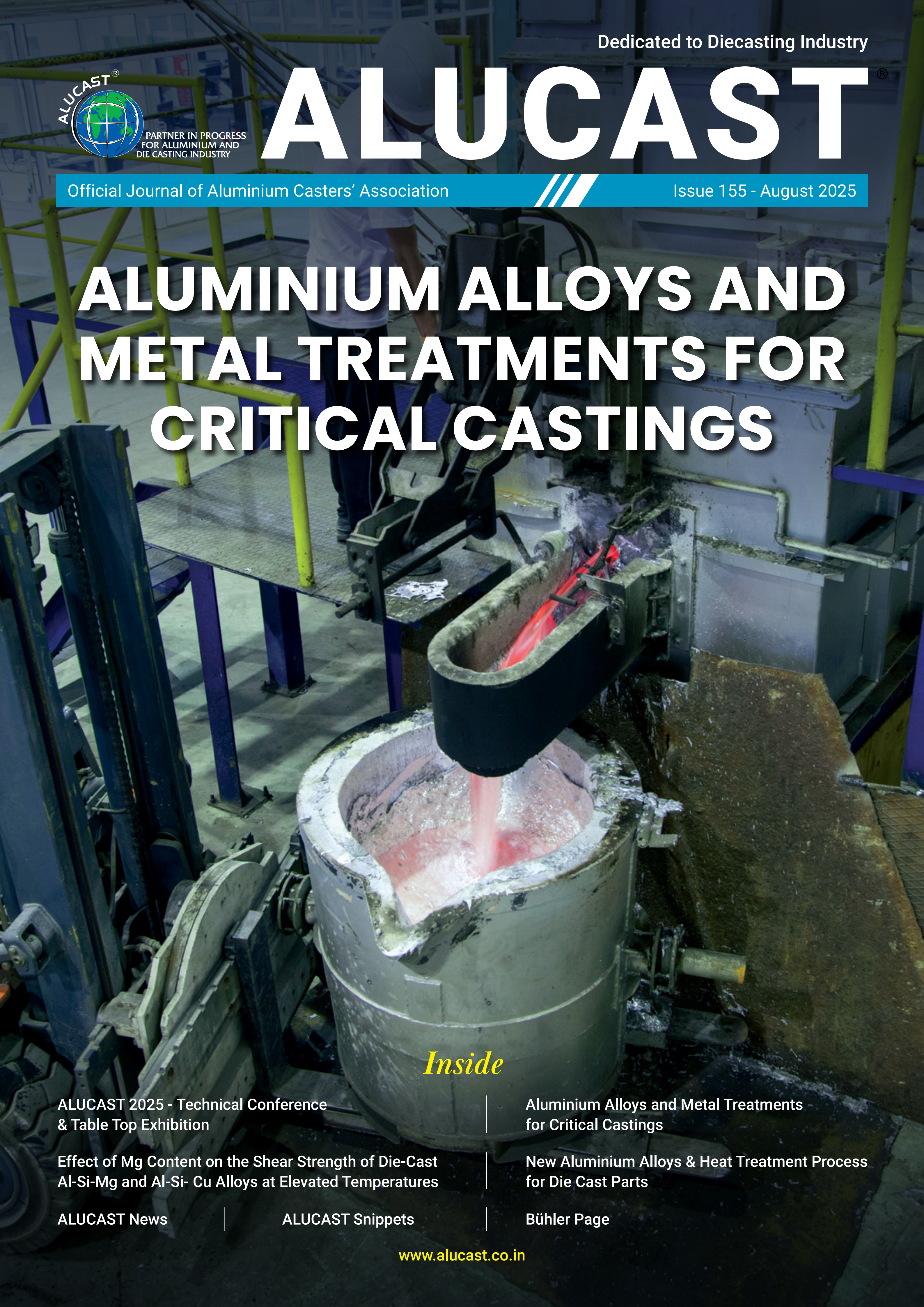

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Issue 155 - August 2025

ALUMINIUM ALLOYS AND METAL TREATMENTS FOR CRITICAL CASTINGS

Inside

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PARTNER IN PROGRESS FOR ALUMINIUM AND DIE CASTING INDUSTRY

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N. Ganeshan
Editor

Dear Readers,

Aluminium alloys and their associated metal treatments play a vital role in the manufacturing of critical and light weight castings, especially in industries such as aerospace, automotive, defence, and high-performance engineering. These castings are often subjected to extreme operating conditions and require the highest standards of strength, durability, ductility and reliability. Further, the electric vehicle (EV) industry is rapidly evolving, pushing the boundaries of lightweighting, thermal management, strength, and corrosion resistance in materials used for critical castings. This has led to the development of new aluminium alloys and advanced metal treatments tailored for EV applications.

To achieve a required strength-to-weight ratio, aluminium alloys are the most suitable as they offer a unique combination of being lightweight and mechanically strong, which is essential in aerospace and automotive applications where weight reduction improves fuel efficiency and performance. Specific alloys (e.g., A356, 7075, 2024) provide enhanced strength through alloying elements like silicon, copper, zinc, and magnesium and by controlling tramp elements like Fe.

All aluminium alloys attain corrosion resistance naturally by forming a very thin and tenacious layer of oxide on the surface. In critical castings that are used in marine or chemical environments, post-casting treatments such as anodizing are carried out to enhance this resistance.

Additionally, aluminium's thermal conductivity makes it ideal for castings like engine components, heat exchangers, battery housings and holders for electronic components. Certain alloys are tailored to maintain these properties under thermal cycling. Additionally, newer process like Vacuum Die Casting / High Vacuum Die Casting (HVDC) needs to be adopted that minimises porosity & gas entrapment and enables thinner walls and higher-integrity components, that are essential for EV motor housings, battery boxes and wheels.

Precision and complex geometries are easily obtained as aluminium alloys are well-suited to investment casting, die casting, and sand casting, enabling the creation of complex, near-net-shape parts with tight tolerances. This is especially valuable in aerospace and electronics where precision is very important. Critical castings often undergo molten metal treatments before the casting operations are carried out to improve their performance characteristics. Later, the cast parts undergo heat treatment (e.g., T6, T7 tempers) operations to alter microstructure to enhance strength, hardness, and ductility. T6 treatment (solution heat treated and artificially aged) is commonly used to increase tensile properties. Rapid heat treatment (RHT) reduces time and energy compared to traditional T6 or T7 processes. On the other hand, self-aging alloys (e.g., Al-Ce alloys) avoid traditional heat treatment thereby saving energy & cost. Other casting treatments like Hot Isostatic Pressing (HIP) which eliminate internal porosity and improve fatigue life, a must for aerospace and structural applications, are also undertaken. These are mainly used on structural EV parts where internal soundness and fatigue resistance characteristics are very important (e.g., suspension knuckles, inverter housings). Surface Treatments like anodizing improve wear and corrosion resistance. Chromate conversion coating (e.g., Alodine) enhances paint adhesion and corrosion resistance.

Failure of a critical casting (e.g., turbine blade, automotive wheels, aircraft parts and structural components) can have catastrophic consequences. Thus, while selecting the aluminium alloy for a particular application, care should be taken to ensure using alloys with precise control over composition and proper metal treatment to ensure reliability, repeatability, and long-term performance. Treatments and alloy selection must balance performance with cost-efficiency, particularly in high-volume or mission-critical applications. The selection of aluminium alloys and their appropriate metal treatments is essential for ensuring the structural integrity, performance, and longevity of critical castings. Whether in aerospace, automotive, or industrial equipment, these materials and processes are the backbone of modern high-performance engineering.

***

Aluminium Alloys and Metal Treatments for Critical Castings

- G Praburam, Managing Director, Alubee Die Casters

"In casting, precision is poured.......but performance is forged in the alloy"

INTRODUCTION

In the evolving world of manufacturing, the demand for critical castings, components that must operate flawlessly under severe conditions, has risen sharply.

Whether it's EV motor housing, an aircraft actuator, or a medical implant, such components require exceptional material integrity and predictable performance.

At the heart of these demands lies the role of aluminium alloy. While conventional casting grades serve well in general applications, they often fall short when life, safety, or mission-critical functionality is at stake.

In this context, special aluminium alloys, backed by precise metal treatment and post-processing, are emerging as the real game changers.

ABSTRACT

This article explores the application of special aluminium alloys and their metal treatments in the context of critical castings.

It provides a clear comparison between standard and high-performance alloys, emphasizing how the latter deliver superior mechanical, thermal, and structural performance.

