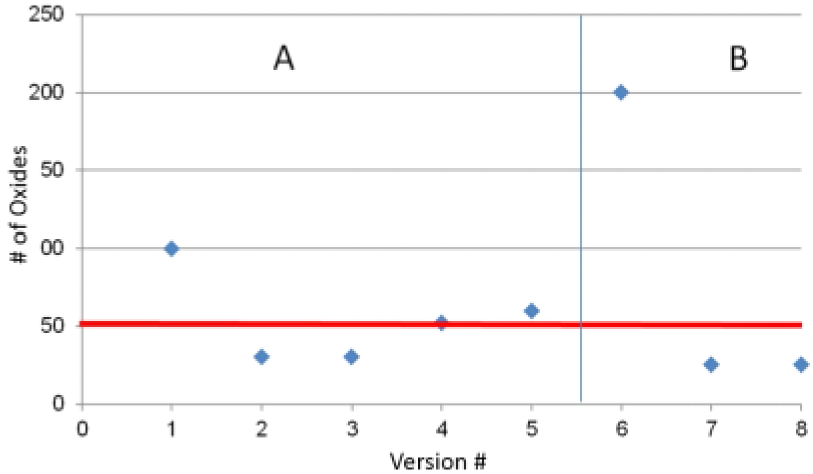


Figure 1. Measured number of oxides in the melt (PREFIL-method) for different process steps in two cylinder head production lines A and B: The red line marks the limit of 50 oxide skins per kg of melt.

Samples #1 through #5 have been taken from a cylinder head production line (A) with its melt being composed of 84% virgin alloy and 16% re-melt. Samples #6 through #8 are from a second production line (B) composed of 45% virgin material and 55% re-melt.

The number of oxide skins found in samples #1 and #6 significantly exceeds the established limit of 50 oxide skins per kg of melt and is, therefore, not acceptable. Melt transfer processes between the furnaces cause these extremely high values, especially when the transport ladle is emptied. The amount of oxide skins inside the furnace (sample #5) is still a little above the critical limit at the end of the pouring process. The oxide skin content of the melt can be reduced after the transfer processes though the establishment of sufficient holding times before or after the degassing treatment. A significant reduction in oxide skins is shown with the implementation of such (samples #2, #3, and #7). The results confirm that it is desirable to utilize a turbulence reducing transfer method, especially when emptying a ladle.

Experimental Evaluation of Flow Phenomena

High-speed video technology, providing up to 1,000 images per second, was used for the qualitative evaluation of flow phenomena during the different process steps (Figure 2).

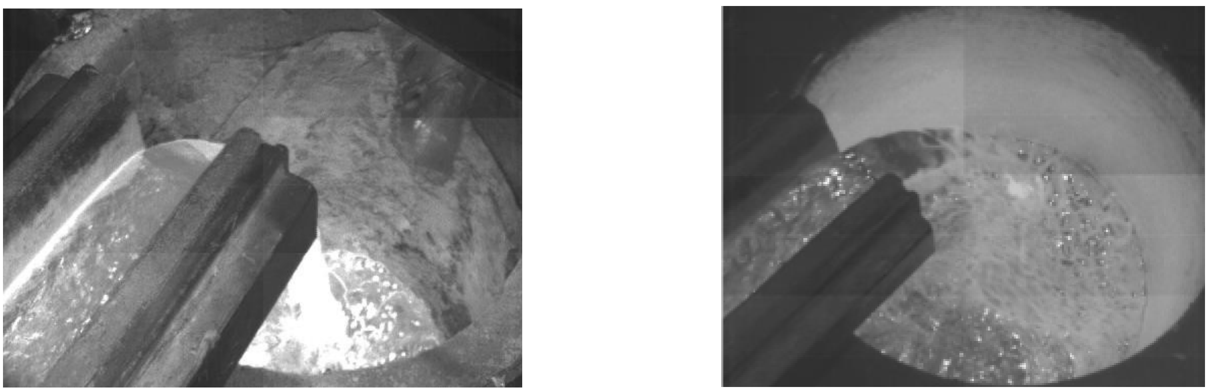


Figure 2. Evaluation of transfer processes with high-speed videos:
Filling of transfer ladle (left), filling of holding furnace (center), filling of pouring ladle (right)

Transporting the melt from the melting furnace to the holding furnace happens via an extended pouring spout when both are in close proximity, or a transfer ladle when a bigger distance needs to be covered. After the melt treatments, the melt will be transferred into the mold via a pouring ladle. With each transfer, turbulences are created on the melt surface. This is a main cause for the creation of new oxides within the melt.

The videos show the mixing of the oxide foam swimming on the melt surface with the falling melt stream clearly visible. The observations from the transfer processes match the results of the PREFIL-measurements. All samples derived from the spout or the transfer ladle after filling of the holding furnace show values in excess of the critical limit (see also Figure 1). After the melt treatment inside the pouring furnace (degassing and holding), the number of oxide skins found in the melt is reduced.

