ALUMINIUM GDC TECH GREAT DIE CASTING

GREAT DIE CASTING TECHNOLOGY FORUM

JOURNAL FOR ALUMINIUM CASTING TECHNOLOGY

Volume 55 - December 2022

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Dear Readers,
We always look forward to your Feedback and comments on the Journal. Please do write to us.

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

Aluminium low-pressure wheel production – end to end solutions

The application of aluminium wheels on light vehicles has become hugely popular over the past 10 years. The reasons behind this are both technical as well as aesthetic as the castings are safety critical as well as pleasing to the eye. Aluminium wheels need to offer mechanical strength and lightness, toughness and rigidity, dimensional precision and style with a perfect aesthetic finish and so today aluminium wheels have become a technologically advanced product required to offer a high level of quality, reliability and safety.

The wheel is a safety critical component which has a decisive effect on the performance of the vehicle. and is responsible for propulsion, steering, supporting the vehicle, braking as well as suspension and so must possess characteristics of mechanical strength, plastic reserve and fatigue strength capable of resisting fracture during the full life cycle. In addition to this roundness and balance must also be maintained over time.

Testing will include dimensional accuracy, alloy composition, hardness, grain size and eutectic structure, fatigue testing and die penetrant inspection after fatigue testing, X-ray inspection, pressure tightness, crash test, detailed visual inspection, radial load testing, meaning that aluminium wheels receive as much inspection as any other aluminium casting and more than most.

The process by which aluminium wheels are manufactured is almost always low-pressure diecasting and this process can be segmented into the following process steps:

- Alloy material selection
- Melting
- Holding
- Melt transfer by ladle
- Melt treatment in the ladle
- Transfer into the low-pressure furnace
- Die filling and solidification
- Removal and initial inspection
- X-Ray inspection
- Heat treatment
- Machining
- Painting
- Pressure test and visual inspection

The Foseco approach is to develop a suite of products and services which can add value to the foundry in all of these Process Steps.

Alloy material selection

In order to achieve the mechanical properties, particularly the elongation, it is essential that the iron content of the alloy is controlled and so commonly primary ingot is used along with foundry returns and the swarf and chippings from the machine line. Around 40% of the as-cast wheel is removed during

the process and so, although the swarf and chippings from machined wheels will have a very large surface area and be the potential source of oxide inclusions, it is commercially essential that this material is recycled and the value retained. A separate process to melt and clean this material is normally used and the use of a powerful cleaning flux, such as COVERAL* GR 6512, is an integral part of this process.
Once cleaned to an acceptable quality level this material can be used, under control, as part of the alloy charge, either as cast ingot or in liquid form.

Melting
Melting in wheel foundries today tends to be by tower melter or reverberatory furnace and there are three key properties that are expected from the furnace itself: High melting rate, energy efficiency and the ability to avoid oxide formation.
In the melting and holding zone there is a strong need for a refractory material that is compatible with aluminium – Silicon alloys, which has good mechanical strength and is non- wetted by aluminium alloys, resisting the growth of corundum. The lining material must also have a high resistance to mechanical damage in impact areas and have as long a service life as is practical.

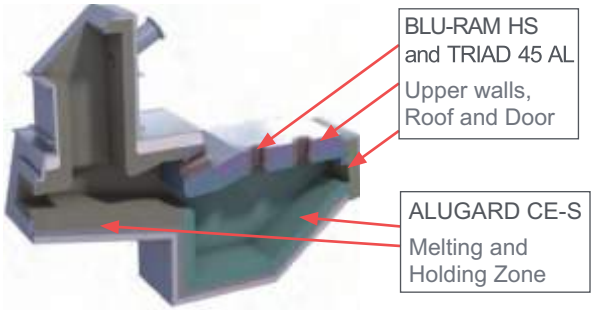


Figure 1. Tower melting furnace showing different refractories for different requirements

ALUGARD* CE-S is a high alumina, low cement castable specifically designed for use with aluminium – Silicon alloys and is well proven in aluminium tower and reverberatory melting furnaces. The **ALUGARD CE-S** lining will offer a long service life and good resistance to corundum growth and be easy to clean.
Within the range of refractory products there is also a lighter weight material for the furnace door, roof and upper walls,
TRIAD* 45 AL and **BLU-RAM* HS.**
For general maintenance and repair **DURAGUN* 66AL** can be used for application by trowelling or gunning methods.
The same range of refractory materials can also be applied if the melting takes place in a reverberatory furnace.
Product selection is vitally important as is correct installation and Foseco can advise and sometimes supervise the installation of our refractory lining products.
In melting furnaces temperature measurement can also offer advantages if it is fast and accurate. Highly conductive **ISOPRIME or 3MSILICIUMNITRID** thermocouple sheaths can both achieve these aims with the later also offering longer service life.
Correct refractory selection and fast response thermocouples can help to maintain the high quality standard of the aluminium alloy melt, the essential foundation of a sound foundry process.

Melt transfer
Once melted the alloy is then poured into a transfer ladle in which the melt treatment is made prior to the ladle being moved to the low-pressure casting machines. This treatment of grain refinement, strontium modification, cleaning and hydrogen adjustment (degassing and sometimes regassing) can take around 10 minutes and so temperature loss can be an issue.
Good insulation and easy cleaning is therefore an essential characteristic of the lining material and Foseco have two options to offer.
INSURAL* 140 is supplied as a pre-cast insert which has already been fired to over 700 deg C and when installed within the **INSURAL 10** insulating backing will offer excellent insulation and non-wetting properties. When installed using the **INSURAL 140** lining system the ladle will have a heat loss of less than 3 degrees C per minute, depending upon the capacity, and will also be very easy to keep clean and free of oxide build-up.

Figure 2. Range of INSURAL 140 lining inserts and INSURAL ATL in service

If the service life of the ladle lining is of particular importance then **INSURAL 270** offers good insulation and oxide resistance coupled with excellent erosion resistance. **INSURAL 270** will therefore offer an extended service life

Melt treatment

In order to achieve the required quality of melt it is necessary to carry out a controlled melt treatment in the transfer ladle.

To ensure the correct eutectic structure is achieved and that excellent elongation properties are assured then the alloy is modified with Strontium. This can be done by using pre-modified ingot, which has already had a Strontium addition, or by adding aluminium – Strontium master alloy prior to degassing.

In addition to the Strontium modification the alloy is also grain refined with Titanium and Boron to achieve optimum mechanical properties and to reduce the chances of shrinkage in thicker sections. In addition to an improvement in elongation and the consistency of mechanical properties, grain refinement also increases resistance to fatigue, improves machinability, reduces the tendency for hot tearing and helps to disperse micro-porosity.

