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JOURNAL FOR **ALUMINIUM** CASTING TECHNOLOGY

Volume 77 - August 2026



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GREAT DIE CASTING TECHNOLOGY FORUM

NEW OFFICE INAUGURATION

With great pleasure we would like to announce the OPENING OF OUR NEW OFFICE in Pimpri-Chinchwad area, Pune, India!

The GDCTECH association started and grew to the current grand state at its Prabhat Road Office. Many a times, industry people used to find it far away from MIDC. Considering the multiple requests to move closer to the

industrial area in Pune, GDCTECH's Core Team decided to move it's office from Prabhat Road to Pimpri - Chinchwad Area. Now this new space in Pimpri-Chinchwad can be more accessible for meetings, communications and for Training purposes. The new office is 500 sq ft. It has attached w/c, a well equipped conference room and administrative area.

We were extremely fortunate to have Shri. Vivek Joshi Ji for this occasion. The inauguration was done at the auspicious hands of Shri. R. T. Kulkarni, Shri. Anilji Kulkarni and Shri. Vivek Ji Joshi.

Vivek Ji delivered an excellent speech conveying importance of an association, and things that will make it successful and useful for its purpose.

The inauguration was attended by all our valued Executive Committee members and well wishers. GDCTECH's vice-president Shri. Jitendra Ji Lakhota, GDCTECH's vice-president Shri. Kishor Ji Dukare, GDCTECH's treasurer Shri. Nitin Ji Bhagwat, GDCTECH's respected advisor Shri. Bajrang Ji Lohia, Shri. Jalinder Ji katkade, Shri. Anil Ji Patil, Shri. Sagar Ji Kaushik, Shri. Rajesh Ji Aggarwal, Shri. Ravindra ji Ghoghare, Shri. Murli Ji, Shri. Anand Ji Joshi, Shri. Pramod Ji Gajare, Shravan Katkade, Bhagyesh Lakhota and Advait Athavale.

Everyone express their well wishes and dedication to the association in super lovely words.

We look forward to everyone's blessings and participation!

New Location: 1st Floor, Sukhwani Chambers, Pimpri Chinchwad, Pune 411018

With Regards,

Anil Kulkarni, Kishor Dukare, Jitendra Lakhotiya, Nitin Bhagwat





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

Articles for GDCTECH Journal

We invite Expert Articles on technical techno commercial and management aspects of Diecasting Industry, for publishing in GDCTECH Bimonthly Journal. We believe that these articles serve as good source of knowledge for foundry industry people. Please contact GDCTECH office for any further information.

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

The Editor's Desk



Ms. Kruttika Apshankar Kher
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Chandrashekhar N. Kate
Co Editor

Dear Readers,

In continuation, We are happy to publish GDCTECH Journal August 2026 Edition, under guidance of Mr. R. T. Kulkarni Sir and focused participation of Executive Committee Members.

GDCTECH is publishing Journal, since year 2012, with various Technical Articles along with Advertisements from various Industrial Partners.

GDCTECH Forum Office shifting ceremony completed on 13 June 2026 at new office at Pimpri from Prabhat Road.

Monthly Training Session in June 2026, 97th Coffee Talk Session conducted in June 2026, and Training Session in July 2026 with good participation, in continuation Quiz Competition in July 2026 and 98th Coffee Talk Session conducted in July 2026.

Preplanned Tour to visit Exhibition during 13 to 20 July need to be canceled due to nonavailability of Visa from China.

Globally Industrial Sector is being affected due to variations in consistent orders mainly due to again restarting of War like situation; subsequent fluctuations in fuel availability, prices; consistency in fuel supplies as outcome of ongoing war effect; there are significant global chain supply chain disruptions ultimately all of which affecting the working of MSMEs and developed new challenges to Industrial Sector.

To achieve overall Techno _Commercial targets, with subsequent technological upgradation; Die Casting Industry need to focus on System Improvements, reduce Energy Cost, Focus on Environmental Conservation, along with Renewable Energy and Need based AI Tools support for Productivity and Team Work improvement.

Readers and Foundry Experts can suggest topics for publishing articles, in the upcoming Journals. We look forward for your support in future.

On behalf of the Editorial Board, we are pleased to publish 77th issue of GDC TECH Forum Journal.

