ALUCAST® 2020

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CHENNAI TRADE CENTRE, CHENNAI | DECEMBER 3-5, 2020

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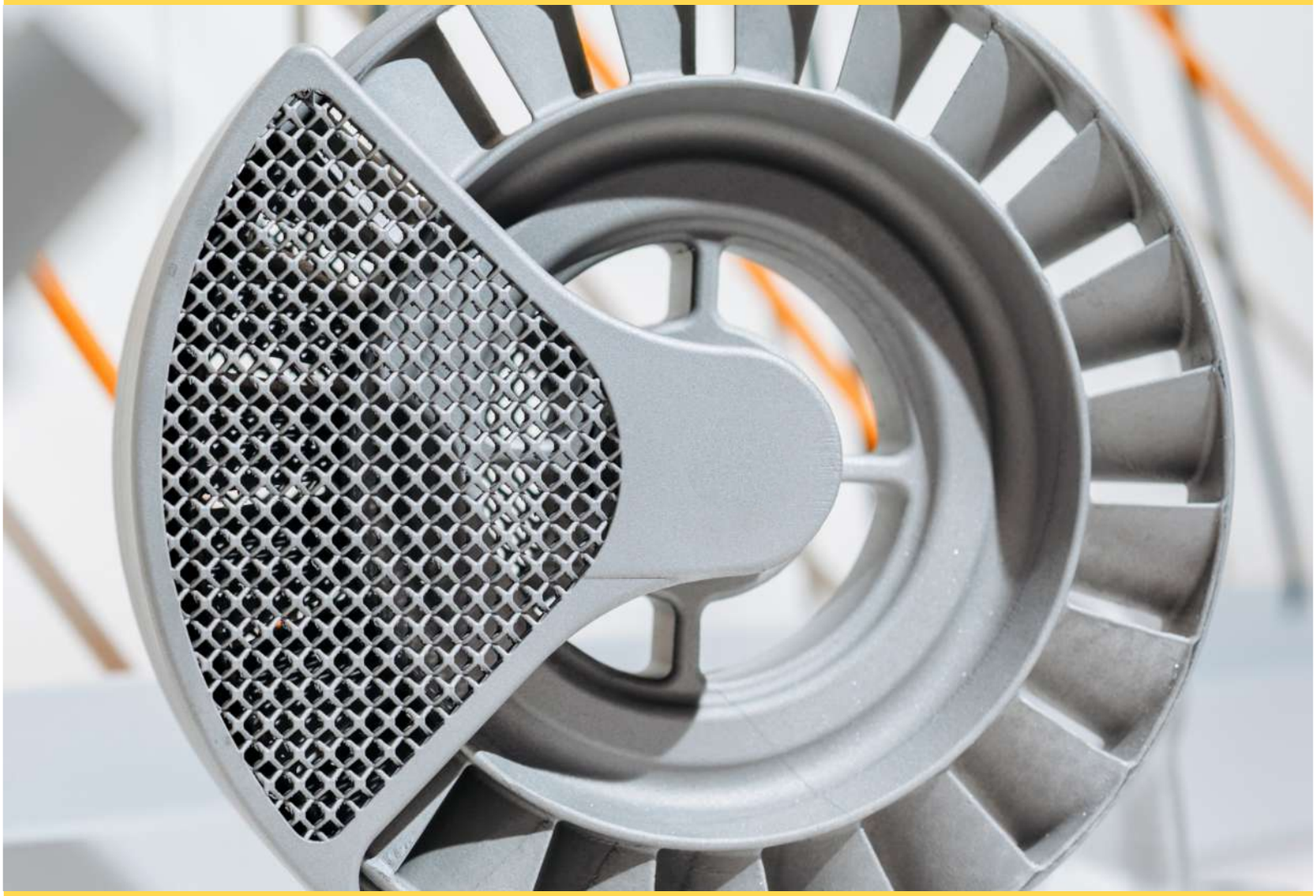