This treatment is best carried out by chemical additions which form fresh Titanium diBoride particles within the melt. A tablet addition with **NUCLEANT* 70 SS** or **NUCLEANT 100 SP** will have this effect but best of all a cleaning and grain refining flux, **COVERAL MTS 1582** applied through a **MTS 1500 Metal Treatment Station**, will give excellent grain refinement, remove oxides and inclusions while ensuring that a very dry dross is generated thereby reducing metal loss.

Melt cleaning and hydrogen control can best be done simultaneously and the traditional method is to add a granular flux **COVERAL GR 6512** to the surface of the ladle and then to carry out rotary degassing with a pumping graphite **FDU XSR rotor** or a **GBF rotor.**

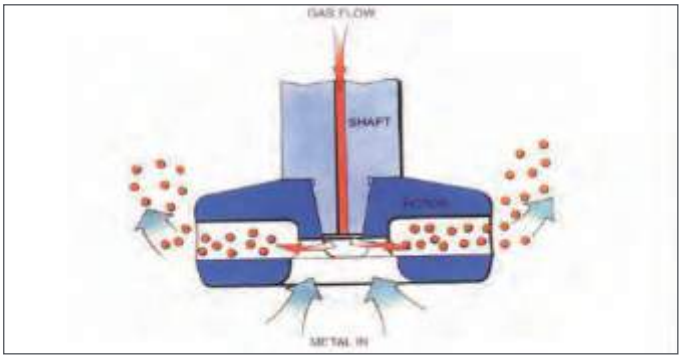


Figure 3. Foseco pumping rotor technology

The stirring action of the rotor will activate the **COVERAL GR 6512** and create an exothermic reaction while the finely dispersed inert gas bubbles will help oxides to float to the surface to be collected in the dross. After several minutes of treatment the melt is cleaner and lower in hydrogen content.

A more modern version of this melt treatment is with **MTS 1500** technology using a more powerful **MTS FDR rotor.** In the early stages of the rotary degassing treatment the baffle plate rises from the melt and a vortex is formed. A specially developed cleaning flux, **COVERAL MTS 1565**, is then added into the vortex. The flux is taken down to the lower parts of the ladle where it can react with the bulk of the melt and after less than 60 seconds the baffle plate moves back into the melt and the vortex disappears.

Figure 4. COVERAL MTS 1565 being added into the vortex during MTS 1500 treatment

Normal rotary degassing then continues but because the fl ux is low in the melt a much more effective cleaning process follows.

The **MTS 1500** process will therefore remove more oxides than **FDU** alone.

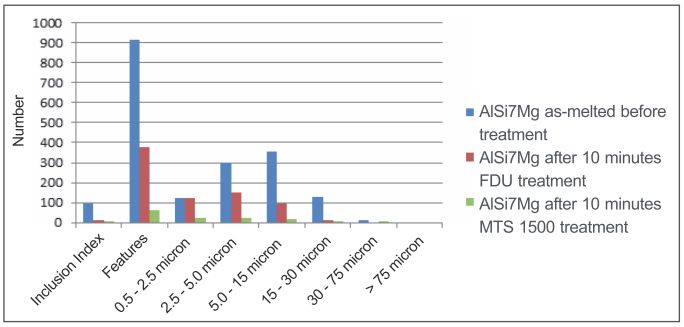


Figure 5. Graph showing relative effectiveness of cleaning from FDU and MTS 1500 treatment. Features are oxides and pores within the sample

However for the most effective and automated treatment the **COVERAL MTS 1565** fl ux can be replaced by **COVERAL MTS 1582**, which when added using the **MTS 1500** unit, will offer hydrogen control, melt cleaning and grain refinement as well as generating a dry dross low in aluminium as shown in FIGURE 6 below, all in one automated treatment.

Figure 6 - Dry dross after MTS 1500 treatment

Figure 7. Excessive dross from standard treatment

Figure 8. Reduced dross from COVERAL MTS 1565 treatment

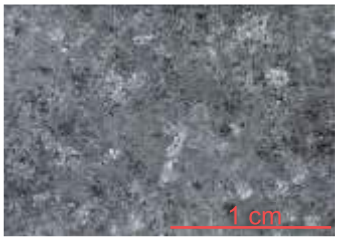


Figure 9. Before treatment

- Alloy: Al-Si7-Mg0,3% (LM25 – A356)
- Initial Ti = 0,11%
- Strontium content = 107 ppm
- Before treatment
- Grain index before = 3

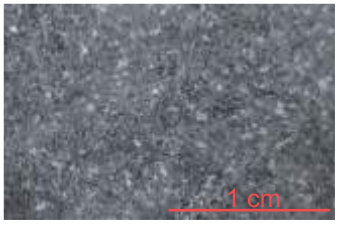


Figure 10. After COVERAL MTS 1582 treatment

- Addition rate COVERAL MTS 1582 = 0,07% of melt weight
- 30s vortex addition in MTS 1500 unit
- 7 min total MTS 1500 cycle
- excellent grain refinement
- Grain index after treatment = 9
- Strontium modification retained

To monitor the effectiveness of the modification and grain refinement treatments a cooling curve can be plotted using **THERMATEST*** equipment. As well as producing a cooling curve, where the undercooling of the liquidus and solidus can be observed, the software also calculates a Eutectic Structure Index; where 5 is the maximum reading and a Grain Index, with 9 being the maximum reading. Thermal analysis is a very effective way of checking that each melt has been correctly treated.

As shrinkage is such a common issue in aluminium wheels it is sometimes advisable not to reduce the hydrogen content of the melt to the lowest possible level. The overall treatment time must be maintained because of the need to clean the alloy and so shortening the degassing is not an option. It is therefore beneficial to degas to a low level and then to reintroduce a small amount of hydrogen at the end of the treatment. In order to retain the advantage of automation and consistency it is possible to programme the **FDU, GBF** or **MTS 1500** unit to make a late addition of Argon – H2 gas for just a few tens of seconds at the end of the treatment. This will adjust the hydrogen content to an acceptable level which will not create porosity but will control the level of shrinkage found in the final casting.

The use of a programmable **MTS 1500** treatment to clean, grain refine and control the hydrogen content of the melt gives the foundry excellent process control and repeatability.

Melt transfer

After treatment the melt is poured into the low-pressure furnace, ready for production. This is another critical stage of the process as turbulent filling of the low-pressure furnace can result in oxide creation and an increase in hydrogen content. A specially designed **INSURAL 140** pouring basin to suit the particular lowpressure furnace can help to control the filling process.