It also highlights the importance of heat treatment as a performance amplifier. By showcasing process capabilities and material behavior, this article builds a case for why material engineering is as important as tool and die design in the casting world.

UNDERSTANDING CRITICAL CASTINGS

Critical castings are components where failure is not an option. These parts are integral to the safety, functionality, or regulatory compliance of the end product.

Key examples include:

- Automotive: Brake calipers, suspension arms, battery enclosures
- Aerospace: Engine housing, control system mounts
- Medical: Surgical tools, orthopedic implants
- Energy: Enclosures for power electronics, high-pressure valves

Such parts must endure high stress, thermal variation, vibration, corrosion, and fatigue,all while maintaining dimensional stability and mechanical strength.

Image 1: Critical Castings

NORMAL ALLOYS VS. SPECIAL ALLOYS – A COMPARATIVE LENS

A comparative analysis between standard and special aluminium alloys used in critical castings is presented below:

Parameter	Standard Alloys (e.g., ADC12, LM6)	Special Alloys (e.g., A356, AlSi10Mg, Al-Cu-Mg)
Primary Focus	Castability, economy	Performance, durability
Strength & Elongation	Moderate	High (post-heat treatment)
Heat Treatable	Limited	Excellent response to T6/T7
Corrosion Resistance	General purpose	Optimized for harsh environments
Porosity Control	Moderate tolerance	Must be near-zero (often requires vacuum casting)
Thermal Conductivity	Standard	Tuned for thermal stability
Fatigue Resistance	Low	High – essential in dynamic environments
Machinability & Weldability	Good	Excellent – with proper composition
Typical Application	Housing, brackets, covers	Structural, load bearing, pressure-retaining parts

Image 2: Special Alloy

METAL TREATMENT – FROM FOUNDRY TO FUNCTIONALITY

Even the best alloy fails if melt treatment is poor. For critical castings, these treatments are indispensable:

- Degassing (Rotary/Argon) – Removes hydrogen, avoiding porosity
- Grain Refinement (Ti-B master alloys) – Enhances strength and machinability
- Modifier Additions (Strontium) – Refines eutectic silicon, improving elongation
- Filtration (Ceramic foam filters) – Eliminates inclusions and oxides
- Vacuum or Squeeze Casting – Reduces gas entrapment and shrinkage porosity

These treatments, when applied consistently, help achieve dense, homogenous, and reliable castings.

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Image 3: Modifiers

HEAT TREATMENT – UNLOCKING ALLOY POTENTIAL

Special alloys exhibit their full potential only after heat treatment, which enhances mechanical and fatigue properties:

Key Heat Treatment Types:

- T4 (Solution Heat Treatment + Natural Aging): Improves ductility; used when parts undergo forming post-casting
- T5 (Direct Aging after Casting): Increases hardness with faster throughput; ideal for pressure die castings
- T6 (Solution Heat Treatment + Artificial Aging): Widely used for critical parts; significantly boosts tensile and yield strength
- T7 (Overaging): Used for stress relief and dimensional stability in aerospace and thermal-critical parts

BENEFITS FOR CRITICAL CASTINGS:

- Doubles strength compared to as-cast
- Enhances fatigue resistance for dynamic environments
- Reduces distortion, ensuring tight tolerances
- Improves consistency, ensuring batch uniformity

However, heat treatment demands precise control of temperature, time, and quenching to avoid internal stresses or over-aging.

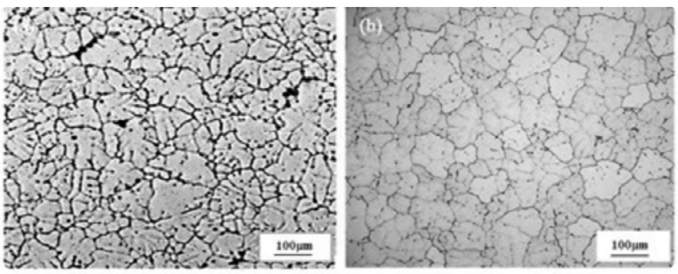

Image 4: Micro Structure

CONCLUSION

Casting Reliability Begins at the Molecular Level. In the journey from design to delivery, the reliability of a casting is ultimately decided at the material and metallurgical level.

As industries demand smarter, lighter, and tougher components, relying on conventional alloys may not be a right move.

Special aluminium alloys, enriched with the right mix of metal treatments and heat processing, offer a transformative advantage. They enable longer service life, fewer rejections, and enhanced safety margins...

To meet the challenges of tomorrow, foundries must invest today,in alloy knowledge, process control, and metallurgical discipline. Because in the world of critical castings, the core truly matters...

Happy die casting!

G. Praburam
Managing Director
Alubee Diecasters, Hosur

***

ALUCAST® 2025

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- Leveraging Automated Optimisation for Die Design and Casting Process through Simulation.
- Leak Testing in Castings: Techniques and Virtual Analysis Using Casting Simulation Software for Cost and Time Optimization
- Heat Treatment Process Simulation for Casting Applications
- Light Weighting of Aluminum Alloy Wheel using Flow Forming Process
- Minimizing Casting Scrap by the Collaborative Methodology of Engineering Expertise with Artificial Intelligence
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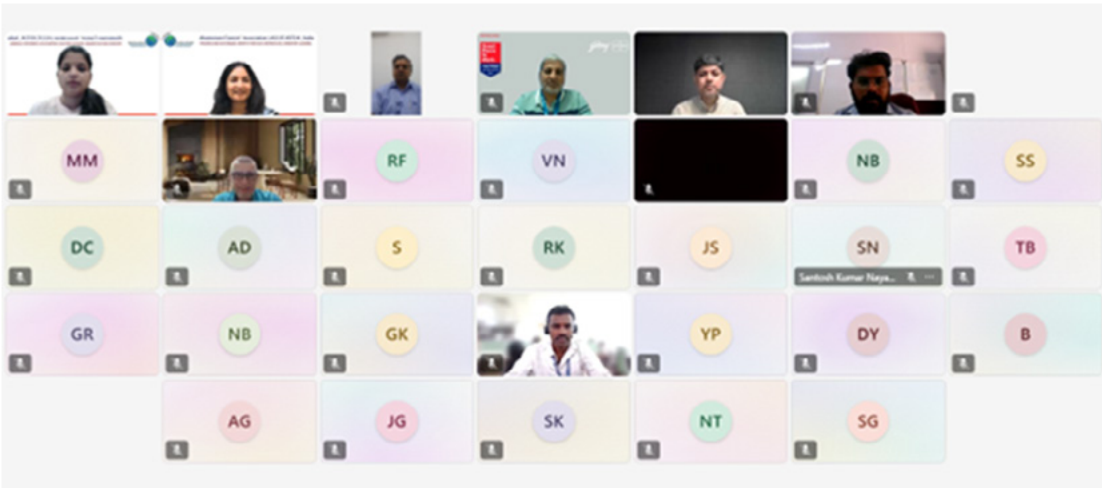
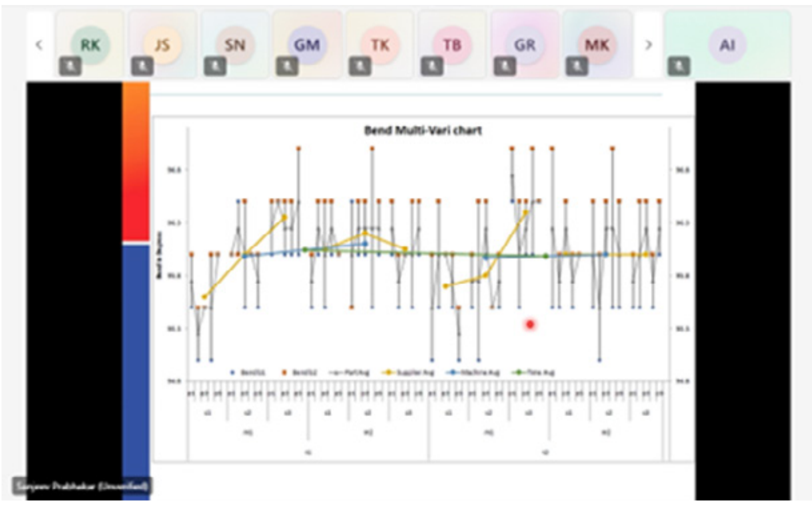
ALUCAST® Activities held in June - July 2025

Workshop Title	Data-Driven Approach to Problem Solving
Trainer	Mr. Sanjeev Prabhakar- Vice President R&D Business Excellence & PE - Rockman Industries Ltd.
Date	20th June 2025
Time	10.00am to 12.00noon
Location	Microsoft Teams
Duration	2 Hours

Topics Insight:

- Using facts and data to solve real-world problemstechniques to analyse processes and identify root causes.
- Techniques to analyze processes and identify root causes.
- Spotting bottlenecks and applying creative solutions.
- Building a data-driven mindset for problem resolution.