The filling of a cylinder head creates a complex flow process. Turbulences caused by the free falling melt in the gating system and when exiting from the gating system into the mold cavity cannot be completely eliminated, but can be reduced. The melt then flows through the different cores. Controlling the flow and reducing turbulence in the complex cavities of a cylinder head with wall-thicknesses of 4 mm requires a lot of experience and a fundamental understanding of flow phenomena.

During the design of runners and the location of gates between the runner and the casting, it is essential to consider melt velocities and to establish laminar flow conditions to avoid undesired flow phenomena when filling the cores. A non-optimal flow direction during the mold filling might lead to a local premature solidification on a core's surface. This leads to an oxide skin, which will be entrapped during the subsequent filling process and will remain in the casting (Figure 3). The intricate inside contour of the mold and the thin walls of the cylinder head increase the risk of oxide inclusion defects and resulting leaks, as trial runs with gravity cast cylinder heads confirmed (Figure 4).

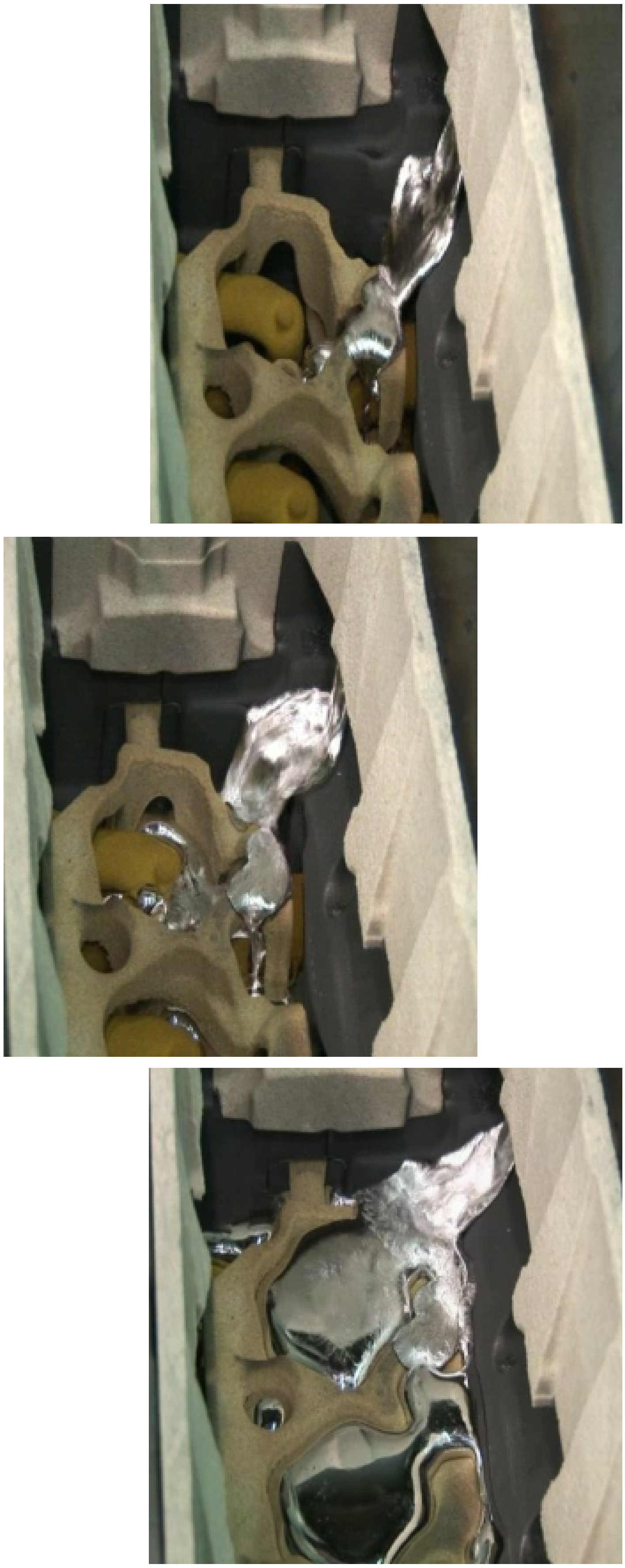


Figure 3. Change in flow direction during the mold filling process of a cylinder head: The cover core was modified to allow high-speed videos of the melt flowing from the runner through the gates to be taken.

a) Cut throughs leaking cylinder head b) Fracture analysis through leaker c) Microstructure analysis

Figure 4. Root-cause analysis on a leaking cylinder head: Leak tests under water indicate two leakers through rising bubbles (a). The fracture analysis shows an oxide skin spanning the entire thin wall (b). The microstructure analysis confirms the cause for the leaker (c).

Quantitative Analysis of Oxide Creation and Optimization Opportunities through the Utilization of Casting Process Simulation

Casting process simulation provides the quantitative impact evaluation of process parameters on the creation of air entrapment and oxides for the entire casting process – from melting all the way through to pouring the casting.