Low-pressure diecasting furnace

As these furnaces can be in service for up to 7 years it is vital to select a refractory which will avoid oxide and corundum growth.

ALUGARD A 95 has been used for several years in these types of furnace and will avoid many of the problems which can be experienced where furnaces run in production for long periods of time. When **ALUGARD A 95** is installed in front of a highly insulating backing system then external steel shell temperatures can be as low as 65 deg C, reflecting a very energy efficient system.

An alternative to casting the lining in the furnace body it is possible to install a pre-cast and pre-fired shape in **INSURAL 270**. This option offers a very fast

reline and guarantees that all combined moisture has been removed before installation begins.

A furnace relined with the **INSURAL 270** system can therefore be put immediately into service after relining, without the need for additional drying and firing.

For the furnace roof an insulating lining is appropriate and **LITEWATE* 80 AL** is an ideal material for this application.

The low-pressure furnace is heated by electric radiant glow-bars in the roof and their service life can be extended by covering them with a highly conductive protection tube.

ISO-PRIME Heater Protection Tubes ensure good heat transfer from electrical element to the furnace atmosphere while protecting the element from mechanical damage, metal splashing and chemical attack during general use or metal treatment and furnace cleaning.

ISO-PRIME heater protection tubes will extend the life of the heater elements. Reducing the running costs of the furnace.

For accurate temperature control a thermocouple sheath with high conductivity is required and **ISO-PRIME thermocouple sheaths** are well proven in the specific application of a pressurised furnace. Again fast response will result in more accurate temperature control and less variation on casting temperatures.

In order to have accurate control of the filling process and to retain pressure for effective feeding during solidification a pressure tight LPS tube is essential.

Two materials are offered for this application. **ZYAROCK*** and **ZYACAST**, both based on fused silica and being well proven in these applications. These LPS tubes can be supplied with a **SEDEX*** or **STELEX*** ZR foam filter installed in the bottom to prevent oxide inclusions entering the tube from the furnace floor.

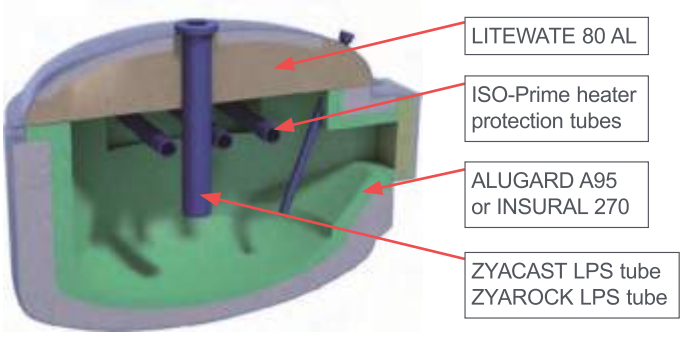


Figure 11. Low-pressure furnace showing different refractories used, LPS riser tube and heater protection tubes

Casting

Above the LPS tube there is the opportunity to apply highly insulating ceramic inserts and INSURAL 140 is an ideal material for these applications. The use of these inserts allow the foundry to increase the amount of water cooling in the die, thus extracting heat from the casting while retaining heat in the feed areas. Castings quality is therefore improved while cycle time is kept short to improve productivity.

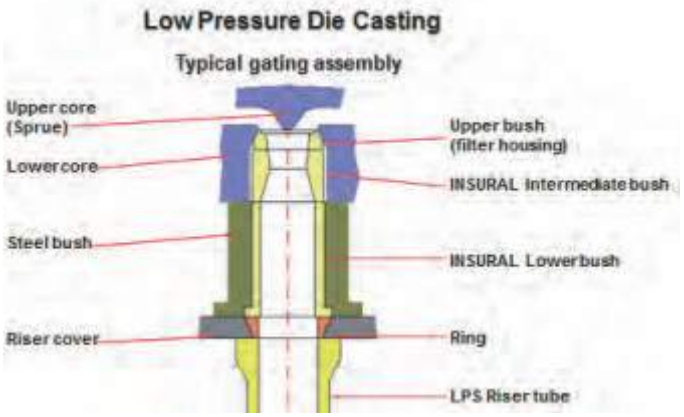


Figure 12. Ceramic assembly

Figure 13. Typical INSURAL 50 inserts

To improve metal flow and trap oxide inclusions a filter can be positioned in the upper bush. Foam filters are the most effective at flow control and **SIVEX* FC** filters are light-weight and can be remelted from the carrot.

The die itself must be coated to control the thermal balance, ensuring good filling while also controlling heat loss during the feeding cycle. The aesthetic quality of the casting is also defined by the surface finish on the main face of the wheel and so a smooth coating is used on the front face, **DYCOTE* 39**. For an extended service life **DYCOTE 3900** or **DYCOTE 3950** can be used.

For the side and top cores a more insulating coating is required and this can be **DYCOTE 34**. As service life of

the coating is important to retain the insulating properties for a longer period a primer coating **DYCOTE DR 87** can first be applied to the die with the other DYCOTES applied on top

To ensure that the DYCOTE used is correctly prepared a special mixer **DYCOTE CARRY and MIX** is offered. This mixer will also maintain the quality of the coating during standing.

Conclusions

The important attributes of the low-pressure diecasting process are:

- Productivity
- Energy usage
- Metal Yield

The important attributes of the casting itself are:

- Surface finish
- Mechanical properties
- Soundness
- Pressure tightness
- Freedom from oxides and porosity
- Machinability

The products listed above form a valuable suite for the lowpressure wheel producer and when used together will have a positive impact on the quality and performance of the castings as well as the commercial success of the foundry. Research and Development projects are now underway to add further elements to this suite and to increase the end to end value offered to the industry.

ALUMINIUM 2022, GERMANY - 27-29 September 2022

Mr. R. T. Kulkarni with Mr. Bhuwan Vashistha
Managing Director Allied Refractory Products Pvt. Ltd.

Mr. R. T. Kulkarni at Morgan Stall

GIFA 2022, THAILAND - 5-7 October 2022

Mr. R. T. Kulkarni & Mr. Jitendra Lakhotia visited stalls of
Messe Dusseldorf & Thai Foundry Association

Instrumentation in Core Making and Testing

Vishwas Kale, Managing Director, Vijayesh Instruments Pvt Ltd, Pune
vish1945@gmail.com

Instrumentation and process control play a vital role in all processes. For energy conservation, resourceful use of instrumentation is possible. It is also a means of raising money/support: make better product with lowest possible rejections and with ease of production.