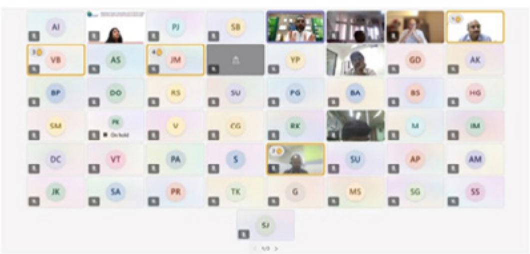


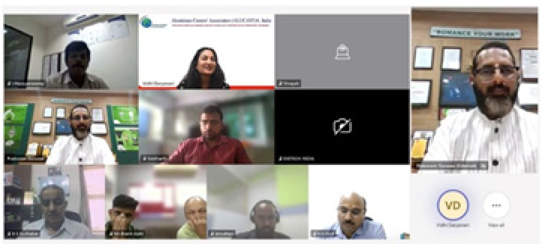


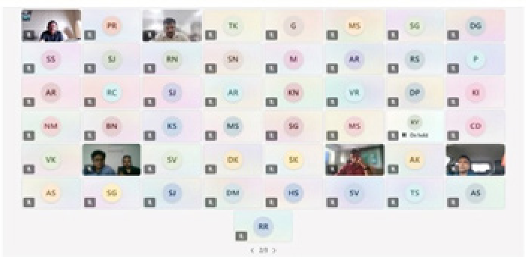
Workshop Title	Cost Management in Diecasting
Trainer	Mr. G. Praburam, Managing Director - Alubee Die Casters Honorary Secretary - ALUCAST Bangalore Zonal Centre
Date	25th June 2025
Time	03:00 pm to 04:15 pm
Location	Microsoft Teams
Duration	1:15 Hours

Topics Insight:

- Cost control through process optimization.
- Efficient use of materials and resources.
- Practical strategies for cost-effective production.
- Real-world case studies from industry experience.



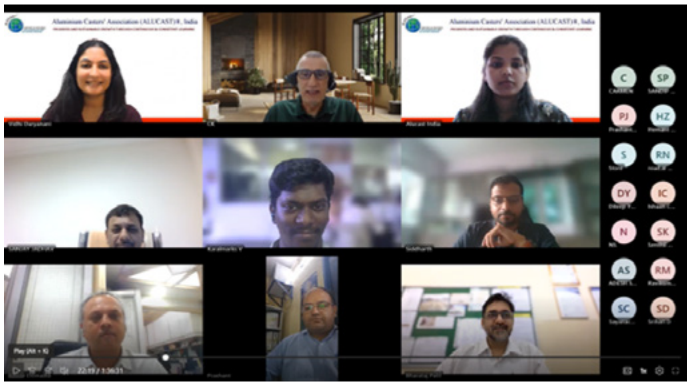


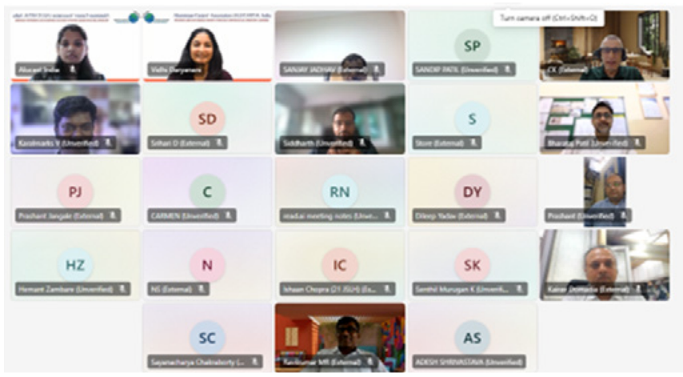


Workshop Title	The 10 Misconceptions When It Comes to Becoming Digital in Your operation.
Trainer	Mr. Christian Kleeberg Founder & Managing Partner, RGU ASIA PTE LTD
Date	18th July 2025
Time	03:00 pm to 04:30 pm IST
Location	Microsoft Teams
Duration	1:30 Hours

Topics Insight:

- Understanding the basics of digitalization
- Common misconceptions and ways to overcome them
- Real-life examples from indian shop floors
- Practical conclusions and industry-specific recommendations





Workshop Title	PQ² Diagram – Importance and its Application
Trainer	Mr. Rajesh Aggarwal, Founder & Director – TechSense Engineering Services
Date	23rd July 2025
Time	09:30 am to 06:30 pm
Location	ALUCAST Training Centre, Pune
Duration	1 Day

Topics Insight:

- In-depth Understanding of All Elements of the PQ² Diagram
- Practical Calculations with Real-World HPDC Examples
- Hands-On Experience in Constructing and Applying the PQ² Diagram

New Aluminium Alloys & Heat Treatment Process for Die Cast Parts

- Chaitanya Anil Daund , Jaya Hind Industries Pvt. Ltd.

ABSTRACT

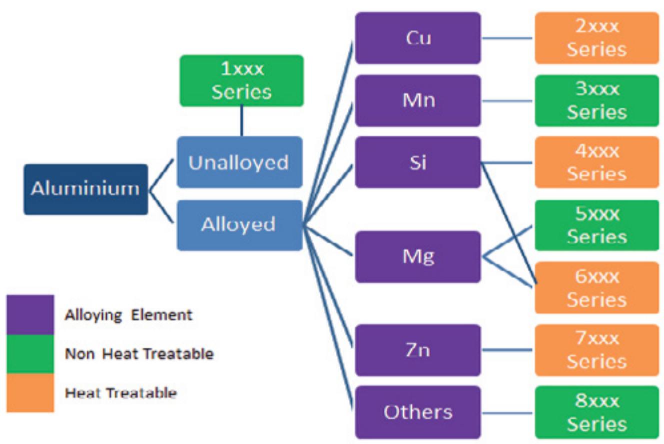
High-pressure die casting (HPDC) is widely used manufacturing process to produce complex, high-precision, close dimensional tolerances with smooth surface finish. Worldwide, HPDC accounts for approximately 50% of all Aluminium (Al) castings and these are commonly used for manufacturing automotive components and other consumer products. As automobile industries are undergoing significant transformations driven by technological advancements, regulatory changes and shifting consumer preferences, demand for lighter, stronger, and more durable components in Al alloys and heat treatment processes are pivotal. This article explores some of the latest Al alloys introduced in the market along with their composition, application and their specific heat treatment requirements in high-pressure die casting parts with one example.

INTRODUCTION

The use of Al casting in automobile parts began in the early 20th century. Al casting was initially limited to small components due to the high cost of Al compared to other materials. The demand for lightweight materials during World War II led to increased research and development in Al casting. The major automakers like General Motors and Ford started using Al to reduce vehicle weight and improve fuel efficiency. Today the automotive industries are focusing more on sustainability, fuel efficiency and performance. Thus innovations in Al alloy compositions and casting processes continued to expand aluminium role in modern vehicles.

OVERVIEW OF ALUMINIUM ALLOYS

Al alloys used in HPDC are generally categorized into two main groups: alloyed and unalloyed. Alloyed Al alloys are further classified into series based on their primary alloying elements such as copper, manganese, silicon, magnesium, zinc and others as follows:



Picture: Aluminium Alloy Categorization

In HPDC process, following Al alloys are been in use and are now well established like AlSi10Cu2Fe (ADC 12), AlSi9Cu3, AlSi5Cu3, AlMg5Si1, AlSi12, AlSi5Cu3, AlSi6Cu4, AlSi8Cu3Fe, AlSi7Mg, AlSi12Cu, AlSi12CuFe, AlSi7Cu3Mn0.5, AlSiMg0.3 etc.