Several quality criteria are used to evaluate the total amount of entrapped air and resulting creation of oxides:

1. The amount of entrained air during the mold filling process

2. The accumulated free melt surface over the entire filling process

3. The amount of time the melt is exposed to air throughout the filling process (criteria 2 and 3 are indicators for the tendency to create oxides)

4. A criteria function depicting the locations where air is entrained during the mold filling process

5. Virtual particles in the melt (tracers), which are also reviewed to evaluate the flow during the mold filling process. These particles can also experience buoyancy and float or sink depending on their assigned mass.

Figure 5 shows examples of such quality criteria: the simulated entrainment of oxides through tracers, the calculated amount of entrapped air during the filling of the pouring ladle, and the velocity distribution inside the melt during the filling of the cylinder head. It is essential for all calculated quality criteria that they provide quantitative results. With that, the impact of changes in the gating system or process parameters (design parameters) can be evaluated and autonomously optimized through objectives defined in the casting process optimization program.

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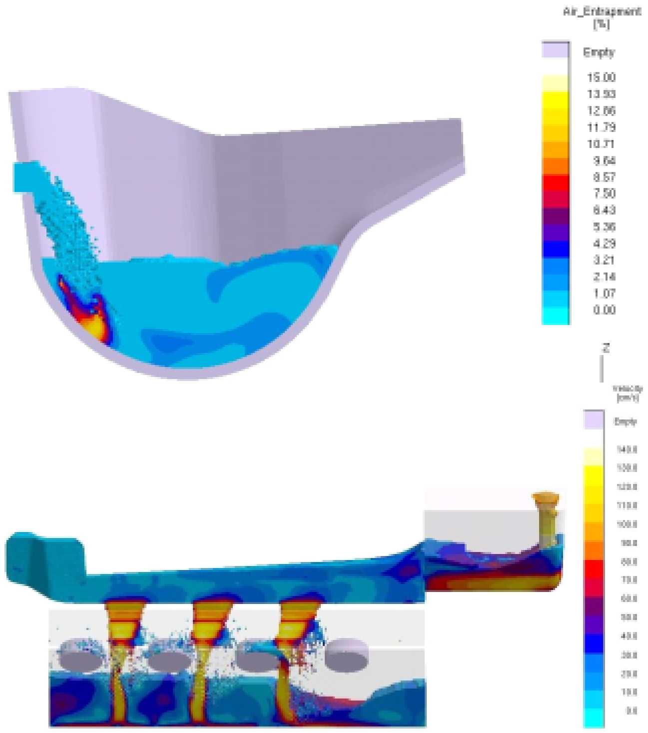
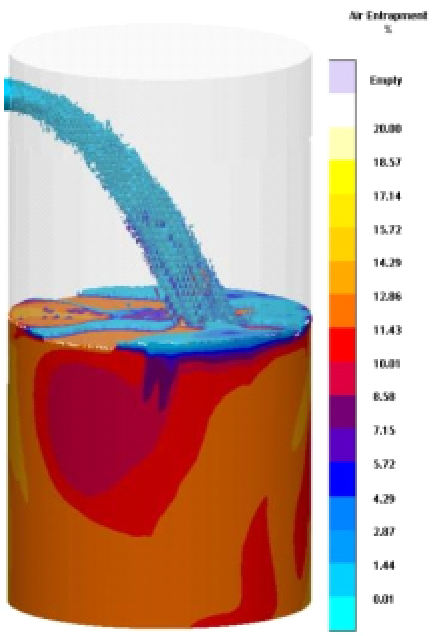
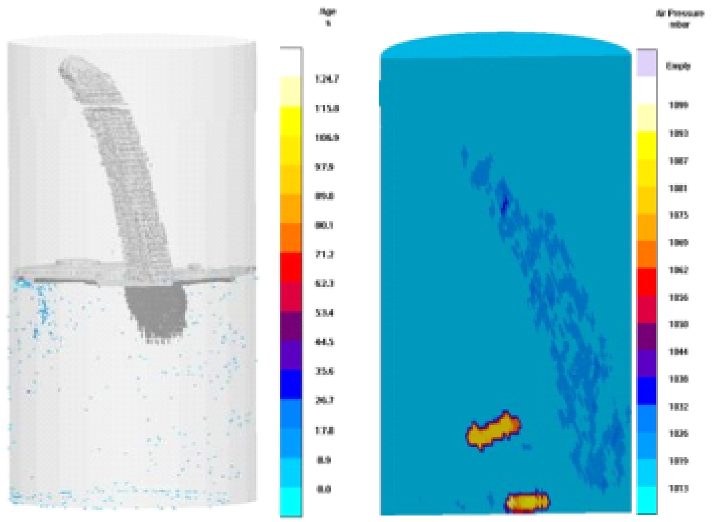


Figure 5. Examples of quality criteria of a casting process simulation tool, used for the evaluation of oxide creation tendency, oxide entrainment (left), entrapped air (upper right) and flow velocities (lower right).