ALUMINIUM CASTING TECHNOLOGY FOR THE TWENTIES

Organizer: ALUCAST® PARTNER IN PROGRESS FOR ALUMINIUM AND DIE CASTING INDUSTRY

Event Producer: NÜRNBERG MESSE

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EMERGING TRENDS IN DIE CASTING – FINDING SOLUTIONS THROUGH LATEST DIE DEVELOPMENT TECHNOLOGY

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Over the past 130 years, the automotive industry has followed a very "linear" development path. But due to the parallel emergence of four megatrends in the last 2 years (MADE – Mobility, Automated driving, Digital experience, Electrification), the industry is likely to be reshaped in the next 10 to 15 years."

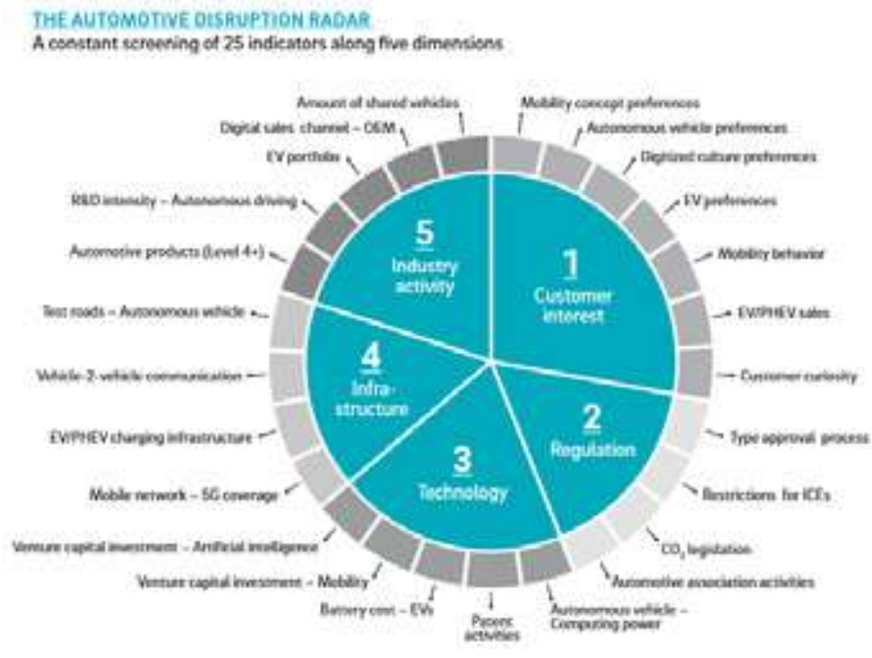
Automotive sector is blessed with whole hearted attention by all its supply chain and feeding industries. Owing to its higher volume requirement, huge investments are done in developing newer technologies to meet the challenge by all supporting industries.

Aluminium and its alloys has a major role in deploying newer technology for light weighting of vehicles. Newer grade of light weighting material, newer processes and disruptive technologies are deployed with extensive researches in making vehicles safer, lighter yet stronger and comfort driven.

This paper deals with these emerging trends in Die casting technology and finding solutions through newer technology in Die development process.

The green environment is the need of the hour and every responsible corporate is engaged in contributing their bit through development of new processes, products, techniques and wants to become Power and Water positive entity.

Figure 1- AUTOMOTIVE DISRUPTION RADAR



a. The market disruptions are initiating hoard of changes in R&D, Product Designs and Manufacturing processes.

b. The 25 indicators of disruption as detailed out in Figure 1 act as pointers monitoring the changes for future readiness.

c. Zero Emissions and minimizing environmentally harmful substances will have solu-tions through technological advancement.

d. Better Fuel Economy and Resource saving will have root into Light weighting aspect of Automobile Engineering. EVs will also de-

mand lighter structural to save on Battery power requirement and increasing mileage per charge.

e. The Reduction in weight of Vehicles can be achieved by 3 methods as indicated.