INNOVATION IN AL ALLOYS

The trend of increasing Al content in vehicles is growing to meet regulatory requirements, enhance performance, improve fuel efficiency, increase safety and to address sustainability concerns. According to consultancy firm Ducker Carlisle, the average amount of Aluminium content per passenger vehicle in the year 2006 was 121Kg, in 2022 205Kg and in 2030 it will be 256kg. This report shows aluminium is replacing other materials in the vehicle and it is possible because of recent advancements have introduced several innovative Al alloys designed to meet performance requirements, precision and complexity requirements, enhanced safety and durability which are meeting application specific needs of the vehicle. Thus car manufactures have started using several advanced Al alloys in combination with High-Pressure Die Casting (HPDC) and heat treatment process to manufacture various structural and electric light weight body parts which not only suit their qualitative requirements but also quantitative requirement. Few of these are as listed below:

1. AlSi10Mg

- Composition: Approximately 90% Al, 10% Silicon, 0.3% Magnesium
- Application: Engine components, Chassis Components, Underbody components, transmission cases and other structural parts.
    a. Example : Rear Underbody Casting
    b. Part Application: This part is a large, single-piece casting that replaces multiple welded components.
- It enhances structural integrity, reduces weight, and improves crashworthiness.
- Heat Treatment Process: Preferred
    a. Solution Heat Treatment: Typically done at 465-540°C to dissolve alloying elements into a solid solution.
    b. Aging: Followed by aging at around 160-190°C for several hours to develop strength and hardness.
- Benefits of Heat Treatment: To enhance mechanical properties such as strength and ductility, ensuring the part can withstand structural loads and impacts.

2. AlSi7Mg

- Composition: Approximately 91% Al, 7% Silicon, 0.5% Magnesium
- Application: Engine blocks, structural automotive components.
    a. Example: Front and Rear Subframes
    b. Part Application: These subframe supports the engine and suspension components, providing strength and stiffness to the vehicle's front end.
- Heat Treatment Process: Generally not required, but can be carried out if recommended.
    a. Solution Heat Treatment: Typically done at 465-540°C
    b. Aging: Followed by aging at 160-190°C.
- Benefits of Heat Treatment: To improve the alloy's mechanical strength and fatigue resistance, crucial for supporting dynamic loads in the vehicle's front end.

3. AlSi9Cu3

- Composition: Approximately 89% Al, 9% Silicon, 3% Copper
- Application: Engine blocks, pump housings, and complex automotive parts.
    a. Example: Cylinder Block
    b. Part Application: It is critical component in internal combustion engines.
- Heat Treatment Process: Generally not required, but can be carried out if recommended.
    a. Stress Relieving: The part is heated to a lower temperature at around 150-200°C to reduce internal stresses without significantly altering the mechanical properties.
    b. Natural Aging : Allowing the cast parts to age at room temperature
- Benefits of Heat Treatment: To prevent warping, cracking, or dimensional changes due to internal stresses. Enhances strength and wear resistance, crucial for handling the mechanical stresses.

4. AlSi12

- Composition: Approximately 88% Al, 12% Silicon.
- Application: Structural components and electric vehicle housings.
    a. Example: Battery Pack Housings
    b. Part Application: Battery pack housing is large casting which enhances structural rigidity and crashworthiness.
- Heat Treatment Process: Not Preferred

5. AlSi10MnMg

- Composition: Approximately 90% Al, 10% Silicon, 0.3% Magnesium, 0.1% Manganese.
- Application: Light weight Structural body parts and electric vehicle parts.
    a. Example: Body Panels
    b. Part Application: Provides durability and high strength-to-weight ratio for the body panels.

- Heat Treatment Process: Preferred
    a. Solution Heat Treatment: Typically done at 465-540°C
    b. Aging: Performed at 160-190°C.
- Benefits of Heat Treatment: To achieve high strength and wear resistance, essential for the demanding requirements of off-road and high-stress environments.

6. AlSi5Cu1Mg

- Composition: Approximately 94% Al, 5% Silicon, 1% Copper, 0.5% Magnesium.
- Application: Structural components
    a. Example: Rear Upper Control Arm
    b. Part Application: Connects the suspension to the vehicle's body, critical for handling and stability.
- Heat Treatment Process: Generally not required, but can be carried out if recommended.
    a. Solution Heat Treatment: Typically done at 465-540°C
    b. Aging: Followed by aging at 160-190°C.
- Benefits of Heat Treatment: Enhances strength and fatigue resistance, important for the control arm's performance under dynamic loads.

7. AlSi9Cu3MgNi

- Composition: Approximately 88% Al, 9% Silicon, 3% Copper, 0.5% Magnesium, 0.5% Nickel.
- Application: High-strength components, structural parts, and wear-resistant parts.
    a. Example: Brake Calipers
    b. Part Application: Needs to withstand high stress and temperature, making this alloy suitable for brake calipers.
- Heat Treatment Process: Generally not required, but can be carried out if recommended.
    a. Solution Heat Treatment: Typically done at 465-540°C
    b. Aging: Followed by aging at 160-190°C.
- Benefits of Heat Treatment: To enhance strength and thermal stability, critical for highperformance brake components.

8. AlSi10Cu2Fe

- Composition: Approximately 88% Al, 10% Silicon, 2% Copper and small amounts of Iron.
- Application: Engine components, pump housings and parts subjected to high wear.
    a. Example: Steering Knuckles
    b. Part Application: Connects the suspension to the wheels, requiring high strength and durability.
- Heat Treatment Process: Generally not required, but can be carried out if recommended.
    a. Solution Heat Treatment: Typically done at 465-540°C
    b. Aging: Followed by aging at 160-190°C.
- Benefits of Heat Treatment: To improve mechanical properties and wear resistance, ensuring reliable performance in steering applications.

9. AlSi11Cu(Fe)

- Composition: Approximately 86% Al, 11% Silicon, 2% Copper and small amounts of Iron.
- Application: Structural automotive components, engine components, and complex castings.
    a. Example: Powertrain Housing
    b. Part Application: Houses the powertrain components, requiring a balance of strength and lightweight properties.
- Heat Treatment Process: Generally not required, but can be carried out if recommended.
    a. Solution Heat Treatment: Typically done at 465-540°C
    b. Aging: Followed by aging at 160-190°C.
- Benefits of Heat Treatment: To enhance the strength and hardness of the housing, ensuring durability and safety.

10. AlSi12CuFe

- Composition: Approximately 85% Al, 12% Silicon, 3% Copper and small amounts of Iron.

- Application: Motor Housings and structural parts.
    a. Example: Door Handles
    b. Part Application: Requires good castability and strength, making this alloy suitable for high-quality door handles.
- Heat Treatment Process: Generally not required, but can be carried out if recommended.
    a. Solution Heat Treatment: Typically done at 465-540°C
    b. Aging: Followed by aging at 160-190°C.
- Benefits of Heat Treatment: To improve the mechanical properties and ensure the durability of the door handles.

11. AlSi17Cu4Mg

- Composition: Approximately 79% Al, 17% Silicon, 4% Copper and 0.5% Magnesium.
- Application: High-strength automotive components, high-stress structural parts.
    a. Example: Battery Pack End Caps
    b. Part Application: Provides structural support and protection for the battery pack.
- Heat Treatment Process: Preferred
    a. Solution Heat Treatment: Typically done at 465-540°C
    b. Aging: Followed by aging at 160-190°C.
- Benefits of Heat Treatment: To enhance the alloy's strength and wear resistance, ensuring the battery pack can handle mechanical stresses and environmental conditions.

12. AlSiMnMgZr

- Composition: Approximately 85% Al, 10% Silicon, 2% Manganese, 1% Magnesium and small amounts of Zirconium.
- Application: Structural components, High-performance automotive parts and parts requiring high strength and corrosion resistance.
    a. Example: Suspension Components
    b. Part Application: These components require high strength and durability, making this alloy suitable for the harsh conditions of off-road driving.
- Heat Treatment Process: Generally not required, but can be carried out if recommended.
    a. Solution Heat Treatment: Typically done at 465-540°C
    b. Aging: Followed by aging at 160-190°C.
- Benefits of Heat Treatment: To achieve high strength and resistance to wear and corrosion, essential for off-road and heavy-duty use.

13. AlSi9MnMgZn

- Composition: Approximately 88% Al, 10% Silicon, 0.6% Manganese, 0.6% Magnesium and Zinc 0.5%
- Application: Structural components, Light weight car body structures, gear boxes, battery housing parts.
    a. Example: Battery housing component
    b. Part Application: It provides structural protection to the battery cells, ensuring safety and durability.
- Heat Treatment Process: Preferred
    a. Solution Heat Treatment: Typically done at 465-540°C
    b. Aging: Followed by aging at 160-190°C.
- Benefits of Heat Treatment: To enhance the strength and stiffness required for handling the stresses and dimensional stability.