The first casting process simulation evaluated the transfer process from a melting furnace to a holding furnace. The dimensions of the holding furnace are 60 cm (1,969 ft.) for the diameter and 150 cm (4,921 ft.) for its height. The total fill time is 60 s.





b) Free melt surface and oxide particles

c) Location of air entrainment

Figure 6. Transfer of melt from melting to holding furnace. Criteria were calculated after 30 s filling time. Simulated air inclusion distribution during filling (a), display of free melt surface including the entrainment of oxide particles (b), amount of entrapped air shown in center cut through holding furnace (c).

The simulation results show how air is entrained in the melt, when the aluminum stream dives into the melt inside the holding furnace (Figure 6a). This process, as well as the movement of the entrained air inside the melt that is affected by its buoyancy and convectional forces, are causes for the entrainment of oxides into the melt (Figure 6 (c)).

The amount of oxide inclusions inside the melt at the end of the holding furnace filling derived from the simulation results, confirms that a large pouring height leads to the entrainment of oxides, which are created on the melt surface through the metal stream. Therefore, it is essential to establish transfer processes that minimize the entrainment of air and the creation of oxides. It is also advisable to place the casting's pouring location as close as possible to the holding furnace, so the use of transfer ladles can be eliminated.

.............To be continued in next issue

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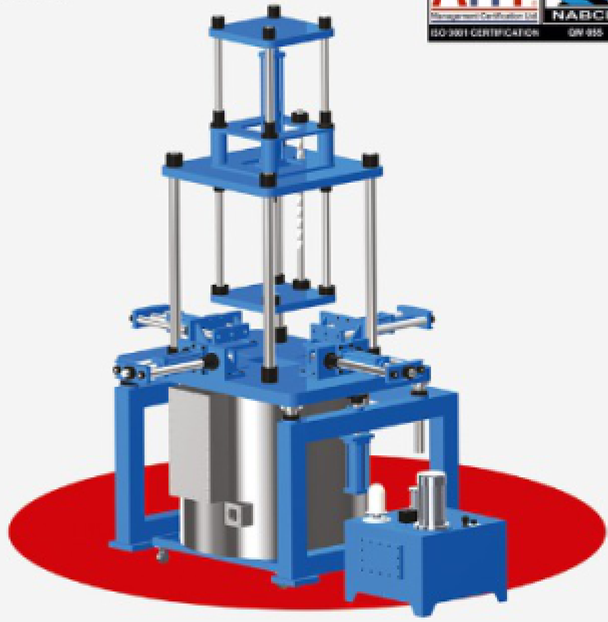

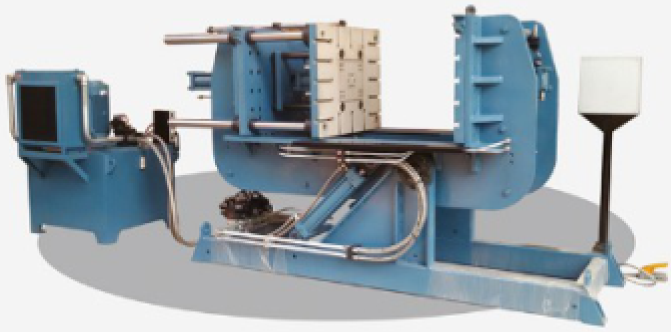

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Die Coating Basics, Composition, Selection and Application

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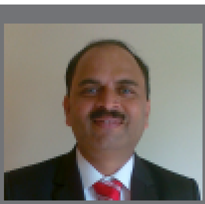


Background:

Close to 40% of Aluminium castings produced globally are made by gravity die casting and low pressure die casting processes. It has always been recognized but less internalized that a major contributor to the successful manufacture of quality die casting parts is the die coating.

In addition to acting as a parting agent between the metallic die and the solidifying Casting, main functions of a die coating can be summarized as:

- Insulation control
- Release from the die
- Encouragement to metal streams to fill thin sections fully
- Control of surface finish and texture
- as· Soundness (feeding ability) of cting

Composition and Classification:

The use of die coatings has been widespread in the foundry industry for years together.

Though the basic functions remain one or combination of the functions mentioned above, the traditional products are now modified over the years to satisfy and address specific customer requirements. The products have also evolved over time to reflect the change in casting processes and productivity requirements.

Typically, a die coating for a gravity or a low pressure die would consist of three main ingredients, a filler material (e.g. talc, graphite, mica, Titanium Oxide, etc.), a binder (e.g. sodium silicate) and a carrier, mostly water.

Specialized binders have been developed for improving the bonding and hence the life span of the coatings.

The prime function of the coating will decide the type and grading of the filler used or vice versa.

Die Coating Basics, Composition, Selection and Application

Therefore, based on the preliminary functions or the basic ingredients of the coating, traditional die coatings can be classified into three distinct product types:

- Insulating coatings
- Conductive coatings
- Lubricating coatings Insulating Coatings:

This is the most commonly used range of the three groups. These coatings are essentially insulating in nature and help maintain the temperature of metal flow and therefore maintain the fluidity of metal during the filling of the mould.