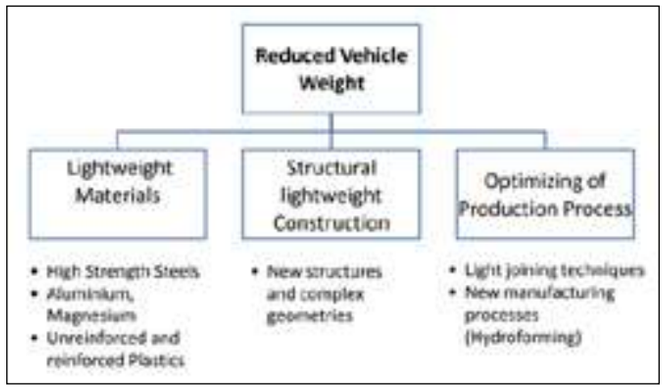


Figure 2 – LIGHT WEIGHTING METHODS

f. A lot has been covered in about “Light Weighting” in various forums in the recent years. With respect to Aluminium Die cast parts we will look-into other 2 methods in detail and understand the specific die design considerations to be made.

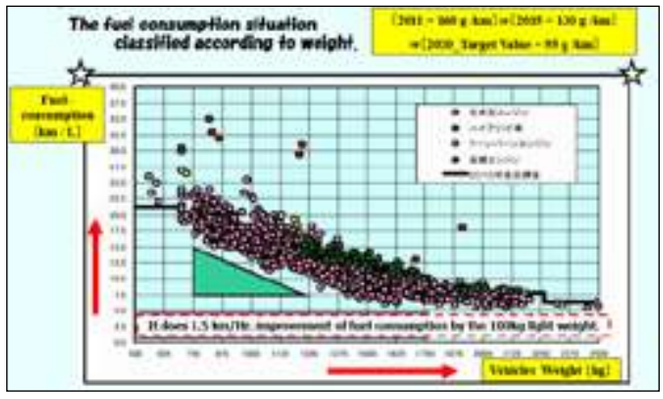


Figure 3 – EFFECT OF VEHICLE WEIGHT ON FUEL CONSUMPTION

(A) Structural Light Weight Construction:

The structural castings have altogether different characteristics that needs specific con-sideration for Die design and usage. Though these are yet to be introduced and put in regular production in our domestic foundries. We must understand the basics of such castings.

High ‘Fe’ content prevents traditional die casting alloys from achieving high mechanical properties, especially elongation. The ‘Fe’ content helps to avoid die soldering.

Figure 4 - STRUCTURAL CASTING ALLOYS

The specifically developed alloys as given in Figure 4 to meet the below given character-istic adds to the complexity in Die design and design related calculations.

Structural castings usually have,

- Large area
- Thin wall
- Complex geometry
- To be heat treatable
- To be joined by welding or riveting
- Need high fatigue and impact strength

Figure 5 - EXAMPLES OF STRUCTURAL PARTS

All the above characteristics become input for Die de - sign calculations. Let us understand impact of each characteristics and the probable solutions to over come the same.

(i) Larger area of castings with relatively thinner walls:

To achieve the above criteria, we must understand the critical factors that will lead to success in obtain- ing the desired results.

- Understanding the behaviour of material during flow and solidification phase in thinner sections
- How to avoid alloy temperature drop before com plete filling
- Protecting Die life under higher pressure condition
- Ejecting thin walled casting without casting defor mation and warpage
- How to avoid shot sleeve erosion

In order to fill the cavity in a shortest possible time and maintain gate velocity within rec-ommended limit of 40-60 m/sec we have to provide maximum number of gates at all the possible locations covering most areas of castings. The below given image Figure 6 demonstrates the same.

Figure 6 – GATING DESIGN FOR STRUCTURAL CASTINGS

(ii) Complex geometry of Castings:

Thin wall structural castings will have many ribbing and dip features that result in thinner sections in Die inserts. These thin inserts pick up heat very fast during material flow and cause soldering and other casting defects. Die design to include provision for faster cooling of these inserts. For ultra-thin sections where conventional method of cooling cannot be pro - vided conformal cooling to be planned. These can be provided by applying latest tech-nology of 3 D Print- ing.