HEAT TREATMENT PROCESS

Effective heat treatment is essential in unlocking the full potential of these advanced Al alloys. The heat treatment processes for high pressure die casting parts typically include T5, T6 and T7 heat treatment and the process includes Stress Relieving Heat Treatment, Solution Heat Treatment, Aging and Quenching. T5 and T6 are commonly used for parts where strength and durability are critical, with T6 providing higher strength. T7 is used when additional dimensional stability is required.

Solution heat treatment, aging, and quenching are steps in achieving specific material properties, while stress relieving ensures stability and prevents warping. The choice of heat treatment method and requirement depends on part application, desired mechanical properties, dimensional stability, etc.

1. Stress Relieving Heat Treatment

This post-casting process helps in reducing residual stresses introduced during casting. It involves heating the parts to a lower temperature (typically around 150-200°C or 300-400°F) and then allowing them to cool gradually. This step is especially important for complex geometries prone to warping.

2. Solution Heat Treatment:

This post-casting process helps to achieve maximum strength and hardness, enhancing mechanical properties. It involves heating the alloy to a temperature where the alloying elements dissolve into the Al matrix, followed by rapid cooling. Al alloy is solution heat-treated at around 465 540°C (1000°F) to dissolve silicon and other elements, which is crucial for achieving the desired mechanical properties.

It should be also noted that, high pressure die cast parts cannot be normally heated at high temperatures due to the presence of pores containing entrapped gases, which lead to the formation of surface blisters. Blistering can be avoided with improved porosity level and by using considerably shorter solution treatment time and temperature.

3. Aging

Aging is carried out to enhance the strength and hardness of the aluminum alloy by precipitating fine particles within the matrix. Aging is carried out in two ways:

Natural Aging: This process allows the cast parts to age at room temperature, which can improve strength and hardness over time.

Artificial Aging: It is also known as precipitation hardening, this involves heating the parts to a specific temperature to accelerate the hardening process. For instance, T6 tempering involves aging at around 155°C (310°F) to significantly enhance tensile strength.

4. Quenching:

After solution heat treatment, quenching is employed to rapidly cool the parts, typically by immersion in water or oil. It helps locking the alloying elements in solution and preventing the formation of unwanted phases. This step is critical for achieving the desired hardness and dimensional stability of cast part.

SUMMARY

The continuous development of new Al alloys and refinement of heat treatment processes are driving significant advancements in high pressure die casting process. These innovations are enabling the production of lighter, stronger, and more durable components across various industries. The parts produced are providing improved performance, mechanical properties, better thermal resistance and enhanced corrosion resistance in its usage from critical engine components in traditional vehicles to structural and protective parts in modern electric vehicles. As technology progresses, the focus will remain on optimizing these materials and processes to meet the everevolving demands of modern manufacturing.

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Effect of Mg Content on the Shear Strength of Die-Cast Al-Si-Mg and Al-Si- Cu Alloys at Elevated Temperatures

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ABSTRACT

Aluminum die casters since the early 20th century have been plagued with challenges unique to the process. Some of these persist today, one of the most common being soldering. Soldering is observed to be aluminum bonded to the die surface and has historically been associated with Al-Fe intermetallic forming between the molten aluminum alloy and the die steel during the casting process. Researchers on the topic have recently been given a new thermomechanical model that rebuts the deep-rooted thermodynamics and kinetics-based theoretical understanding of soldering.

This new model accounts for the strength of the aluminum alloy, specifically the shear strength, as a function of temperature. This work fills in the knowledge gap of die cast aluminum shear strength at elevated temperatures observed at the time of part ejection. To further test the model, varying amounts of magnesium were added to A356, A362, and A380 to increase the alloy shear strength. Data from the experiment shows the shear strength increased with increasing amounts of magnesium even at higher temperatures.

INTRODUCTION

Die cast aluminum alloys are widely used in various industries due to their excellent combination of mechanical properties, low density, and good corrosion resistance. These alloys are particularly favored for applications up to 200°C requiring high strength and lightweight components, such as automotive and aerospace industries [1]. However, the mechanical performance of aluminum alloys, including shear strength, can be significantly influenced by alloy composition and processing conditions [2]. One crucial element in aluminum alloys is magnesium, which is commonly added as an alloying element to enhance mechanical properties. Magnesium plays a vital role in the solidification process, grain refinement, and precipitation hardening mechanisms of aluminum alloys. When present with the addition of silicon, magnesium forms the intermetallic compound Mg2 Si that strengthens the matrix, improving the alloy's overall strength and mechanical properties.

Magnesium silicide has a high melting point (1087°C) and high hardness (4500 N/mm2) with a typical size range of around 30 nm making it perfect for pinning dislocations 3. Yang et al. found that Mg additions increased the strength of die cast specimens 10%, from 0% wt.% Mg (302 MPa UTS) to 0.9 wt.% Mg (332 MPa UTS) in the as-cast condition in Al–Si–Cu alloys (AA 3xx series) 4. At 557°C, Mg2 Si precipitates out along with Al2 Cu (θ) making both phases of interest, but relatively high levels of copper, as in A380, destroys the corrosion resistance of aluminum which is critical in certain applications such as marine components.

While the effect of magnesium and magnesium silicide on the mechanical properties of Al-Si alloys has been extensively studied 4 5 6 7 8 9 10 11, limited research has been conducted to specifically investigate its influence on shear strength at elevated temperatures. Understanding the relationship between magnesium content and shear strength is crucial, especially in applications where the components are subjected to high-temperature conditions, such as engine components, heat exchangers, and power transmission systems. Moreover, the high temperature shear strength of aluminum alloys has recently become of interest for the prevention of solder during the die casting process.

Figure 1- Die cast tooling with solder at end of core pin (photo courtesy of Mercury Marine).

Soldering (Figure 1) is a common defect encountered in aluminum die casting, where aluminum material from the casting surface adheres to the die surface. Historically this phenomenon has been associated with the Al-Fe intermetallics commonly found in die solder but recently a new thermomechanical model suggests that Al-Fe intermetallics fail to form during a casting cycle kinetically and that solder is a symptom of sticking 12. Monroe goes on to provide Equation 1 where the Tresca friction factor, Tr, is the ratio of the shear strength of the casting/die interface, $\tau\tau_{eeee}$, and the shear strength of the aluminum as a function of temperature, $\tau\tau_{AAAA}$ 13.This model suggests if the shear strength of aluminum die cast alloys is increased, especially at high temperatures, then the tendency to solder will decrease because the Tresca friction factor will be below the 0.7 threshold.

$$Tr = \frac{\tau_{ej}}{\tau_{Al}(T)} < 0.7 \qquad \text{eq. 1}$$

The clean ejection of a die casting results from the shear strength of the aluminum-steel interface to be the weakest compared to the shear strength of the cast alloy and tooling material 12. How differences in alloy chemistry affect the underlying mechanism-property relationship that controls aluminum's elevated temperature shear strength is still not clear. To expand our knowledge on this unknown, this paper aims to investigate the effect of varying magnesium content on the shear strength of commonly die cast aluminum alloys at elevated temperatures.

MATERIAL & METHODS

PREPARATION OF THE ALLOYS

The aluminum alloys used in this study were high pressure die cast (HPDC) A356, A362, and A380 with varying magnesium concentrations (Table 1). 0.94±0.03 kg of each base alloy (A356, A362, and A380), of known compositions, were individually melted using induction in a clay-graphite crucible. 50/50 Aluminum-magnesium master alloy was then added to raise the magnesium concentration from the base alloy levels to 0.4%, 0.6%, 0.8%, and 1.0% Mg for each alloy. Note that A362 has a higher Mg base content and thus started at 0.6% Mg.

Table 1- Composition of die cast Al-Si-Mg alloys with varying Mg contents used in this study (wt%).

Alloy	Mg	Si	Ti	Cr	Mn	Fe	Ni	Cu	Zn	Sr	Al
A356	0.29-1.0	6.91	0.12	0.01	0.01	0.20	0.01	0.01	0.01	0.018	Bal.
A362	0.58-1.0	10.86	0.09	0.01	0.29	0.46	0.01	0.04	0.02	0.044	Bal.
A380	0.04-1.0	8.14	0.06	0.06	0.22	0.83	0.07	3.01	1.56	0.003	Bal.