Thanking you,
Warm Regards,

Krutika Apshankar-Kher
Editor

Chandrashekhar N Kate
Co Editor



BEYOND AUTOMOTIVE: DIVERSIFYING INTO HIGH-PERFORMANCE INFRASTRUCTURE & OIL & GAS CASTINGS

Karthikeyan Jawahar, Director, KARMA INNOVATION, karthikeyan.j@karmainnovations.com

The Indian foundry industry stands at a critical historical juncture. Valued at USD 28.72 billion in 2026 and projected to scale to USD 46.72 billion by 2031 at a robust compound annual growth rate (CAGR) of 10.22%, the industry represents a vital pillar of the national manufacturing economy. Historically, passenger vehicle and two-wheeler automotive applications have been the dominant drivers of foundry capacity, accounting for 31.88% of national foundry revenues in 2025 and 43.9% of the aluminum cast alloy market in 2026. However, this single-market concentration represents a systemic vulnerability. Indian secondary aluminium and die-casting foundries face severe operational margin squeezes, driven by Middle East maritime disruptions, skyrocketing scrap import logistics costs, volatile London Metal Exchange (LME) prices, and intense price competition from hyper-rationalized automotive supply chains.

High-volume automotive High-Pressure Die Casting (HPDC) contracts typically yield paper-thin operating margins in the single digits (5% to 8%). Under this conventional model, foundries absorb the compounding risks of raw material volatility, energy tariff hikes across industrial states like Tamil Nadu, Maharashtra, and Gujarat, and aggressive OEM price-reduction mandates. In contrast, high-performance structural sectors—buoyed by the central government's ₹185 trillion National Infrastructure Pipeline (NIP)—offer massive, unprecedented opportunities with operating margins reaching 15% to 25% or higher. Transitioning from thin-walled, cosmetic passenger vehicle components to thick-walled, defect-free, load-bearing infrastructure and process-industry castings is no longer merely an option for incremental growth; it is an urgent strategic mandate for long-term survival and futureproofing.

1. THE INFRASTRUCTURE GOLD RUSH: TAPPING THE ₹185 TRILLION PIPELINE

The fundamental catalyst for this structural diversification is the rapid expansion of India's social and economic infrastructure. The National Infrastructure Pipeline (NIP) has ballooned to cover over 13,000 active projects with an estimated total capital outlay of ₹185 trillion. Crucially, the transport and energy sectors represent a massive slice of this investment, with roads, bridges, railways, power networks, and metro rail systems concentrating huge project values. This provides a natural, domestic structural hedge for foundries seeking non-automotive volume.

The demand for localized manufacturing is further bolstered by aggressive import-substitution policies and protective tariffs. For instance, the 40% basic customs duty on Chinese castings has effectively forced domestic localization and cut ordering cycles from a prolonged 90–120 days down to a rapid 30–45 days from domestic Indian hubs. This policy environment shields local manufacturers who possess the necessary quality credentials, creating a protective technical entry barrier.

To systematically map out these opportunities, foundry leaders must evaluate where their technical capabilities intersect with gross margin potentials. The data grid below visualizes the strategic positioning of various target sectors, establishing a clear value matrix for CEO decision-making.

Strategic Sector Matrix for Foundry Diversification

Target Casting Segment	Technical Entry Barrier (Scale 1-7)	Gross Margin Potential (Scale 1-7)	Primary Market Drivers & Catalysts
Agri-Machinery Castings	1.5	2.0	Highly commoditized; driven by seasonal domestic tractor and pump volumes.
Passenger Vehicle Castings (ICE)	2.0	2.5	Extreme cost-cutting pressure from OEMs; high-volume dependency.
EV Battery Enclosures	3.8	4.5	Growing demand for thin-walled structural integration; rapid development cycles.
High-Voltage Grid Switchgear	4.3	5.0	National Green Hydrogen Mission & massive HVDC power grid links.
Metro & Rail Structural Parts	4.5	5.2	Urban transit expansion across 25+ cities; strict RDSO fatigue standards.
Oil & Gas Multi-Way Valves	5.5	6.0	Absolute pressure tightness mandates; global "China+1" sourcing shifts.