The insulating characteristics of the coating come partly from the constituents of the coatings and partly from the fineness of the particles. The most commonly used ingredients being Talc, Lime stone, Mica, Quartz, etc.

Similarly, surface finish is also a combination of the ingredients, the application and the particle size.

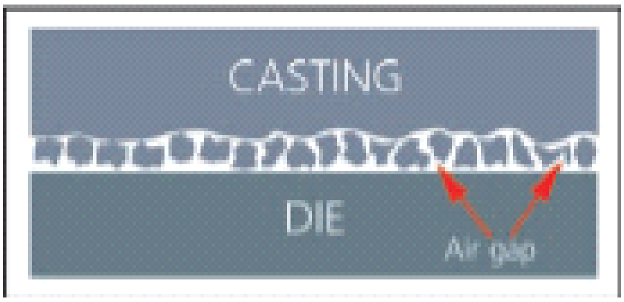
Flat-shaped filler particles lead to smooth surface (e.g. DYCOTE 39) whereas Grain-shaped filler particles lead to rough surface (e.g. DYCOTE 34)

The surface roughness or fineness is generated by the particle size of the refractory fillers and varies between 10 and 100 microns as per the requirement.

In general, the coarser the particle size of the coating or the refractory filler, the higher will be the insulation effect, since the coarser size of the particle grains will generate larger air pockets between the metal and the die surface. It would therefore help in filling of the die cavity relatively easily.

However, on the contrary, the coarseness would also impact the surface finish of the casting.

Thus, selection of a die coating, is almost always a compromise between the required surface finish of the casting and the filling of the mould / die cavities.



Fluidity and Coating Thickness:

With increasing thickness of the coating, the heat transfer from the molten metal through it to the mould gets reduced in a direct proportion, but only up to a coating thickness of 300 Microns. After around 250 to 300 Micron thickness, the insulation properties get almost flattened to thickness.

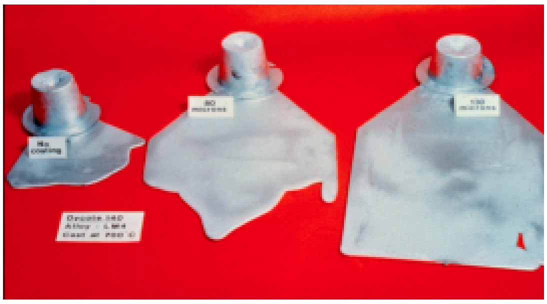
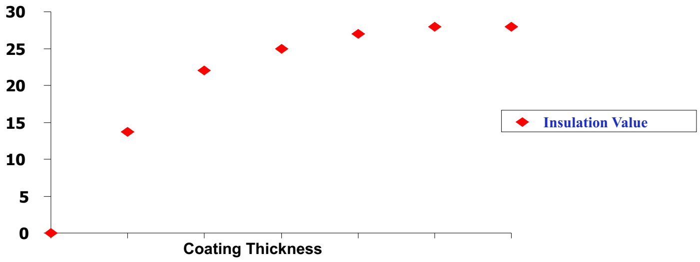


Figure: With increasing coating thickness, the insulation (below) and hence the Fluidity (Filling of casting above) is improved



Conductive coatings or lubricating coatings:
In certain applications it may be necessary to apply heat conducting coatings to increase the rate of heat transfer and encourage rapid cooling.

Use of Graphite based coatings for this purpose is very common. Almost all these coatings are graphite based and thus they can also be simultaneously used for lubrication of moving parts or metal cores.

Selection of die coatings
A number of factors must be taken into consideration when selecting a die coating:

Firstly, the section thickness of the casting; one of the main properties of a coating is its ability to facilitate the filling of the molten metal in to the die. If the casting has a thin section, then the die coating with high insulation properties and coarser particle size should be considered.

Second important criteria for casting acceptance is the surface finish. However, as discussed above, the surface finish of the coatings and insulation provided by them is almost inverse. The balance of surface finish and insulation will therefore always be a compromise.

The selection of the die coating is also decided by the geometry of the casting. A coating is therefore also critical for efficient feeding and maintaining the flow. For feeding isolated thick sections in a casting, a specific coating thickness may be required which gives a greater insulation to help directional solidification. In a casting having uneven section thicknesses, directional solidification patterns may be promoted by using different die coatings or different thicknesses of a suitable insulating coating.

Where a casting has very small draft angles and release of the casting from the die is an issue, a coating with good releasing properties may be required. A coating based on Titanium Dioxide or a combination coating in the form of a graphite coating on a regular insulating coating can be considered as a very primary practice.

Finally, the casting process will also influence coating selection.

e.g. low-pressure castings may need a different coating or a different coating practice than gravity castings operated manually that will need a robust coating in comparison.

By carefully selecting the die coating with the required features, optimum performance in terms of filling, surface finish, directional solidification or release can be achieved.

Process control:
In order to achieve the optimum performance from a particular coating, the preparation, mixing and application of the coating is very critical, too. A systematic and dedicated die coating station under the control of a skilled and trained operator enables the foundry to maintain the preparation and application of coating under close control.