Once the melt temperature reached the targeted pouring temperature specified for each alloy (Table 2), the dross from the melt was removed, and the alloy poured into an 800-ton high pressure die cast machine to cast tensile bars (Figure 2). After ejection, parts were degated and left to air cool.

Table 2- Pouring temperature for each alloy. Temperature was measured before being poured into the shot chamber.

Alloy	Pouring Temperature (°C)
A356	723 ± 11
A362	679 ± 8
A380	653 ± 5

Figure 2- Tensile bar die casting. Hot shear specimens were taken from the middle-reduced section of the tensile bars.

Shear specimens were machined out of the die cast tensile bars to modified ASTM B769-11 specifications measuring Ø10.097mm x 100mm. To effectively heat the aluminum specimens, both ends of the samples were drilled out to accept a ¼" diameter 100W insertion heater. The drilled section of the specimens with the heaters installed was confirmed to not interfere with the stress-strain fields of the test using finite element analysis (FEA). The shear specimens were taken from the reduced section of the tensile bar 1) for consistent cooling rate throughout the reduced section of the bar and 2) lowest amount of porosity present identified using x-ray (Figure 3).

Figure 3- X-ray image of shear specimen showing a porosity free center testing region. The light regions of either end of the specimen are the bores for the insertion heaters.

HOT SHEAR TESTING

Shear testing of the alloys was performed using an Instron 6800F-100kN tensile tester with an Amsler shear tool (Figure 4). To perform the shear test at elevated temperatures, the fixture and samples were modified from the ASTM B769 standard as the standard is written for testing only at room temperature. To measure the temperature of the specimen, a threaded hole was added to the center shear die to which a threaded K-type thermocouple was inserted.

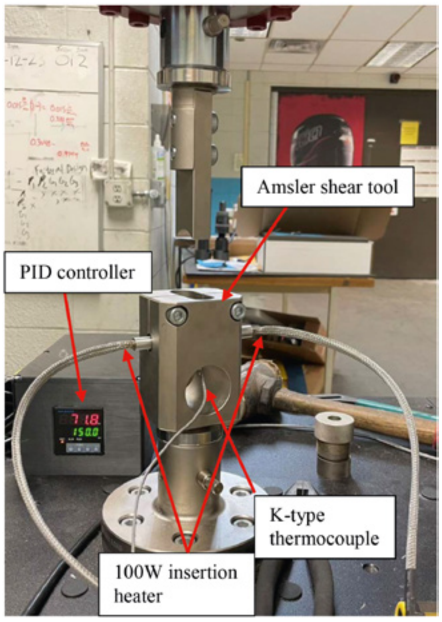

Figure 4- Hot shear testing set up using Amsler shear tool and insertion heaters controlled by PID.

The diameter of the bar was measured using a Mitutoyo 293-832-30 digital micrometer at the two shear planes then averaged per ASTM B769. The specimens were then inserted into the fixture and heated using the two 100W insertion heaters. The temperature was regulated using a PID controller. The shear tests were conducted at a crosshead speed of 1 mm/min 14.

TRANSMITION ELECTION MICROSCOPY (TEM)

Samples for TEM analysis were cut from the broken shear specimens at the shear plane using electrical discharge machining (EDM) then ground down to ~100µm before being electropolished (15V, 80µA, -30°C) using 30% nitric acid in methanol to the final thickness. Microscopy images were taken using a FEI 200kV Titan Themis scanning TEM with the viewing orientation perpendicular to the shear plane.

RESULTS AND DISCUSSION

AS-CAST SHEAR STRENGTH OF AL–MG–SI ALLOYS WITH VARYING MG LEVELS

The effect of Mg levels on the hot shear strength of diecast A356 alloys in the as-cast (F) condition is shown in Figure

5. The general trend shows the elevated Mg alloys maintained a higher shear strength over the base alloy; however, at 200°C the shear strengths start to converge. This is about the onset temperature of creep (~0.5 Tmelt) 15. To resist creep, a dispersion of fine and stable particles is needed which A356 lacks compared to A362 and A380. The shear strength was set to zero at the liquidus temperature of the alloys because shear strength is a property of solid-state matter. Therefore, liquid aluminum does not have a definitive shear strength value. At room temperature, there is a considerable 23% increment in the shear strength from 151.5MPa (0.29% Mg) to 185.8MPa (1.0% Mg). However, the temperature range of interest for this study is at ejection temperatures of hot spots typically found at the tips of core pins in heavy sections which is in the 200°C-400°C range. At 300°C, there is a 16% increase in shear strength from 54.9MPa (0.29% Mg) to 63.7MPa (1.0% Mg) which equates to a 16°C increase in ejection temperature tolerance. According to the Tresca friction factor (Eq. 1), a casting on the edge of soldering (Tr~0.7) locally at 284°C would now be solder free.

The effect of Mg levels on the hot shear strength of diecast A362 alloys in the as-cast (F) condition is shown in Figure 6. Interestingly, the effect of Mg is negligent for A362 at room temperature, but at higher temperatures the elevated Mg alloys were significantly stronger. This likely is due to the increase in eutectic Si and other intermetallic particles. At 300°C, there is a 31% increase in shear strength from 51MPa (0.58% Mg) to 66.6MPa (1.0% Mg) which equates to a 38°C increase in ejection temperature tolerance.

The effect of Mg levels on the hot shear strength of diecast A380 alloys in the as-cast (F) condition is shown in Figure 7. The elevated Mg content in A380 had the largest effect of the three alloys showing the highest shear strength over any alloy. At room temperature, there is another considerable 22% increment in the shear strength from 183MPa (0.29% Mg) to 223.4MPa (1.0% Mg). At 300°C, there is a 34% increase in shear strength from 50.8MPa (0.29% Mg) to 68.2MPa (1.0% Mg) which equates to a 42°C increase in ejection temperature tolerance.

The results from the hot shear testing show that adding Mg to non-tradition die cast alloys, being A356 in this paper, can increase the shear strength to levels seen in traditionally cast alloys. The shear strength of A356Mg1 at 300°C exceeded that of the base A380 alloy. Table X1.1 in ASTM B85-18 arbitrarily rates A380 a best performer in anti-soldering to the die 16. Although there is no data supporting the rating system, it would be hypothesized that the A356Mg1 alloy would have a similar rating. An experiment measuring the solderability of the alloys in this study is required to answer this unknown.

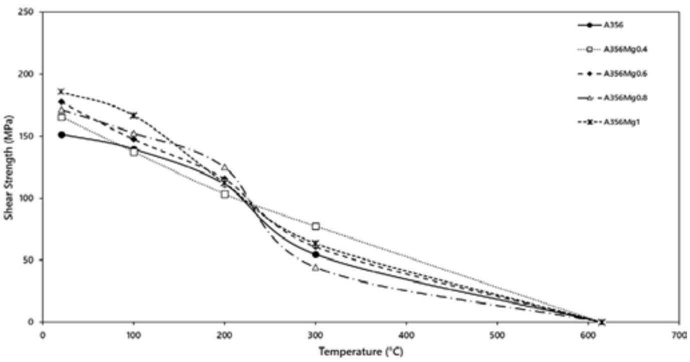

Figure 5- Effect of Mg content on the shear strength of A356 in the as-cast condition over a temperature range of 20°C - 600°C.

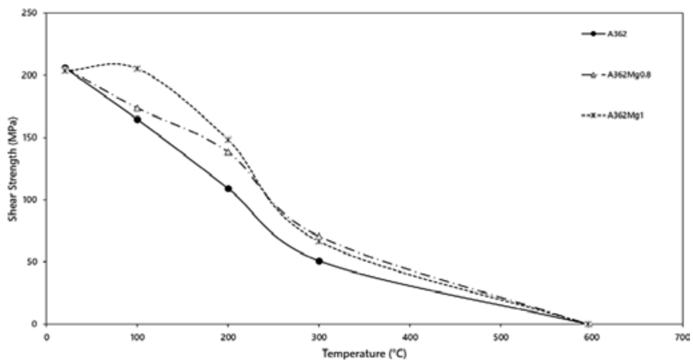

Figure 6- Effect of Mg content on the shear strength of A362 in the as-cast condition over a temperature range of 20°C - 600°C.