Hot Distortion

The Hot Distortion Test measures the distortion behaviour of chemically bonded sands when exposed to heat. This provides information about how chemically bonded molds or cores will react when subjected to molten metal.

A typical hot distortion curve from a shell bonded core or molding sand is comprised of four basic regions:

Region 1-Upward Deflection
Region 2-Thermoplastic Relaxation (Plasticity)
Region 3-Thermosetting
Region 4-Degradation and Failure

By using hot distortion curves foundries can reduce process variation and improve casting quality. In this test, a cured sand specimen is preferentially heated on one side, and the small deflection of that specimen is measured over a period of time and recorded as a curve.

Hot Distortion Tester

The basic instrument unit uses standard AFS test prices (25 x 6.35 x 120 mm) These are prepared by blowing the sand mixture into a core box. Any other test pieces of such dimensions cut from core and moulds can also be used.

The test is based on the fact that a strip of bonded sand when heated at one face will curl away from the source of heat. This is due to differential thermal expansion between the hot and opposite cold face. This amount of bend can be measured. It is proportional to the coefficient of thermal expansion of the bonded sand.

The unit consists of a test piece clamp, gas burner, gas pressure indicator, linear displacement sensor and associated instrumentation.

Thermal Conductivity Tester

Different mechanisms of non-steady state heat transfer in sand molds can occur during casting processes. These processes include: thermal conduction through a skeleton of solid sand particles, gas conduction in closed pores, air convection in open interconnected pores and, radiation at high temperature. In addition, water vaporization could dramatically change the rate of heat transfer. It is difficult to theoretically take into account all these processes. A novel experimental/computing method is designed for dynamic measurements of the thermal properties of foundry molds. The method is based on generation of a precise energy impulse in mold media by small electrical heater and measurement of temperature response near the heat source within the molding media. A computer and data acquisition interface are used for controlling impulse cycles and obtaining high resolution temperature measurements. The device has a 5 mm diameter and easily could be imbedded in different parts of molds. The coefficient of thermal conductivity is calculated on the basis of measured temperature response and non-steady state heat transfer modelling with software. The small impulse of heat which is applied has a minimal influence on existing thermal processes and properties of sand media, while the short relaxation time after the impulse allows the possibility of frequent sampling measurements of the thermal properties under rapidly changing conditions. The method is used for the measurement of the thermal properties of a green sand mold near the surface of a mold cavity during steel pouring and thin ceramic shell properties during de-waxing.

Methods commonly used are based on a steady state measurement technique. During these steady state measurements, a sample is placed between a heat source and a heat sink, and the value of the coefficient of thermal conductivity is determined directly from the temperature gradient after equilibrium has been reached.

Another method is designed for the non-steady state

measurement of the thermal properties of materials used in metal casting processes. The method is based on a generation of a heat impulse and precise measurement of the temperature response inside the investigated media. The thermal properties were determined by computing non steady state heat transfer.

Exothermic Properties Tester

The effectiveness of a riser sleeve is determined by how long the sleeve can delay the solidification of the metal within the riser. The heat released by an exothermic sleeve can slow and even prevent heat loss from the riser through the sleeve, thus retarding the formation of a solid shell in the early stages of casting solidification, as well as extending the total solidification time of the riser. In extreme cases such as spot feeding, the riser sleeve can be designed to provide a thermal mass capable of also re-heating the metal within the riser sleeve, which results in a significant increase in riser solidification time. For this reason, knowledge about the heat generated by an exothermic sleeve is important for correctly modeling the solidification of the riser metal and how this metal feeds the casting.

The unit has a plate of 150 x 150 mm which is heated by a temperature control unit. The temperature is adjustable in the range of 0 to 1200 deg C. When hot but not in use, it is to be covered by a ceramic wool cover to avoid heat loss. The temperature is shown on Temperature Indicator Controller. The heater is designed to work for 24 hour duty cycle. Higher temperature up to 1300 deg is possible as a specific option.

The unit has two additional plates mounted on two sides of the unit, but these are plates at ambient temperatures. These plates are to be used for keeping the sleeves during testing.

As an option one or two thermocouples of type PtPtRh13% (max temp. 1660 deg c) are provided which are connected to the data logger. These thermocouples in a silica tube are to be inserted into the sleeve as desired. The silica tube is for generally one time use. The thermocouples can be taken out after the test.

When the temperature of 1000 degrees C is achieved, the sleeve is put on the plate along with the thermocouple. The sleeve starts burning. It is lifted and put on a side plate. The time and the temperature rise and fall are recorded on the data logger. The data logger as a specific option can also monitor the temperature of the hot plate.. The data logger will show temperatures continuously. The record may be downloaded on PC and a graph may be printed. The time interval for logging temperature may be adjusted as desired. At any one time only one sleeve may be tested.

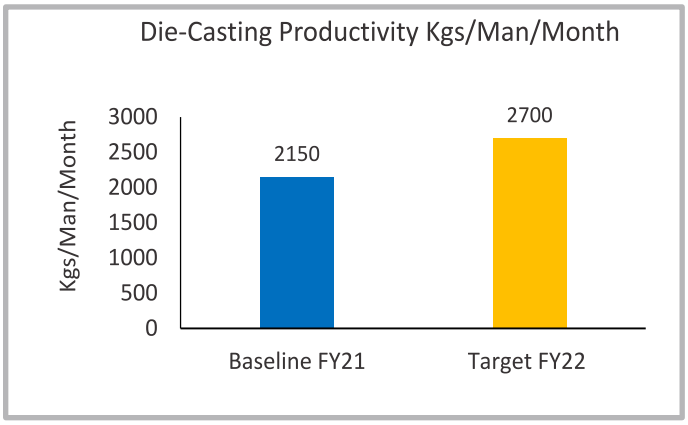
Productivity Improvement Case Study

Sigma Electric Manufacturing Corporation PVT. LTD., Pune

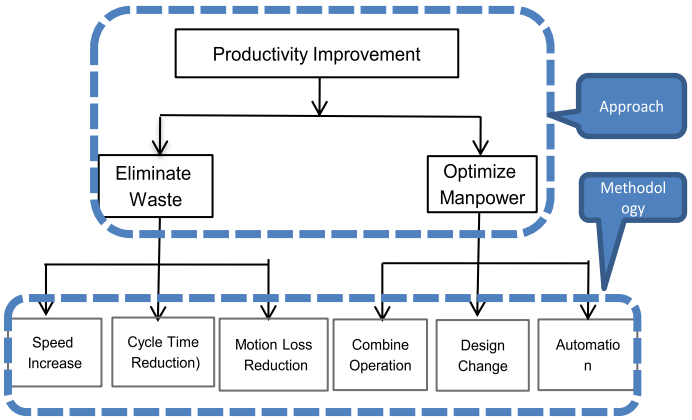
- **Kaizen Theme** : To Improve productivity at 900 Ton Die-casting machine
- **Team Members** – Kadu Jagtap
  Ajit Padale
  Balasaheb Awari
  Pramod Gaikwad (Facilitator)