A major sub-sector of immediate interest is India's massive urban transit and metro rail network expansion, which is actively executing upgrades across major metropolitan zones. Concurrently, Indian Railways is implementing a structural modernization program under the National Rail Plan to meet projected freight and passenger requirements up to 2050. This plan targets 100% electrification of the national rail network, requiring millions of structural electrical connectors, catenary brackets, and substation components.

Furthermore, the National Green Hydrogen Mission's USD 2.35 billion budget is catalyzing the rapid build-out of high-capacity energy transmission systems. This includes massive projects like the ± 800 kV, 6,000 MW bi-directional High-Voltage Direct Current (HVDC) power grid link spanning 1,200 km between Khavda and Nagpur. These high-voltage substation grids require heavy-engineering, corrosion-resistant, high-conductivity cast aluminium switchgear bodies, terminal connectors, and gas-insulated switchgear (GIS) housings that standard automotive foundries cannot produce without significant process upgrades.

2. THE TECHNICAL PARADIGM SHIFT: FROM TURBULENT HPDC TO CONTROLLED GDC & LPDC

Entering heavy engineering and process industries requires foundry managers to critically evaluate their core casting processes. Automotive engine ancillaries and thin-walled parts have historically favored High-Pressure Die Casting (HPDC) due to rapid cycle times (typically around 45 seconds). In HPDC, molten aluminum is injected into

the steel die at extremely high velocities, typically exceeding 0.5 m/s. This high-speed injection generates highly turbulent fluid-dynamic behavior, causing excessive air entrapment and gas porosity. For structural, pressure-tight, and load-bearing applications in civil engineering, railways, or chemical plants, these internal porosity defects represent critical mechanical points of failure, severely compromising fatigue resistance and hydrostatic containment.

To achieve the required mechanical properties and structural soundness, foundries must pivot toward Gravity Die Casting (GDC) or Low-Pressure Die Casting (LPDC). GDC relies solely on gravity to fill the reusable metallic mold, keeping flow velocities low and laminar, which minimizes gas entrapment. GDC is exceptionally well-suited for producing thicker, high-strength structural parts. However, GDC castings typically require large conventional risers and feeders to compensate for solidification shrinkage, which lowers the overall process yield (often to around 73%) and significantly increases remelting and recycling energy costs.

In comparison, Low-Pressure Die Casting (LPDC) presents a superior compromise between metallurgical soundness and process economics. LPDC involves forcing the molten aluminum upward against gravity through a pressurized refractory stalk (rising tube) at very moderate, controlled gas pressures (typically 0.3 to 1.5 bar). The pressurized stalk acts as a continuous 'virtual feeder,' allowing molten metal to constantly feed the solidifying core, completely eliminating the need for massive conventional risers. This results in an extraordinary process yield exceeding 90% (up to 99% in optimized lines), massively cutting raw-material melt losses and downstream machining, riser cutting, and fettling costs.

Casting Soundness and Porosity Analysis Across Processes

Component Type	Casting Method Deployable	Average Porosity Content (%)	Metallurgical & Structural Implications
Heavy-Duty Safety Boxes	LPDC	0.54%	High structural soundness; uniform density; minimal sub-surface micro-voids.
	GDC	1.72%	Moderate gas entrapment; requires strategic risers to combat shrinkage hotspots.
Industrial Safety Covers	LPDC (Optimized)	0.19%	Near-perfect structural integrity; ideal for safety-critical field duty.
	Sand Casting (SC)	0.70%	Low velocity, but vulnerable to minor sand inclusion and mold-wall movement.
	GDC	0.99%	Acceptable for structural parts; requires tight thermal management.
	HPDC	2.97%	Severe gas porosity due to turbulent air entrapment; highly prone to pressure leaks.

The experimental data explicitly demonstrates why High-Pressure Die Casting (HPDC) fails the leak-free barrier, exhibiting a high average porosity content approaching 3%. For an automotive bracket or external cover, minor sub-surface porosity may pass inspections. However, for a fluid actuator housing or switchgear casing, that same porosity causes catastrophic failures under mandatory hydrostatic testing. Conversely, Low-Pressure Die Casting (LPDC) consistently delivers exceptional structural soundness, driving total porosity levels below 0.2% on cored industrial safety components.