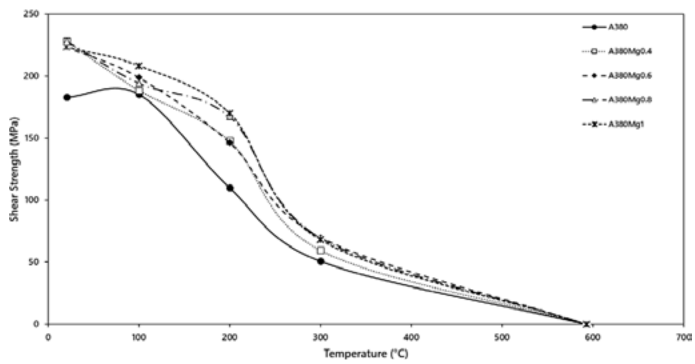

Figure 7- Effect of Mg content on the shear strength of A380 in the as-cast condition over a temperature range of 20°C - 600°C.

TEM OF AS-CAST A380

The effect of Mg levels on the microstructure of diecast A380 alloys in the as-cast (F) condition is shown in Figure 8. Figure 8a shows the dislocation-Si and dislocation-Al2 Cu (θ) precipitate interactions in the base A380 alloy. Very little Mg2 Si is present due to the low Mg levels in the alloy thus, the strength is mainly due to the coherent Al2 Cu (θ) precipitates and the misfit strain field around the semi-coherent Si precipitates 1 17.

In contrast, Figure 8b shows the dislocation-Si and a high-volume fraction of dislocation-Al3 Cu2 Mg9 Si7 precipitate interactions in the A380Mg1 alloy. The dislocations can be seen to be pinned by the Mg2 Si precipitates which contributed to the higher shear strength of the A380Mg alloys.

CONCLUSION

Elevated levels of Mg in Al-Si-Mg and Al-Si-Cu alloys showed an increase in the shear strength across the temperatures tested. At the temperatures of interest, the higher Mg alloys would be predicted to have higher solder resistance based on the Tresca friction criteria.

It was shown that adding a strengthening mechanism to a non-traditional die cast alloy, in this case Mg2 Si in A356, can increase its shear strength to levels above that of the best solder resistant die cast alloys. The increased strength was shown via TEM to be from the increased volume fraction of Mg rich intermetallic particles and their interaction with dislocations.

ACKNOWLEDGMENTS

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Segment wise Comparative Production, Domestic Sales & Exports data for the month of May 2025

Report I - Number of Vehicles									
Category	Production			Domestic Sales			Exports		
Segment/Subsegment	April			April			April		
	2024	2025	% Change	2024	2025	% Change	2024	2025	% Change
Passenger Vehicles (PVs)*									
Passenger Cars	1,42,367	1,36,859	-3.9%	1,06,952	93,951	-12.2%	28,802	33,902	17.7%
Utility Vehicles(UVs)	2,13,462	2,38,226	11.6%	1,82,883	1,96,821	7.6%	24,490	32,411	32.3%
Vans	13,819	14,406	4.2%	10,960	12,327	12.5%	699	868	24.2%
Total Passenger Vehicles (PVs)	**3,69,648**	**3,89,491**	**5.4%**	**3,00,795**	**3,03,099**	**0.8%**	**53,991**	**67,181**	**24.4%**
Three Wheelers									
Passenger Carrier	63,637	75,676	18.9%	45,445	44,354	-2.4%	22,448	30,838	37.4%
Goods Carrier	9,918	10,504	5.9%	8,863	8,720	-1.6%	292	246	-15.8%
E-Rickshaw	1,106	1,230	11.2%	1,203	720	-40.1%	-	-	-
E-Cart	218	145	-33.5%	252	148	-41.3%	-	-	-
Total Three Wheelers	**74,879**	**87,555**	**16.9%**	**55,763**	**53,942**	**-3.3%**	**22,740**	**31,084**	**36.7%**
Two Wheelers									
Scooter/ Scooterettee	6,05,114	6,76,490	11.8%	5,40,866	5,79,507	7.1%	50,844	47,182	-7.2%
Motorcycle/Step-Throughs	13,64,299	13,89,167	1.8%	10,38,824	10,39,156	0.0%	2,62,023	3,33,149	27.1%
Mopeds	41,033	39,133	-4.6%	40,394	37,264	-7.7%	264	648	145.5%
Total Two Wheelers	**20,10,446**	**21,04,790**	**4.7%**	**16,20,084**	**16,55,927**	**2.2%**	**3,13,131**	**3,80,979**	**21.7%**
Quadricycle									
Quadricycle	664	371	-44.1%	32	1	-96.9%	656	294	-55.2%
Grand Total of All Categories	**24,55,637**	**25,82,207**	**5.2%**	**19,76,674**	**20,12,969**	**1.8%**	**3,90,518**	**4,79,538**	**22.8%**

*** BMW, Mercedes,JLR, Tata Motors and Volvo Auto data is not available. Society of Indian Automobile Manufacturers (16/06/2025)**

Segment wise Comparative Production, Domestic Sales & Exports data for the month of June 2025

Report I - Number of Vehicles									
Category	Production			Domestic Sales			Exports		
Segment/Subsegment	April			April			April		
	2024	2025	% Change	2024	2025	% Change	2024	2025	% Change
Passenger Vehicles (PVs)*									
Passenger Cars	1,20,577	1,01,882	-15.5%	1,00,406	85,091	-15.3%	41,250	41,371	0.3%
Utility Vehicles(UVs)	2,05,126	2,17,572	6.1%	1,83,056	1,81,335	-0.9%	34,160	34,051	-0.3%
Vans	8,802	9,151	4.0%	10,771	9,340	-13.3%	887	1,297	46.2%
Total Passenger Vehicles (PVs)	**3,34,505**	**3,28,605**	**-1.8%**	**2,94,233**	**2,75,766**	**-6.3%**	**76,297**	**76,719**	**0.6%**
Three Wheelers									
Passenger Carrier	74,412	82,946	11.5%	48,780	51,350	5.3%	25,673	36,741	43.1%
Goods Carrier	9,610	8,888	-7.5%	9,166	9,141	-0.3%	387	447	15.5%
E-Rickshaw	945	665	-29.6%	1,208	1,043	-13.7%	-	-	-
E-Cart	306	77	-74.8%	390	294	-24.6%	-	-	-
Total Three Wheelers	**85,273**	**92,576**	**8.6%**	**59,544**	**61,828**	**3.8%**	**26,060**	**37,188**	**42.7%**
Two Wheelers									
Scooter/ Scooterettee	5,92,453	5,70,627	-3.7%	5,42,851	5,33,875	-1.7%	39,262	43,586	11.0%
Motorcycle/Step-Throughs	12,82,186	13,37,331	4.3%	10,30,906	9,92,627	-3.7%	2,49,621	3,42,892	37.4%
Mopeds	41,115	35,372	-14.0%	40,397	33,349	-17.4%	84	1,284	1428.6%
Total Two Wheelers	**19,15,754**	**19,43,330**	**1.4%**	**16,14,154**	**15,59,851**	**-3.4%**	**2,88,967**	**3,87,762**	**34.2%**
Quadricycle									
Quadricycle	723	357	-50.6%	28	-	-	594	462	-22.2%
Grand Total of All Categories	**23,36,255**	**23,64,868**	**1.2%**	**19,67,959**	**18,97,445**	**-3.6%**	**3,91,918**	**5,02,131**	**28.1%**

*** BMW, Mercedes,JLR, Tata Motors and Volvo Auto data are not available. Society of Indian Automobile Manufacturers (15/07/2025)**

ALUMINIUM - STRONG SUBSTITUTE IN LIGHTWEIGHTING, SAYS VEDANTA ALUMINIUM CMO ALOK RANJAN

As automakers prioritize lower emissions and better fuel economy, its integration into non-load-bearing components is accelerating.

The automotive industry is looking for more efficiency and sustainability with a focus on lightweighting for better fuel efficiency, lower emissions and improved performance. Aluminium is emerging as a critical enabler for lightweighting, an alternative to steel particularly on non-load-bearing parts.

Lightweighting has become a necessity with its ability to reduce costs, enhance fuel efficiency and lower carbon emissions, according to Alok Ranjan, Chief Marketing Officer of Vedanta Aluminium, who was speaking at the Autocar Professional's Vehicle Lightweighting Webinar.
"Aluminium, with two-thirds the density of steel, is highly durable, corrosion-resistant, and infinitely recyclable, making it a very strong substitute for various parts of an automobile," Ranjan said.

Aluminium offers a great advantage in vehicle lightweighting, being significantly lighter than steel. Its lower weight directly improves fuel economy and lowers emissions, making it a compelling choice for OEMs and advanced vehicle designs. Aluminum enables manufacturers to produce more efficient vehicles without compromising on performance or safety.
Vedanta Aluminium, India's largest aluminum producer and among the top six globally, is at the forefront of this transition. The company has an annual capacity of nearly 3 million tonnes of aluminum, with over 700 kilotonnes dedicated to automotive-grade alloys.