Figure 7 – 3 D PRINTING / ADDITIVE MANUFACTURING/ STEREOLITHOGRAPHY

3D printing, also known as additive manufacturing, is any of various processes used to synthesize a three-dimensional object.

In 3D printing, successive layers of material are laid down under computer control.

Use of 3D technologies to reduce time to market, pro - duce stronger and Lighter parts, im-prove efficiency, reduce waste, and create complex geometries.

(iii) Applications for Die casting Dies /Aluminium parts:

1) 3D printing method enables free-form designs that may be difficult to create through traditional ma- chining processes. Conformal cooling / heating helps to maintain required temperature for thin wall casting geometries & also thick sections.

Figure 8 – 3 D PRINTING FOR CONFORMAL COOLING

2) Additive manufacturing techniques promise to sig- nificantly reduce costs by enabling faster and cheap - er Repairs. 3D printing can also significantly extend the lifespan of dies.

Figure 9 – ADDITIVE MANUFACTURING FOR REPAIRING DAMAGED INSERTS

3) DMLS (Direct Metal Laser Sintering) with AlSi10Mg is used most commonly in transportation and aerospace for making components. These industries revolve around speed to mar - ket and innovation to result in increasingly more lightweight compo-nents.

A few common applications we see demand for DMLS AlSi10Mg include:

- Steering knuckles
- Heat exchangers
- Small prototype housings
- Brake handles
- Complex brackets
- Hinges, latches

Figure 10 – EXAMPLES OF COMPONENTS MADE FROM DMLS PROCESS

Figure 11 - CONFORMAL COOLING FOR THIN AND SLENDER CORES

Light weighting of casting is challenging to Die designer and Die caster. Following points need to be understood well by both to achieve the desired results.

- Foundry should meet the higher temperature conditions, shorter filling time, higher first phase velocity with healthy Diecasting machines.

- Thicker gates are real challenges to get during trimming and fettling.

- Vacuum assisted venting is one of the conditions for producing good thin walled castings. It needs well-built dies with proper parting line sealing and good mainte-nance practices.

- Operating almost at the threshold limit of all-parameters Die life takes its toll and as a guideline one should consider 20% less die life than normal conditions.

(B) Optimizing of Production Process:

Die casting operations have been technologically neglected in majority of domestic foundries. In order to cater to the needs of tailor-made alloys for Structural castings and meeting its stringent quality standards, foundries need to work towards revamping and upgrading its equipment and processes. It can be done through stage wise implementa-tion of 5S, TPM and Go-Green initiatives and gradually introducing Industry 4.0 into its operations.

In the earlier ALUCAST forums various organizations took part offering solutions to digit-ize the Die casting foundry operations. It is now turn of industry leaders to identify the benefits of adapting the same.

• **The basic principle of Industry 4.0 is that by connecting machines, work pieces** and **systems**, businesses are creating intelligent networks along the **entire value chain** that can control each other **autonomously**.

• Some examples for Industry 4.0 are machines which can **predict failures and trigger maintenance processes autonomously that react to unexpected changes in production**.

• A lot has been done at Die casting Machine end in digitizing the process and re-cording the parameters for online monitoring and data analyzing.

• The Die is still an un-communicating object that affects the smooth operation of foundry process.

• It can malfunction or breakdown at any time, more so with its diminishing Die life or complex design.

• Need has been felt to make Dies smarter with feed-back mechanism for online monitoring by Godrej Tooling.

• The solution developed by Godrej Tooling is named as “SMART DIE” with futuris-tic features.