Quality checks like Density or Solids content may be made for the Die coating products, but may fall beyond the scope of a busy producing foundry.

Mixers:
The ingredients of the coating in concentrated and diluted condition would tend to settle and separate over period of time. Therefore, the use of a proper mixer to ensure that the coating is not only mixed well but is also held in suspension during the working period is essential to keep the performance of the coating mix consistent. The speed of the mixer is critical not to break the solution or the die coating.

Die Coating Thickness gauges:
For generating the thermal gradient within the die, it is a common practice to build different thicknesses of coating in the casting profile so as to attain a directional solidification pattern.

Various types of Coating thickness gauges help check and control the thickness.

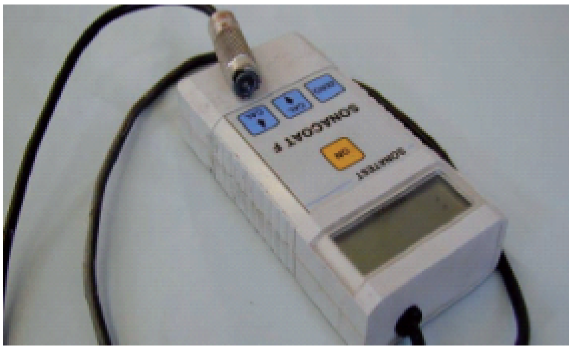


FIGURE: Different Types of Coating Thickness Gauges

New Developments
To cope with increasing productivity trends in foundries new ranges of coatings are being developed which would provide longer lives and better performance of the coatings with minimal maintenance.

Development and use of different types of binders and carefully chosen grading and specifications of filler additives is thus critical to improve life and performance.

Differential thermal gradients may be developed by using the highly insulating coatings developed for improving the feeding capacity of risers. This recent development helps to improve the yield and reduce the shrinkage rejections.

Another popular development is the Long Life Die Coatings.

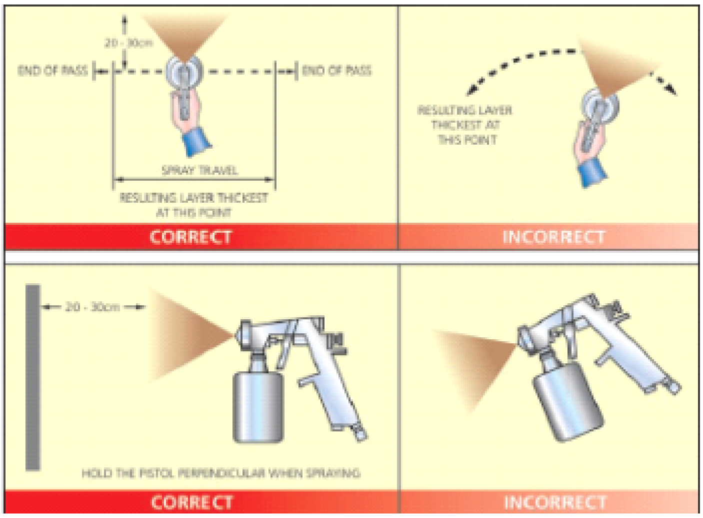
Advantages of Long Life DYCOTE die coatings

- Improved Productivity - Dies run for longer and hotter and so the frequency of stopping production to change to a newly coated die is reduced.
- A reduction in scrap on startup of a newly coated die: It is common when a newly coated die is first cast that the temperature profile may not be correct. Shrinkage or mis-running sometimes results. With a less frequently coated die fewer problems are created.
- Reduction in frequency of coating leads to a reduction in labour required in die preparation.
- As the Long Life die coating is tougher and more wear resistant the die will run longer at the optimum thickness and condition of the coating, resulting in better quality castings.
- With the special composition of Long Life die coatings there is less likelihood of settling and segregation during mixing.
- Reduction in frequency of die cleaning will result in less die wear, improved die life and consistent casting definition.
- Foundries will traditionally touch up the coating on the die to extend the coating life, without removing and recoating. The amount of touching up required will be far lower with Long Life die coating.

Typical Long Life Die Coat Application Practice:

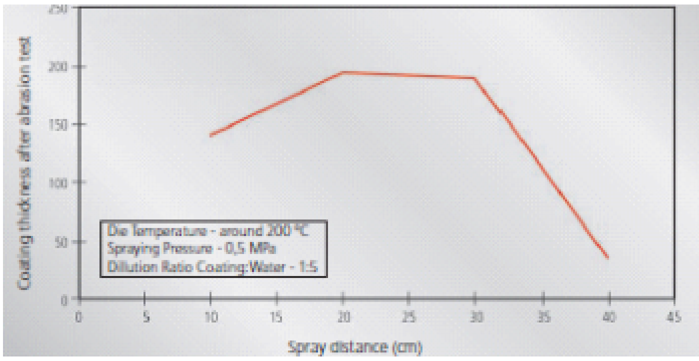
- Generally, best results are achieved with dilution rates of around 1 (Die Coating): 3 (Water)
- For touch up and repairs, dilutions of 1 (Die Coating): 4 or more (Water) should be used
- Preheat the die assembly to 200 - 250ºC
- Spray the diluted die coating on to the die at 200 - 250ºC
- Cure the Die Coating at 400-450 Deg C just over one hour
- Curing is critical for the life span of the Long Life Die coating
- Start casting