3. HIGH-VALUE TARGET SEGMENTS IN INFRASTRUCTURE & ENERGY

To successfully execute a diversification strategy, Indian foundry CEOs must focus their sales and engineering teams on highly specialized non-automotive sectors where global conglomerates are actively seeking local supply alternatives.

Three core target segments stand out:

A. Oil & Gas and Process Industries

The fluid-handling segments of petrochemical refineries, oil pipelines, chemical processing plants, and heavy water treatment infrastructure require an array of high-performance aluminium components. Key product targets include multi-way valve housings, hazardous-area explosion-proof electrical enclosures, pump impellers, centrifugal volutes, gas meter bodies, and pneumatic actuator assemblies.

These components generally steer completely away from standard automotive secondary alloys like ADC12 or LM24, which contain high levels of copper that compromise corrosion resistance. Instead, they demand premium alloys such as the Al-Si-Mg series (e.g., LM6, LM25, or A356). These alloys provide exceptional fluidity during pouring, making it easier to fill intricate internal shapes, and they offer superior resistance to atmospheric, marine, and chemical corrosion once placed in the field.

B. Electrical Power Transmission & Smart Grids

As global and domestic energy networks undergo a major transition toward renewable energy integration, the demand for Gas-Insulated Switchgear (GIS) components, high-voltage connector clamps, circuit breaker housings, and substation busbar supports has surged. Aluminium is the material of choice due to its non-magnetic

properties, which prevent inductive heating, along with its excellent strength-to-weight ratio and electrical conductivity.

The fundamental engineering challenge in this sector is achieving an optimal balance between mechanical yield strength and electrical conductivity. Traditional grain-refining elements used in foundries can sometimes disrupt the metal's internal lattice structure, lowering electrical efficiency. Foundries must therefore deploy highly precise melt chemistries, strict modification protocols, and precise heat-treatment profiles to satisfy both electrical and mechanical quality specs simultaneously as mandated by bodies like the Power Grid Corporation of India.

C. Modern Rail, Metro, and Mass Transit Systems

With the rapid expansion of Metro rail networks across dozens of Indian cities and the scaling up of high-speed passenger train manufacturing (such as the Vande Bharat platforms), transit systems have become massive consumers of premium castings. Applications range from critical pneumatic braking blocks and suspension brackets to interior structural links and large HVAC blower housings.

Rail applications carry strict Fire, Smoke, and Toxicity (FST) compliance standards, alongside intense dynamic fatigue life demands. Components must withstand millions of high-vibration duty cycles over a decades-long operating lifespan without developing structural micro-cracks. This environment demands top-tier foundry control, making it virtually impossible for low-end, unorganized operations to compete.

4. ELEVATING STRUCTURAL INTEGRITY: THE METALLURGICAL IMPACT OF T6 HEAT TREATMENT

A major limitation of high-pressure die-cast components is their inability to undergo standard T6 heat treatment (solutionizing, quenching, and artificial aging). Because HPDC parts contain extensive pockets of entrapped gas, heating them to high solutionizing temperatures (above 500°C) causes these gas bubbles to expand violently. This leads to severe surface blistering, dimensional warpage, and structural embrittlement. GDC and LPDC castings, being virtually free of entrapped gas, can safely undergo full T6 thermal processing to unlock the absolute maximum mechanical potential of premium aluminum cast alloys.

In high-performance structural applications, the dominant material is the silicon-based hypoeutectic A356 alloy (Al-Si-Mg grade), which is projected to capture 51.9% of the national aluminum cast alloy market by 2026 due to its exceptional fluidity, corrosion resistance, and high castability. A highly authoritative metallurgical study conducted on gravity die-cast A356 components analyzed the precise quantitative gains of T6 heat treatment (solutionizing in a furnace at 540°C for 6 hours, followed by a rapid water quench, and artificial aging at 160°C for 6 hours).

The metallurgical transformation was profound: solid-state diffusion caused the brittle, acicular (needle-like) silicon eutectic flakes responsible for stress concentration to fragment, spheroidize, and coarsen into fine, rounded silicon particles embedded uniformly in the alpha-aluminum matrix. Simultaneously, precipitation hardening triggered the uniform dispersion of fine, coherent Mg₂Si and Al₂Cu particles, providing extreme barrier resistance to dislocation motion. The quantitative results are presented in the technical data table below.