With the launch India's first primary foundry alloy (PFA) for alloy wheels in 2019, Vedanta has become a leading supplier to the automotive industry, providing materials for wheels, engine blocks, and a growing range of EV components.

The company offers three products from aluminium which goes into various components of an automobile - PFA which goes into alloy wheels, pellets which go into making extrusion for body parts and then mold products which can go into sheets in various parts of the automobile.

Ranjan noted that the properties of aluminium – infinitely recyclable, highly durable, and corrosion resistant - translate into significant benefits for vehicle manufacturers and consumers alike, and makes it an important source of lightweighting. Lightweighting through aluminum can lead to a 4-5% reduction in carbon emissions, a 22% mass saving, and roughly a 5% reduction in cost per mile, he added.

"When we talk about speed or acceleration, which is also an important criterion, aluminum vehicles have far better pickup and acceleration. Thanks to the lower mass, there is an edge. Also since it is durable, recyclable and corrosion resistant, the cost of maintenance is typically on the lower side, it could be 10-15% lower as compared to its alternative," Ranjan said.

When it comes to battery performance, he said aluminum offers significant benefits there as well. "When we look at the battery life, aluminum usage results in much lesser frequent charging cycles and much better longevity of the battery. This is especially important as energy storage becomes an important criterion."

Though aluminum may present a higher upfront material cost compared to steel, Ranjan emphasized the importance of looking at the total cost of ownership. Considering its positive impact on fuel economy, reduced maintenance needs, extended battery life, and higher resale or salvage value due to its recyclability, aluminum presents a more economically favorable choice.

Going forward, Ranjan sees strong growth potential for aluminum. Right now, per capita consumption of aluminum in India is one eight despite being the third largest car maker. Aluminum usage per vehicle in India is 70-80% of global standards. However, government policies focusing on cleaner and efficient vehicles provide a significant growth potential.

"So, there is a policy push, there is a sustainability push. And if we rely on the data coming from other countries like China or the West, we see significant growth in terms of EVs which again means up to 80 kgs per vehicle more aluminum usage," he added.

According to Ranjan, the requirement of aluminum in India is at around 6 million tonnes per annum, while the current capacity is around 4 million tons. Vedanta Aluminium is augmenting its capacity to around 5 million tons.

DIE-CASTING ZINC ALLOY IMPORTS AND EXPORTS IN MAY SHOW MIXED PERFORMANCE: WHAT'S NEXT?

According to the latest customs data, China's imports of unwrought zinc alloy reached 4,285.04 mt in May, up 13.60% MoM and 21.62% YoY. Exports fell to 168.68 mt, down 86.84% MoM and 79.09% YoY.

From the perspective of specific importing and exporting countries

The top three countries for China's unwrought zinc alloy imports in May were South Korea (1,370.46 mt), Malaysia (1,197.89 mt), and Japan (595.73 mt), accounting for 31.98%, 27.96%, and 13.90% of China's total imports in May, respectively. Although Japan remained among the top three importing countries, MoM data showed that China's imports from Japan fell by 33.21% this month. Additionally, the quantities of die-casting zinc alloy imported from Vietnam and Australia also decreased.

From the export perspective, the top three countries for China's exports in May were Vietnam (68.21 mt), Bangladesh (37.31 mt), and Uzbekistan (33.83 mt), accounting for 40.44%, 22.12%, and 20.06% of China's total exports in May, respectively. Vietnam and Bangladesh recorded MoM changes of -55.89% and 20.94%, respectively. After Taiwan, China received a large amount of alloy from China in April, exports to Taiwan, China fell sharply to 0 mt in May.

In May, China's imports of unwrought zinc alloy increased slightly both MoM and YoY, while exports fell significantly due to a sharp decline in imports from Taiwan, China. What's next for China's import and export orders of unwrought zinc alloy? From the import side, June gradually enters China's seasonal consumption off-season. With weak domestic demand, the market's demand for imported zinc alloy is expected to pull back slightly. Meanwhile, recent feedback from enterprises indicates that orders for unwrought zinc alloy exported to Southeast Asia remain relatively stable overall. However, due to macro uncertainties and factors such as production cycles and shipping, there will be some interference in the imports of die-casting zinc alloy. Therefore, it is expected that China's exports of unwrought zinc alloy in June will continue to remain at a relatively low level.

ALUMINIUM CASTERS' ASSOCIATION (ALUCAST) - MEMBERSHIP FEE

Structure w.e.f 16 December 2016 (Tax updated w.e.f. 01 July 2017)

Membership Category	Admission Fees (₹)	Annual Fees (₹)	Total (₹)	Final Amount with GST (₹)	Admission Fee (₹)	Life Membership (₹) - Annual Fees X 15	Total (₹)	Final Amount with GST (₹)
Ordinary Member	500	1500	2000	2360	500	22500	23000	27140
Ordinary Member (MSME)	1000	3000	4000	4720	1000	45000	46000	54280
Corporate Member	1000	15000	16000	18880	1000	225000	226000	266680
Coporate Member (Overseas)	US $50	US $150	US $200	US $236	US $50	US $2500	US $2550	US $3009

Please send cheques in the name of Aluminium Casters' Association (ALUCAST) payable at Pune along with the membership form. **Membership form and details of membership are available on our website: www.alucast.co.in**

Please send cheques in the name of Aluminium Casters' Association (ALUCAST) payable at Pune to:

ALUCAST® PARTNER IN PROGRESS FOR ALUMINIUM AND DIE CASTING INDUSTRY

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Unlocking the Power of Semi-Solid Metal: Rheocasting Explained

Bühler Group & Comptech Rheocasting AB

Rheocasting is an innovative advancement in the field of high-pressure die casting (HPDC), offering a new approach to producing high-quality, lightweight, and sustainable components. At its core, rheocasting involves the preparation of a semi-solid aluminum slurry before it enters the conventional HPDC process. This technique alters the metal's microstructure from dendritic to globular, unlocking new possibilities in part quality, mechanical properties, and application scope.

HOW RHEOCASTING WORKS

The rheocasting process begins with a slurry maker, which treats the molten aluminum before it is transferred to the die casting machine. Using a carousel system, the process creates an Enthalpy Equilibrium Material (EEM) by carefully stirring the liquid metal in the dosing ladle. This controlled stirring at a reduced temperature of around 620°C results in a semi-solid slurry with unique flow characteristics.

Unlike traditional molten aluminum, this semi-solid slurry flows more slowly and with significantly less turbulence and has a longer flow length due to its thixotropic properties. This controlled flow behavior is crucial for achieving superior casting quality, especially in complex or large-scale components.

BENEFITS OF RHEOCASTING IN MEGACASTING

The semi-solid slurry enables laminar flow with minimal turbulence, drastically reducing gas porosity and allowing for longer flow lengths. This means manufacturers can produce larger parts using the same machine size, effectively lowering production costs.

In terms of quality, rheocasting supports the use of advanced aluminum alloys with enhanced properties such as higher strength and thermal conductivity. The resulting parts exhibit extremely low porosity levels, which not only improves mechanical performance but also enables post-processing techniques like thermal treatments and welding.

Another key advantage is the lower metal temperature used in rheocasting. This reduces shrinkage-related porosity and extends die life by minimizing soldering and heat checking— common issues in conventional HPDC.

A SUSTAINABLE MANUFACTURING SOLUTION

Rheocasting also contributes to sustainability goals. It allows the use of low CO_2 emission alloys, particularly those with reduced silicon content—silicon being a major CO_2 contributor in secondary alloy production. Furthermore, the ability to design lighter parts using high- performance alloys leads to material savings and lower carbon footprints. Alloys with higher thermal conductivity also support lightweight designs, further enhancing environmental and economic benefits.

SUMMARY

Its ability to improve flow characteristics, reduce porosity, and enable the use of advanced, low- CO_2 alloys make rheocasting a valuable technology - especially in megacasting and lightweight component production. As industries continue to seek innovative solutions for performance and sustainability, rheocasting offers a compelling path forward.

Bühler corporates with Comptech Rheocasting AB in applying rheocasting for HPDC: https://comptech.se/

Stirring of the metal in the slurry maker

Rheocasting is especially well-suited for thin-walled parts

For more information: die-casting@buhlergroup.com