Problem Definition & Target Setting

Target Setting



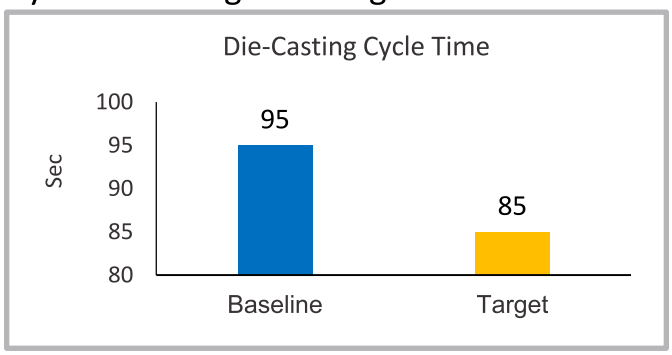
Approach



Sr. no.	Area of improvement	Action/countermeasure taken	No of Kaizen / Improvement Projects
1	Cycle time reduction	To reduce cycle time be eliminating NVA's	3
2	Line Balancing	Standardize work Implementation	4
3	Motion loss reduction (MUDA of Movement of Worker)	Layout changes/Provide LCA's	6
64	Set up reduction	SMED	4
Total Projects/Improvement			17

Kaizen – Productivity Improvements

Cycle Time Target Setting



Analysis & Brainstorming all elements

Sr. No	Elements	Cycle Time in Sec
1	Front safety door close time	3
2	Side core in time	4.5
3	Moving platen forward & die close time	6
4	Metal pouring time	11.3
5	Shot delay time	1
6	Cooling time	11
7	Die open time	2.5
8	Side core out time	5.5
9	Extractor forward time	6
10	Ejector delay time	0.5
11	Extractor return time	6
12	Auto spray descending time	1
13	Air blowing time before spray	1
14	Diecoat spray time	0.7
15	Air blowing time after spray	2
16	Auto spray-Ascending time	2
17	Front safety door return time	3
18	Manual air blowing time	9
19	Loose piece placing time	17
20	Die close button push time	2
21	**Total**	**95**

Kaizen – Cycle Time Reduction

Before

Extractor forward & core out overlap programme not inbuilt in Zitai machine.

After

Extractor forward & core out overlap programme added in Zitai machine.

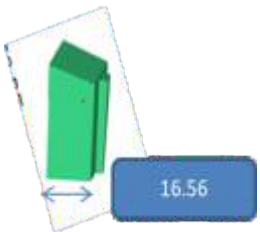
Before

Semi auto operated safety door programme not inbuilt in Zitai machine

After

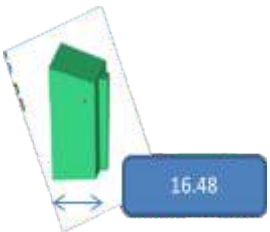
Semi auto operated safety door programme added in Zitai machine.

Before



Loose insert fitting tight observed due to less clearance at the bottom side . This consumer more time for insert fitment

After



Loose insert clearance increased at the bottom side to fit easily in the core. This consumed less time for insert fitment

Before

Loose piece cooled in normal water.

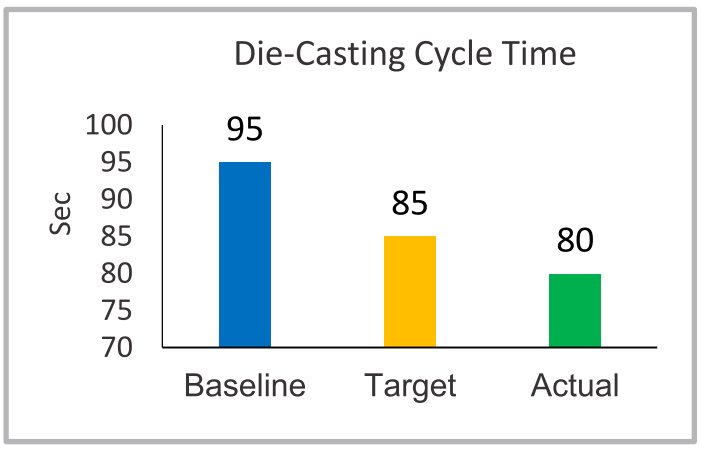
After

Loose piece cooled in die coat water

Results – Cycle Time Reduction

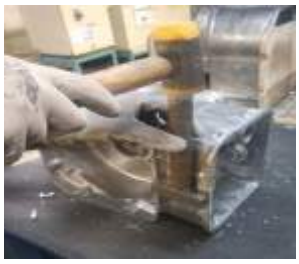
		Before	After
Sr. No	Eliments	Cycle Time in Sec	Cycle Time in Sec
1	Front safety door close time	3	3
2	Side core in time	4.5	4.5
3	Moving platen forward & die close time	6	6
4	Metal pouring time	11.3	9.95
5	Shot delay time	1	1
6	Cooling time	11	10
7	Die open time	2.5	2.5
8	Side core out time	5.5	4
9	Extractor forward time	6	6
10	Ejector delay time	0.5	0.5
11	Extractor return time	6	4
12	Auto spray descending time	1	1
13	Air blowing time before spray	1	1
14	Diecoat spray time	0.7	0.7
15	Air blowing time after spray	2	2
16	Auto spray-Ascending time	2	2
17	Front safety door return time	3	0
18	Manual air blowing time	9	9
19	Loose piece placing time	17	11
20	Die close button push time	2	2
21	Total	95	80