Quantitative Mechanical Property Enhancements of GDC A356 Alloy via T6 Heat Treatment

Mechanical Property Parameter	As-Cast GDC A356 Estado (F)	T6 Heat-Treated GDC A356	Net Percentage Improvement
Brinell Hardness (HRA)	16.47 HRA	33.93 HRA	+106% Improvement
Ultimate Tensile Strength (UTS)	123.0 MPa	253.5 MPa	+106% Improvement
Ductility / Strain at Fracture	0.07 mm/mm (7%)	0.22 mm/mm (22%)	+214% Improvement
High-Cycle Fatigue Life (5kg - 50Hz)	22,747 Cycles	28,020 Cycles	+23% Improvement

The technical implications of this data are profound. By converting the microstructure from brittle, interconnected flakes into isolated, fine spheroidized particles, the foundry completely eliminates micro-structural stress concentrators. Yield strength and ductility double, while high-cycle fatigue limits expand by nearly a quarter, enabling reliable field performance under high-vibration railway, metro, and industrial environments.

FACT BOX: The Metallurgical Imperatives for Heavy Castings

- **Hydrogen Control:** Molten aluminium acts like a sponge for hydrogen gas at elevated temperatures, particularly in high-humidity industrial clusters like Coimbatore, Chennai, and Pune. Automated rotary degassing using high-purity dry argon or nitrogen is mandatory to drive the Density Index below 1.5% using Reduced Pressure Testing (RPT).
- **Bifilm Elimination:** Turbulent pouring folds the oxidized top surface of the liquid metal into the casting cavity, creating double-layered oxide films (bifilms). These act as internal micro-cracks, severely reducing structural fatigue life.
- **Shrinkage Prevention:** Unlike gas porosity, shrinkage porosity manifests as jagged, irregular, interconnected cavities in thick hot spots. Enforcing strict directional solidification via advanced thermal simulation and cooling lines is the only way to eliminate these leak paths.

5. CRACKING THE LEAK-FREE BARRIER: PRESSURE TIGHTNESS IN OIL & GAS CASTINGS

Process industries require absolute pressure tightness. Valve bodies, pump housings, manifold blocks, and gas regulators must sustain high internal hydraulic and pneumatic pressures without a single micro-leak. In these fluid-transmission systems, the primary defect responsible for expensive casting rejections is shrinkage porosity. Because aluminum undergoes significant volumetric contraction as it cools from liquid to solid, if the thicker regions solidifying last lack a clear pathway to be fed with additional molten metal under pressure, vacuum voids form between the dendrite arms, creating interconnected fluid channels.

To eliminate shrinkage porosity, foundries must combine Design of Experiments (DOE) with CAD-integrated 3D solidification simulation software. Simulation tools analyze active thermal gradients during cooling, helping engineers position gating systems, chills, and active die cooling channels to enforce strict directional solidification—guaranteeing that solidification proceeds sequentially from the thinnest, most distant regions back toward the pressurized riser or LPDC stalk. For highly complex internal geometries (such as multi-way valve chambers), foundries must employ high-density shell sand cores assembled inside the permanent steel mold to shape complex hollow passageways without thermal defects.

AUTHORITATIVE CASE STUDY: Valve Body Optimization

A globally prominent hydrostatic component manufacturer faced catastrophic rejection rates when producing A356 aluminum vehicle control valve castings using traditional high-velocity die-casting methods. Due to high internal gas and shrinkage porosity, the cast valve bodies suffered severe pressure leaks, failing quality tests even after undergoing expensive double resin impregnation. The foundry executed a strategic shift, transitioning the casting line to electromagnetic low-pressure permanent mold casting using a three-piece shell sand core assembly to form the complex internal channels. The results were transformative: the low-pressure bottom-fill process achieved 100% porosity-free and pressure-tight valve bodies, completely eliminating the need for any post-casting impregnation. This process optimization delivered a staggering 66% total cost savings to the customer by driving shop scrap rates to near-zero and skipping the material and labor costs of dual-resin impregnation cycles.