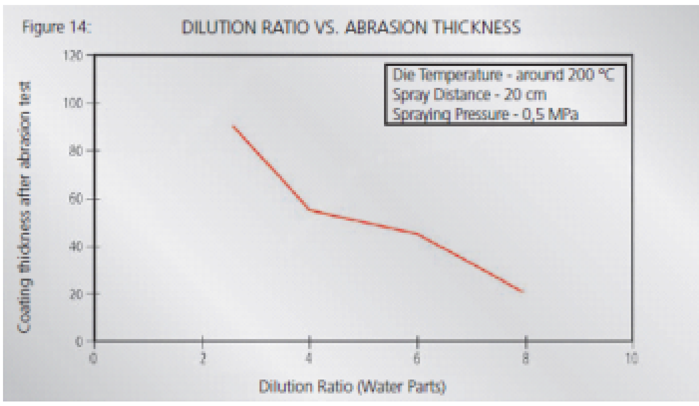
Best Practice for Die Coating Spray:



Precaution: The distance between the spray gun and the Die face is critical, since at shorter distances, the die coating spray may not stick to the die and may get bounced back, while at longer distances, the filler and binders may not reach the die face and water would get evaporated.

Spray Distance v/s Abrasion:





Conclusion:

Thus, a carefully chosen, prepared and applied die coating will not only provide a superior surface finish of casting, but would also help in improving the feeding of the casting providing directional solidification, improve productivity by reducing downtime and improve the die life due to reduced die coating maintenance.

References:

The information and discussions herein are based on various case studies, experiments, FOSECO Literature: Foundry Practice, Manuals, Handbooks and the FOSECO wisdom over years.

ANNEXURE: Typical issue faced in Die coatings and general remedies:

Flaking of Coating	Coating wears away quickly	Coating will not adhere to the Die	Coating surface is too uneven	Misruns / Cold Shuts
Layer too thick	Spray distance too great	Coating has been frozen	Coating is under-diluted	Incorrect coating selection
Coating under-diluted	Die too hot	Lack of die surface preparation	Spray distance too short	Insulating coating layer too thin
Lack of surface preparation - poor cleaning	Coating under-diluted	Die temperature too low / high	Plugged or worn spray nozzle	Coating too smooth
Die temperature too low	Coating has been frozen		Low spray pressure	
Coating layer too thick	Contaminated coating			

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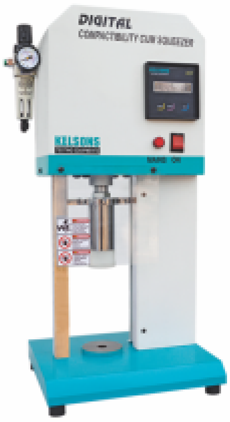

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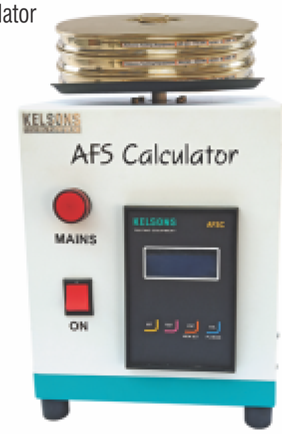

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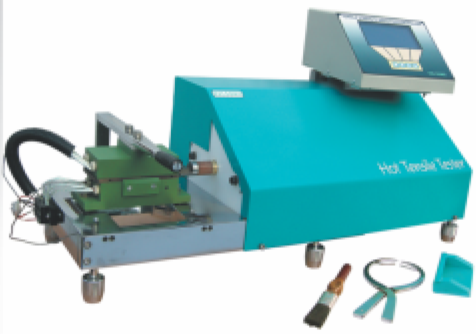

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7. Die Coating Basics, Composition and Application - 12th September 2020
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1. Non Destructive Testing for Aluminium Castings

2. Metallurgy of Cast Alloys
   - Effect of Alloying Elements & Phase Diagrams – Two sessions
   - Heat Treatment of Aluminium Alloys – One Session

3. Comprehensive Die Design PDC
   - Basics of Die Design for Aluminium HPDC
   - Selecting right material for each die parts and its recommended treatments
   - Simulation for optimisation – A Die Designers' guide
   - Exploiting 3D Modelling software for maximum benefits.
   - Design for Manufacturing and maintenance

4. HPDC Machine Maintenance

5. Problem Solving Techniques
   - 7 QC Tools
   - Methodology of use
   - Examples
   - Case Studies of use in Aluminium Foundries