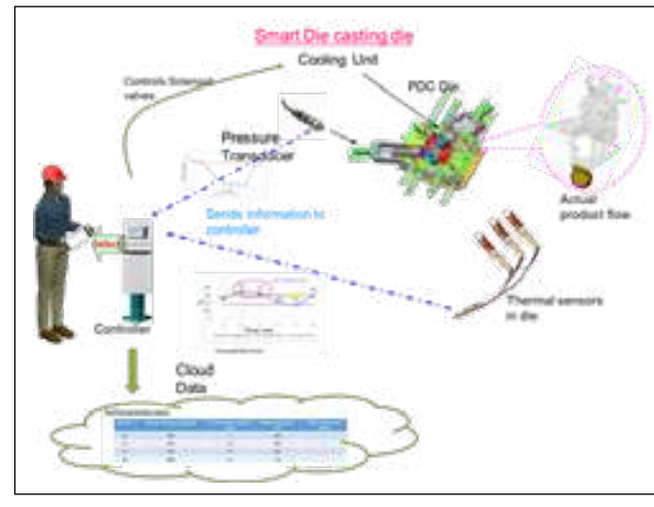


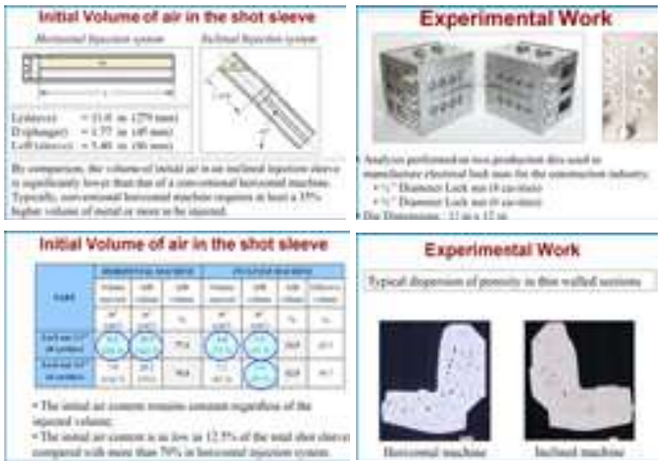
Figure 12 – SMART DIE CONCEPT DEVELOPED BY GODREJ TOOLING

(C) EMERGING TECHNOLOGIES IN DIE CASTING:

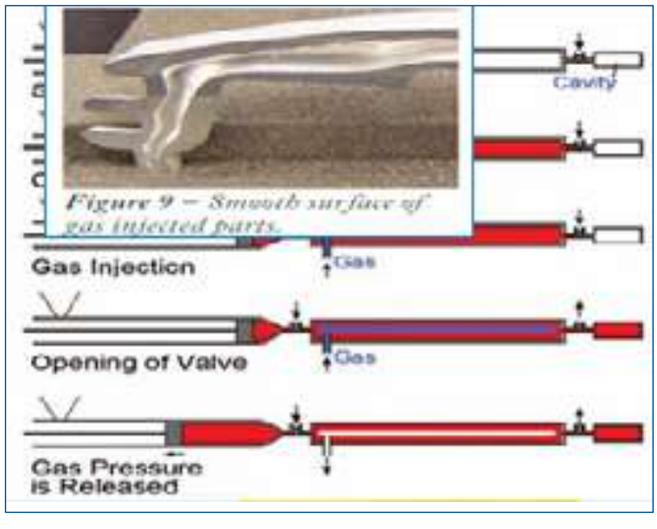
Porosity level in High Pressure Die casting is almost impossible to eliminate owing to its inherent high velocity and high pressurized filling of Aluminium melt

into the die cavity. Turbulent melt flow and mixing of air entraps the gases that remain within casting and makes it vulnerable to failure in usage. Vacuum technology and vertical injection process has been introduced and being used whenever the exorbitant cost of equipment is justified. A more logical process that combines benefits of Horizontal in-jection and Vertical Injection Die casting is developed called as