6. THE OPERATIONAL PARADIGM SHIFT: HIGH-MIX, LOW-VOLUME (HMLV) PRODUCTION Excellence

Perhaps the biggest shock to an automotive foundry team transitioning to heavy engineering is the operational shift from high-volume predictability to a High-Mix, Low-Volume (HMLV) workflow. In automotive production, a machine line might run a single steering knuckle or engine bracket for months at a time, allowing engineers to continuously tweak parameters for maximum efficiency. In heavy engineering, a foundry might have to produce 40 valve bodies for an oil pipeline, followed by 15 switchgear enclosures for an electrical grid provider, followed by 100 brake components for a metro rail project. Dies and sand molds are changed frequently, sometimes even multiple times within a single work week.

Without strict operational controls, this high-mix variety can cause shop-floor chaos, skyrocketing setup times, and massive productivity losses. CEOs must fundamentally rethink factory management, focusing heavily on two key methodologies:

A. Implementing Industrial 5S and Rapid Changeovers (SMED)

When die changes happen frequently, the traditional approach of hunting for misplaced bolts, standard tools, or riser inserts destroys profitability. The shop floor must implement strict 5S principles (Sort, Set in order, Shine, Standardize, Sustain). Heavy dies, core boxes, and dedicated tool kits must be organized in clearly marked, color-coded zones right next to the casting stations. Applying Single-Minute Exchange of Die (SMED) techniques is essential. By preparing cores, pre-heating GDC molds externally using dedicated gas manifolds before mounting them, and using standardized quick-clamping systems, tool changeover times can be cut from several hours down to under 30 minutes. This preserves critical melting furnace utilization and maintains steady output levels.

B. Modular Tooling Strategies

Heavy engineering clients are highly sensitive to upfront tooling and die costs, especially when ordering small batches of parts. If a foundry quotes a massive, solid, dedicated tool steel die package for a low-volume part, the project's economics quickly fall apart. To overcome this barrier, foundries must adopt modular tooling concepts. By investing in universal master die bolsters and frames, the foundry only needs to manufacture interchangeable cavity inserts for each specific customer part. This approach cuts upfront tooling costs for the client by 40% to 60%, drastically lowers lead times, and makes low-volume production highly profitable and competitive.

7. THE ECONOMICS OF TRANSITION: CAPITAL EXPENDITURE & BREAK-EVEN ANALYSIS

Transitioning from high-volume automotive casting lines to structural infrastructure components requires a deep, rational analysis of capital expenditure (CapEx) against operational expenditure (OpEx) benefits. Setting up a dedicated Low-Pressure Die Casting (LPDC) production unit demands a higher initial investment of approximately €200,000 (roughly ₹1.8 crore), compared to a standard Gravity Die Casting (GDC) setup, which costs around €100,000 (roughly ₹90 lakhs). This capital differential is driven by the automated pressure-control equipment, sealed electric holding furnaces, and specialized ceramic stalk assemblies required for LPDC. Additionally, LPDC tooling and die development require rigorous initial engineering, with high-quality multi-part dies and core-boxes costing around €16,000.

However, the operational economics of LPDC rapidly reclaim this capital overhead due to a substantial difference in process yield (99% for LPDC versus 73% for GDC) and a massive 41% reduction in labor and cycle time (0.088 hours per piece for LPDC versus 0.15 hours per piece for manual GDC). To establish the exact production volume at which LPDC becomes more economical than GDC, foundries utilize Break-Even Analysis based on equivalent annual cost structures. This analysis reveals a highly critical trend: ****the economic break-even point is a strong, inverse function of the casting's weight****. The table below delineates the quantitative thresholds across specific component weight profiles.

Economic Break-Even Thresholds as a Function of Casting Weight

Casting Scenario / Component Profile	Finished Casting Weight (kg)	LPDC Process Yield	GDC Process Yield	Annual Break-Even Volume Required
Case A: Simple Light Linkage	6.9 kg	99%	80%	3,558 pieces / year
Case B: Medium Grid Safety Box	13.0 kg	99%	73%	2,143 pieces / year
Case C: Heavy Valve Housing	21.5 kg	99%	73%	1,034 pieces / year
Case D: Heavy Industrial Casing	35.0 kg	99%	73%	725 pieces / year

For small, simple castings, GDC remains highly competitive even at moderate volumes because raw material waste is low. However, for larger, heavier, and more complex castings, the high metal yield of LPDC completely dominates the economic equation. As the weight of the casting increases, the waste associated with GDC's massive risers and gates scales exponentially, whereas LPDC maintains a flat, riser-less high-yield profile. Consequently, for foundries targeting heavy-engineering railway or Oil & Gas components weighing above 20 kg, LPDC becomes the most economical choice even at highly customized, low-volume runs below 1,000 pieces per year, allowing rapid amortization of the ₹1.8 crore capital asset.