Results



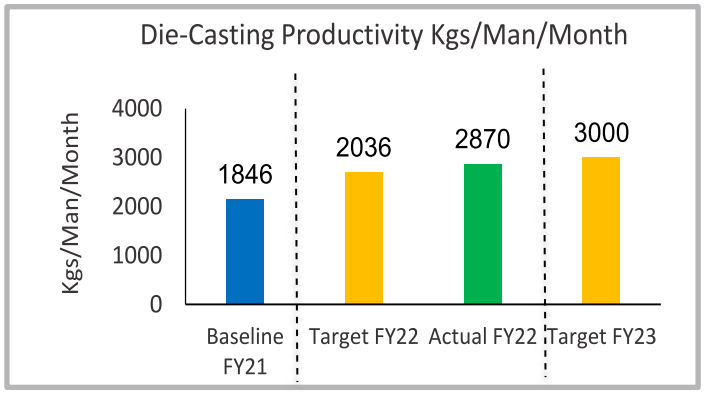
Kaizen – Productivity Improvements

Before	After	Before	After
			
▪ Six Head/Day for Overflow Breakage. ▪ Two Belting Operator/Shift	▪ Zero Man head for Overflow breakage. ▪ One Belting/Shift	▪ Chill went and overflow breakage activity is manually ▪ High potential operator fatigue	▪ Chill went and overflow breakage activity is in auto mechanism ▪ Reduce operator fatigue

Before	After	Before	After
			
▪ Heavy casting shot lifting from1490 mm height. ▪ Chances of Big fall, Burn injury and cut injury hazards. ▪ HTA for clean & maintenance	▪ Height reduced by 590mm height and easy to lift shot. ▪ Eliminated safety hazards. ▪ Easy to clean & Portable unit	▪ C type flash removing activity is manual operation. ▪ Operator Fatigue and hazards of pinch injury in hammering operation	▪ C type flash removing activity is auto operation on SPM. ▪ Eliminated Operator Fatigue and hazards of pinch injury in hammering operation.

Results & Benefits

Results



Benefits

- Cost Saved $22K/Annum
- Ergonomics eliminated
- OTD Improved by 8%

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The 'FUTURE-READY' Core shop for Die-casting Industry

B. B. Lohiya, Director, Compax Industrial Systems Pvt. Ltd.
bblohiya@compaxindia.com

ABSTRACT:
Advent of Electric vehicles, evolution of new materials and the emerging disruptive technologies have put the manufacturing sector in turbulence. Foundry industry being the basic industry, is no exception.
The nature of casting requirements is changing continually at a faster pace. Aluminium tends to be the preferred casting material for many applications. The Die-casting industry will have to adapt to the rapid changes to benefit from the emerging opportunities.
Core remains the most critical element to match the changing requirements of the castings. The core shop of the future will have to, therefore, absorb the rapid technological changes to ensure relevance and growth of the Aluminium foundries.
The paper reviews the potential impact of the new technologies like 3D- printing, Advanced Digital technologies like IOT & Artificial intelligence, Core making processes & new Binder technologies etc on the manufacturing culture of the core shop - with respect to changing casting requirements and new application areas for the Die-casting industry.

Introduction

Over a period, the consumption of Aluminum castings is on the rise in Automotive and other engineering fields. Light weighting has become a keyword in use of such castings in Automobiles to improve the fuel efficiency. There have been consistent efforts to replace
CI components with Aluminium components wherever possible. Developments in Aluminum alloys has accelerated this trend. use of aluminum components for brake systems, engine components etc. has become a norm in vehicles. The high importance given to Electric vehicles may bring in a different culture of components and will provide new opportunities for innovation in Aluminium casting development as well as new business opportunities.
Most of the castings produced by Gravity or Low Pressure die casting processes use cores to create cavities of desired shape and dimensions. The need to reduce wall thicknesses and machining allowances, has put increased and stringent demands on the quality of the cores in terms of dimensional accuracy and surface finish. The high productivity requirements need cores with ease of de-coring & finishing operations.

Core making processes and developments

Present Processes

Core making processes like Co2 Silicate process, Shell or Hot box processes, No-bake and Cold box processes, have been employed in producing cores for Aluminium castings. The Co2 silicate cores are the most economic ones. However, they suffer from difficulty in de-coring operations which also affects productivity. Surface finish also poses some issues.
The development of Shell process helped produce cores of high dimensional accuracy and good surface finish. High binder content of this process leads to blow holes and similar defects for critical castings. The Hot box process has better capability to address such issues. However, both the Shell and Hot Box processes are highly energy consuming.
No bake binder technology has provided ease of operation, good surface finish and decoring properties. But the long cycle times compromise the productivity aspect in core production.
The development of the energy efficient Cold box process brought n an era of high productivity core production. Of late, special binders have been developed to improve decoring ability of cold box cores, making this process a preferred choice for core production. A new catalyst. DMPA (Di methyl iso-propyl Amine) is now available which improves productivity while reducing the pollution related issues and odour. Phenolic binders cured by CO2 is a good environment friendly alternative to cold box process.
All these processes except the Co2 silicate process use organic binders. Organic Binders have become very popular for Core making due to their high

strength and high production rates. With process like shell / Hot Box, No Bake and Cold Box, certain issues like environmental concerns and shakeout of sand from castings have been posing some problems on the shop floor. Although De-coring has become easy with new Cold Box binders for Aluminium, the pungent odour makes the operator uncomfortable. With these Organic binders, sand reclamation is also not very easy and requires complex installations. The increasing awareness about health & safety of the operating personnel, there has been a constant search for alternate binder systems retaining the advantages of organic binders.

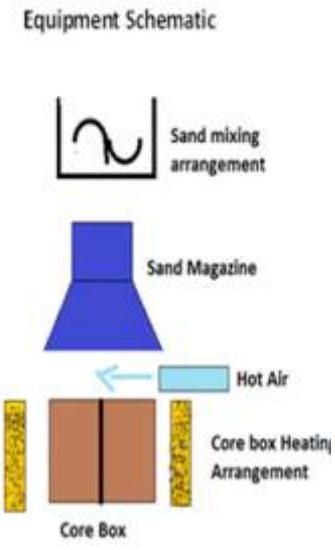
Inorganic Binders

Few Inorganic Binders have been developed to address these issues. (The conventional Co2 Silicate process, although inorganic does not provide advantages of organic binders). These binders are water soluble and use combination of Silicates, Borates, Sulphates, phosphates & Hydro-Oxides. Binders have been developed which impart certain properties of Organic Binders to the Inorganic Binders like High strength, fast curing and collapsibility commercially available binders in this category are GM Bond, Hydro bond, Beach Box, Cordis , Inotec etc.

Inorganic Binders

Composition

- **Silicates : for High trength**
- **Phosphates : for Good Solubility**
- **Borates : for High Strength**
- **Hydroxides : for Fast Curing**
- **Sulphates : for Good Solubility**



Presently their use has been well established but primarily restricted to Aluminiun castings produced in western countries. The De-coring operation is by using water since these binders are water soluble. Separating sand from water makes reclamation an easy proposition.