6. Process Control for manufacturing of Quality Castings.
   - Raw Materials
   - Melting & Metal Treatment
   - Core shops – Core Boxes, Sand
   - Heat Treatment
   - Die Preparation and Maintenance
   - Fettling, Shot blasting, Impregnation

B. SINGLE SESSION PROGRAMMES

1. Costing
2. Cost Reduction – Operating Expenses Reduction.
3. Productivity Improvements
4. Yield Improvements
5. Low Cost Automation
6. Methoding Cylinder Head

PROFICIENCY IMPROVEMENT PROGRAMME

2 Weeks Certificate Course for
FRESH WORKING ENGINEERS
To MOVE TOWARDS NEXT LEVEL

Duration: Daily Two hours in the evening of 3rd & 4th Week of November 2020

Panel Discussion

Theme : "Uncertainty in Manpower, Demand, Capacity, Utilisation and Quality Demands by the Buyers" – 1st November 2020

For Further Details Please Contact :-

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Look forward for the Dates

ANNUAL EVENT

GDC TECH 2020

Technical Conference

Theme : Aluminium Castings - The Decade ahead

* Technical Presentations by experts
* Project Presentations
* Panel Discussions
* Technology Day

Project Competition

The project competition will help in developing good foundry people who will contribute significantly to the well-being of the companies. This award has been sponsored by 'Aurangabad Electricals Limited'.

Earlier Award Winners

Aurangabad Electricals Limited
Continental Engines
Endurance Technologies
GABRIEL ANAND
Inspiron Engineering Private Limited
Kirloskar Oil Engines Ltd.
Noble Cast
Pooja Casting
Rockman Industries LTD.
Roots Cast Pvt. Ltd.
Sundram Clayton
SPARK MINDA
SIGMA
Tata Motors Ltd.
United Metallurgical
VIVEK Engineering

Best Casting Award

GDCTECH has a motto to motivate the die casting industry to improve their systems and processes which lead to significant enhancement of performance parameters such as quality, cost, delivery and development. As a part of this motto 'Best Die Casting Award of the Year' has been instituted. This award has been sponsored by 'Aakar Foundry, Pune'.

Earlier Award Winners

Aurangabad Electricals Limited
Dr. Dinesh & Ramesh Engineers Pvt. Ltd.
GABRIEL
Growell Industries
Inspiron Engineering Private Limited
MCC Alcast Private Limited
Noble Cast
Rockman Industries LTD.
San Enterprises
Sentinel Manufacturing India Pvt. Ltd.
Walsekar Metal Pvt. Ltd.

LEARNING FROM CUSTOMERS

Deepak Bhalerao
Business Consultants & Management Services
L.N. Enterprises, Pune
E-mail : deepakbhalerao2212@gmail.com

As is said 'Learning Never Ends'. There is always a scope to learn from others when we interact with them, Listen to some one or only observe someone.

I believe, customers are also a very good Source of Learning, which can help you improve your Product, Processes, and Attitudes etc.

I am sharing two such examples which changed our Organization Chemistry to a large extent and helped us change our trajectory of Growth path.

1) I was working for an Auto Component Manufacturing Company based in Pune, pretty well known and we had achieved a name for ourselves in our domain.

   We were under the impression that we have done great job and started to become contended. Then the time came when the Leadership at the top was reshuffled.

   The new Leader wanted us to acquire new customers and probably that was the time, without which survival in next few years would have become difficult.

   This was the Era Post Liberalization of Economy. There were Joint ventures getting established with overseas Partners.

   We started working with one such Jv for developing components for them. (Their process was to first do Dip Stick assessment of the Company).

   When they visited our facility the team consisted of R & D and QA persons. During their visit we learnt the concept of Six-Sigma, Critical, Minor Dimensions, Millipore tests & its importance etc.

   Working with them very closely helped us to improve our operations & this laid Foundation for us to go ahead & become the first Indian Company in our category of product to get QS9001 accreditation. This certification & those we were supplier to this customer became our Selling proposition to acquire new customers.

2) The Second case is again on the Learning from customer about process improvement.

   As you all may be aware, most of the manufacturers are working on improving the Equipments in terms of Life, Fuel Efficiency, Noise, Vibration, Weight Reduction etc.

   We were working with one such company they wanted the products to be supplied in very close tolerances to Reduce Friction, Wear and Tear of mating parts as also the noise levels. We were not able to achieve the tolerances they had demanded.

   However, after working closely with them we understood the Technology of Selective assembly through selection of tolerance Bands and creating matching groups of Mating parts.

   This again helped us improve our Manufacturing Process and Be Ready to face Next Generation Equipments demanding Newer Technology.

   Thus when we work closely with the customers, we Learn New Technology and improve overall operation and business.

> The more you engage with customers, the clearer things become and the easier it is to determine what you should be doing
>
> ....John Russell

Foundry Products for Non-Ferrous Metals

Since 1856, Morgan Molten Metal Systems is a pioneer and a global leader in supplying technically advanced range of foundry products to Non-Ferrous Foundries.

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