8. THE CEO'S COMMERCIAL PLAYBOOK: BIDDING, CERTIFICATIONS, AND CASH MANAGEMENT

Transitioning technically is only half the battle; the commercial rules of engagement in heavy engineering are completely different from automotive procurement. Automotive sales rely on open-book costing sheets where OEMs dictate margins down to the paise. Heavy engineering, however, values technical risk mitigation. If you can prove your casting will not fail under extreme field pressure, buyers are entirely willing to pay a premium price. To win this lucrative business, foundry CEOs must systematically check three key commercial boxes:

A. The Certification Gateway

A standard ISO 9001 certification is rarely enough to secure contracts with global heavy engineering companies or public sector undertakings (PSUs). CEOs must upgrade their quality compliance frameworks to match target industry expectations:

- **Oil & Gas:** Align operations with API (American Petroleum Institute) system specs and secure material certifications under EN 10204 Type 3.1.
- **Power & Rail:** Obtain specific product and facility approvals from key national and international oversight bodies, most notably the Research Designs and Standards Organisation (RDSO) for Indian Railways, Power Grid Corporation of India Limited (PGCIL), or global vendor networks like Achilles.
- **Testing Lab Infrastructure:** Invest in an in-house, NABL-accredited testing facility equipped with optical emission spectrometers, digital radiography (X-ray), universal tensile testing machines, and hydrostatic test rigs to verify absolute compliance before parts ship.

B. Navigating Long Procurement Cycles

Bidding for heavy engineering contracts requires patience and long-term strategic relationship building. The sales cycle can easily take anywhere from 6 to 18 months, encompassing rigorous trial pours, prototype testing, destructive testing, and extensive facility audits by client engineering teams. However, once a foundry becomes an approved, qualified vendor for a global giant like Siemens, ABB, GE, or L&T, the vendor position is highly defensible. Unlike automotive OEMs who frequently swap

suppliers for minor cost differences, heavy engineering buyers value consistency and reliability. They are highly reluctant to risk shifting to an unproven foundry just to save a few rupees, ensuring steady, predictable business for qualified partners.

C. Financial Realities: Cash Flow and Working Capital Management

While gross margins in heavy engineering are double those of automotive contracts, CEOs must prepare for distinct working capital dynamics. Automotive accounts typically offer predictable, high-velocity cash flow loops. In contrast, heavy engineering orders often feature extended payment timelines, longer testing sign-offs, and capital tied up in slow-moving raw materials or intermediate work stages. Foundry owners must manage cash reserves carefully to balance this out. They need to secure flexible working capital facilities and structure commercial terms that include advance payments for tooling and milestone-based billings for large orders. This financial cushion allows the foundry to confidently support the longer development phases required to deliver premium, high-value components.

9. FUTUREPROOFING AGAINST GLOBAL LEVIES: THE DECARBONIZATION MANDATE

As Indian foundries successfully scale their non-automotive heavy engineering capacities, the horizon must expand to international export markets. However, global procurement is undergoing an environmental paradigm shift. The European Union's Carbon Border Adjustment Mechanism (CBAM) imposes carbon levies on embedded emissions of imported engineering components. Entry into premium global engineering chains requires not just structural excellence, but a low carbon footprint.

Forward-thinking Indian foundries are already pioneering this transition. For example, advanced facilities are actively integrating rooftop solar arrays and long-term wind power purchase agreements (PPAs) to run their energy-intensive melting operations. By shifting away from coal or gas-fired furnaces toward high-efficiency electric induction melting backed by renewable energy, top-tier domestic foundries have managed to drive down

their embedded emissions to an impressive 0.8 tonnes of CO₂ per tonne of liquid metal. This proactive environmental stance bypasses impending CBAM financial penalties, giving Indian casting exporters a massive competitive edge in Western markets over high-emission global competitors.