The Future core shops will have to be equipped with core making installations that employ Inorganic binders for core production. The present installations can be converted for these applications with some modifications and retrofitting solutions.

SALT Cores

Salt cores also known as Lost cores are used to create intricate cavities or undercuts in castings. The de-coring problems faced when sand cores are used for complex shapes, are addressed by the salt cores because they can be easily removed using high pressure water jet. Presently such cores are introduced in HPDC process. These cores are formed in permanent moulds by use of different water soluble salt compositions by HPDC or LPDC process. Use of such cores in casting processes like GDC or LPDC can be envisaged for economic reasons for small batches in near future.

3D Printing of Cores

3D printing of sand cores is a process of manufacturing sand cores, by building the sand layers and injected adhesive, layer by layer using the CAD design data of the core geometry. 3D printers (a modified inkjet printer) are used for this purpose. This has proved to be very useful for Rapid prototyping work or small batch production of castings. Since no Tooling is required the cost and the development time is saved. It also provides “Freedom of Design” making complex cavities or undercuts feasible for casting production with ease. Although a slow process, It turns out to be economical for small batch production. It has proved out to be a boon for incorporating innovative design changes of components specially for Prototype testing and implementation.

Other Technologies related to Core Shop Simulation of Tooling and Process parameters

The CFD (Computational Flow Dynamics) technology has benefitted the foundry industry by providing a tool to simulate the performance of the core box design and optimize the operating parameters

especially for the cold box cores. The Blow tube pattern & the venting pattern of the tooling can be checked in advance for optimization of the design. Thus the CAD data of Tooling design can be validated for manufacturing. For critical cores, 'the rule of thumb' design practice does not guarantee reliability of performance of the tooling. Simulation in advance can help not only to cut down on the rejection levels of the core production but also those during casting production.

Automation & Robotics

In order to have consistent high quality & high productivity core output, the entire production process has to be properly controlled at each stage. Monitoring and Control of Process Parameters can be efficiently done by employing modern Instrumentation & Digital technology. Parameters such as Temperature, Pressure, Flow rate, quantity, Process time etc. are controlled accurately due to availability of Sensors of high resolution & fast response as well as superior signal processing devices. PLC technology has enabled repeated operations with high consistency, while allowing for flexibility in process execution and ease of operations. Material handling from raw sand to finished cores, Mixing and dosing operations, core finishing as well as post core making treatments etc. can be easily automated using different control and actuating mechanisms. Robotic automation is picking up rapidly in engineering fields due to easy availability of Robotic systems with end of the arm tooling & peripherals. Cost effective and job specific solutions are now within the reach of foundry industry too!

Robotic Core handling & finishing:

Such automation makes the production process consistent in performance while eliminating the human skill influence. Reduced human resources are required at different stages of core production. Besides, the operations become safe, accurate, predictable and well monitored.

Robustness and reliability of the Automated set up will be the key to un-interrupted high quality-high productivity core shop output. ROBOTIC CORE HANDLIN G & FINISHING AIR CLEANING SYSTEM

Environmental aspects

Environmental considerations are gradually gaining more importance in various areas of human activity. Emission standards are being raised continually. The health of the operators in any area of foundry operations is being viewed with more concern. Hence the exposure of the operators to VOCs and gaseous pollutants need to be monitored closely. In processes like Amine cold box core making, Air cleaning systems like scrubbers or dust collection systems at sand handling stages are becoming integral part of any core shop installations.

A clean environment and "Green" processes will become the norm than a dream in the core shop.

Industry 4.0 and Foundry core shop

With the onset of the Fourth Industrial Revolution (Industry 4.0) i.e. the era of "Digital Technology Revolution" coupled with Automation & Robotics, the manufacturing sector will go through a sea change. Emerging technologies like 'Artificial Intelligence', 'IOT', sensor & other technologies will bring in disruption of the existing manufacturing methods and operations. It must be remembered here that the word "DISRUPTION" connotes a positive sense and indicates a more innovative approach and superior way to carry out manufacturing operations & processes.

With these technologies, the manufacturing operations will become more autonomous in nature as the various subsystems will be 'intelligent enough to make simple decisions on their own and support human effort. Machines and humans will communicate with each other. The systems will create a virtual 'physical' world and generate data through sensors. The data analysis systems will help the humans to arrive at major decisions more accurately. Industry 4.0 will also bring some challenges with it. Cyber security will be most important aspect. High degree of reliability and stability of the systems and data communication will have to be ensured and maintained. Small lapses could prove to be very expensive. The manufacturing installations could tend to be more capital intensive than human intensive. New skill sets will have to be developed. However, the benefits of the Fourth Industrial revolutions will outweigh the challenges and concerns. The supply chain will be better controlled as the manufacturing process and delivery process become better synchronized due to efficient data communication.

Operations in risky or dangerous environments will be safe and smooth. New opportunities for innovative solutions will crop up & Investments will be more safe.

Conclusion

The 'Future Ready Core shop' will have to exist in the environment of Industry 4.0. It has to employ 'GREEN' processes & operations. Use of Inorganic binders will be common and will assure eco-friendly operating environment. The core shop has to transform itself in the 'intelligent' mode with more automation, Robotics and digitalized operations. Robustness and reliability of the employed systems will be the key factor in ensuring desired performance.

Any fears about the life of the existing installations, possible loss of the present investments or employment are unwarranted and need to be removed totally. Timely steps to convert existing machines into intelligent machines by incorporating sensors & data acquisition systems is easily possible at minimum investment. Many industries are already doing it and getting future-ready. The human resources can be trained for the new skill sets required and can have better opportunities to realize their full potential & capability.

In fact, this scenario offers opportunities for more efficient utilization of all resources and better returns. The potential for innovation in various areas, can make the foundries only stronger. Let us, therefore, start now, to become 'Future Ready'.