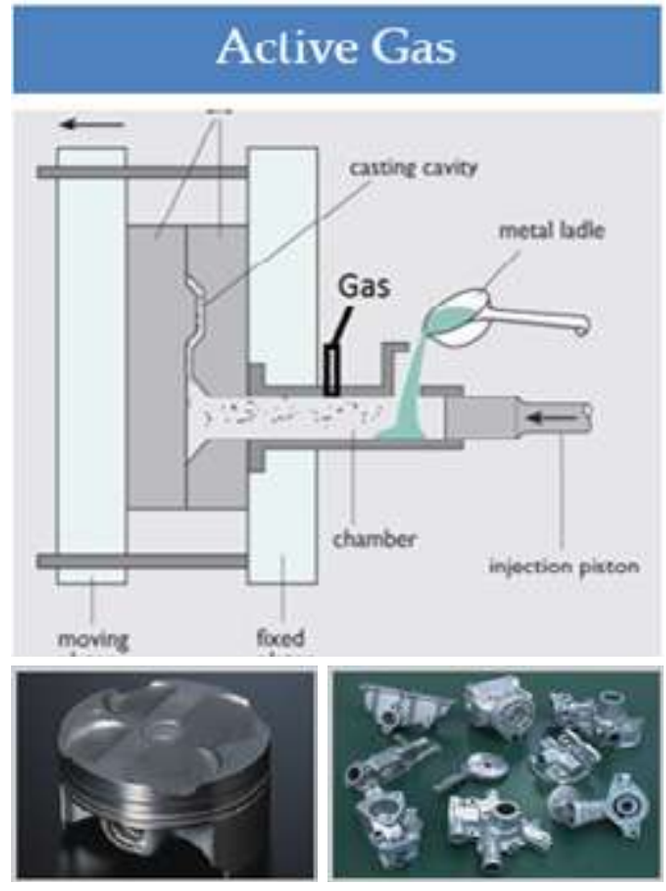
a) Inclined Injection Process: Despite advantages the Inclined Injection Process remains at very nascent stage in our country. Such technology waiting to be exploited to derive benefits.



b) Gas Injection in Die casting: A lot of possible applications exist for gas injection in high pressure die castings. Some are using gas injection for channels in oil filter housings would allow 3-D struc-tures instead of straight lines and optimized fluid flow with less resistance. Many other applications where long cores can be avoided are possible. There are various pro-cesses known for gas injection, but only one is described here. The cavity is filled with liquid melt. After a partial solidification of the melt, gas is injected into the cavity while a valve is opened. The liquid material is pressed into the cavity that was opened by the valve. After total freezing, the gas pressure is released.



c) Gas Injection in Die casting: It's a PF (Pore Free die-casting) method. The PF method is a specialized die-casting method where air in the cavities, runners and a shot sleeve is replaced by active gas (mainly oxygen) before molten metal is shot into the dies. As oxygen becomes minute solids of aluminum oxide reacting to the aluminum alloy, you can get dense castings with minimized number of pores. This method is applied to pressure-resistant products: castings which require heat-treatment; and highly reliable castings with little strength variation. In the PF method, as soon as molten aluminum is jetted into the active gas atmosphere, the cavities become vacuum. Even with the PF method, shrinkage due to solidification may generate casting porosities.



Summary

ADAPTING EMERGING TECHNOLOGY

BETTER PROCESS COMPLIANCE

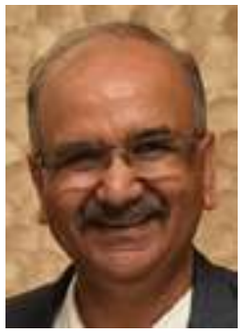
FUTURISTIC PRODUCTS

References:

• All Case studies – Courtesy Godrej Tooling, Mumbai.

• Journals and broadcast materials published in public domain are taken.

AUTHOR



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31 years of experience in Design and development of dies for 4-wheeler vehicles and for 2-wheeler parts. Dealt with Dies & Moulds Industries at Japan. Exposure to various Toolrooms in Japan, Korea, Taiwan, Germany, USA & France. Contributed Technical Papers at NADCA, ALUCAST, GDC TECH, ILZDA, AAI and IFC.

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