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(iii) Classification of casting defects
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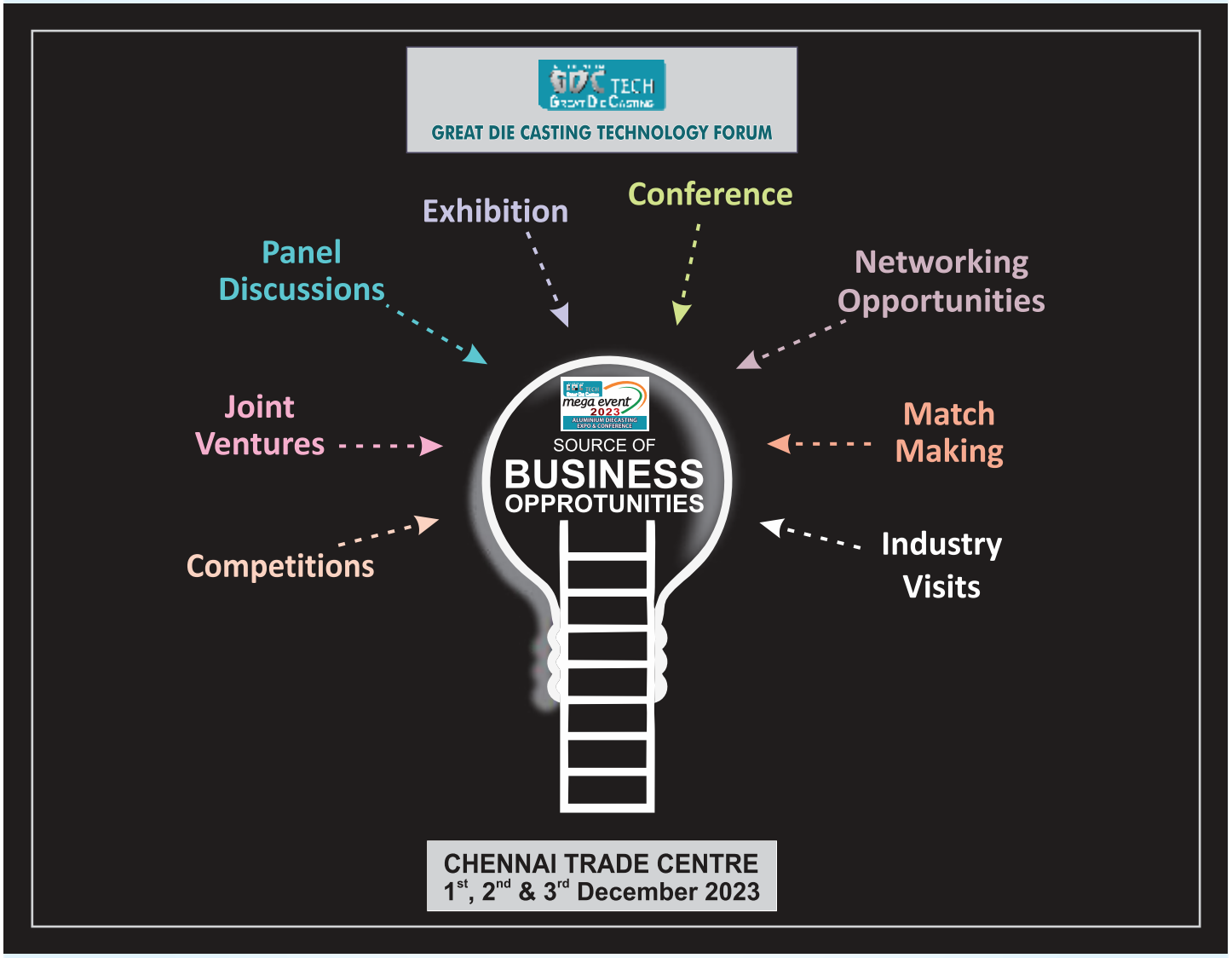

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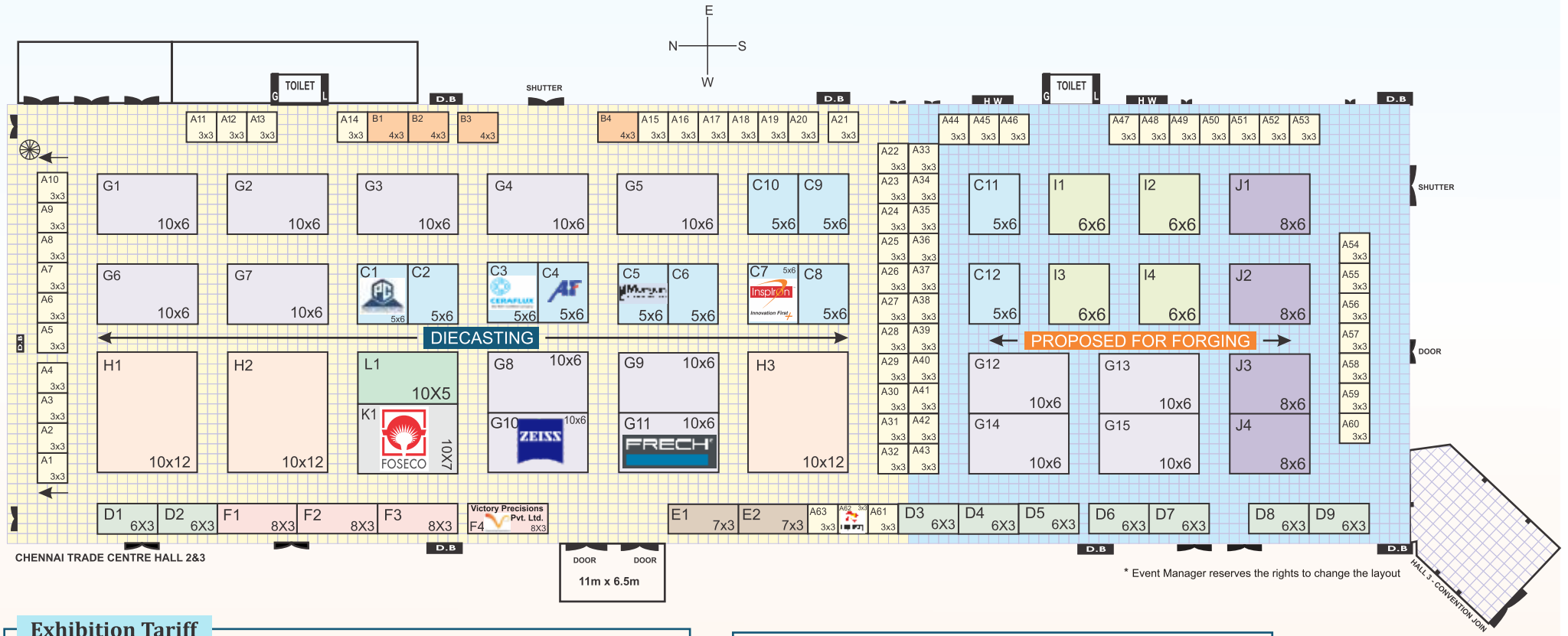

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