CONCLUSION: OPERATIONAL ACTION PLAN FOR THE INDIAN FOUNDRY CEO

The diversification of Indian aluminium castings foundries from low-margin automotive lines to high-performance, certified infrastructure, energy, and process sectors represents the most significant strategic value play of this decade. To successfully shift capabilities, CEOs must structure their execution roadmap across four clear operational pillars:

- **Pillar 1:** Advanced Melt Quality Control. Eliminate gas and oxide defects at the liquid stage. Implement automated rotary degassing with argon or nitrogen to drive hydrogen content below critical thresholds. Maintain metallurgical consistency through the systematic addition of Al-Ti-B grain refiners and strontium modification to refine silicon flakes into tough, fibrous morphologies.
- **Pillar 2:** Solidification Simulation & Gating Design. Move the design department away from costly trial-and-error methodologies. Invest in CAD-integrated thermal solidification simulation software to model heat-flow gradients and hot spots, allowing engineers to optimize active die cooling channels and enforce strict directional solidification.
- **Pillar 3:** Tooling and Sand-Core Integration. Build robust tooling capabilities. To cast leak-proof, multi-way valve bodies and complex industrial

housings with intricate internal hollow chambers, integrate high-density shell sand core blowers and automated assembly lines that feed the permanent mold casting stations.

- **Pillar 4:** Certification and Agility. Upgrade operational compliance frameworks to secure API, RDSO, and PGCIL credentials. Implement rigorous 5S and SMED changeover protocols to seamlessly manage High-Mix, Low-Volume production runs without sacrificing furnace utilization.

By leveraging the ₹185 trillion National Infrastructure Pipeline and optimizing core processes—combining Low-Pressure Die Casting efficiencies, T6 artificial age hardening, and advanced solidification simulation—Indian foundries can break free from the margin squeezes of automotive passenger OEMs and establish themselves as highly profitable, internationally competitive, and technologically advanced leaders in the global heavy-engineering supply chain.

EDITORIAL DISCLAIMER

This feature article is intended solely for general informational and educational purposes for industry members. Technical figures, metallurgical parameters, CapEx estimates, and market projections are illustrative and based on broader industry data. They do not constitute formal engineering, operational, or financial advice. Process results, yield percentages, and cost economics will vary based on individual shop-floor conditions. Neither the author nor the publication accepts liability for commercial, technical, or financial decisions made based on this content. Readers are urged to conduct independent engineering evaluations and professional audits prior to implementation.



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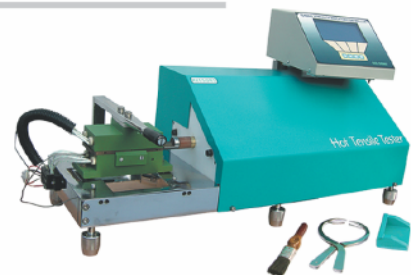
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Layered process audits for Aluminium Foundries: Part 1

Pramod Gajare – Consultant. Email: pramodgajare2013@gmail.com

Layered Process Audits are most common in automotive industries. Layered process auditing (LPA) is a structured manufacturing audit method where multiple organizational levels verify critical process controls on a recurring schedule. In manufacturing, it works by assigning frontline, supervisor, manager, and leadership checks to the same high-risk processes. The most important feature is layered accountability, that is more than one level of the organization confirms whether standard work is actually being followed at the point of work.

If we look back in the history these didn't start as "LPAs". The idea came from Toyota Production System (TPS) in the middle of twentieth century.

Toyota used the concept of "Management by walking around" for process confirmation. Supervisors, managers, and even executives would go to the floor daily to verify that standardized work was being followed.

The goal of such walks was to catch small process deviations before they became defects. This was never called an "audit" yet.

During the journey of Quality Management System standards from ISO 9000 to IATF 16949, the practice of conducting audits by personnel at all levels gained importance. Although there is no direct mention of the term "Layered Process Audits" in these standards.

The industry kept calling it LPA because the practice stayed the same: Multiple layers of management audit the same critical process steps weekly/daily using a short checklist. As a part of "Customer Specific Requirements" these audits are now embedded in automotive culture for a period of more than a decade.

Automotive perception

The automotive sector works with High volume and low margin philosophy. Even a very small amount of defect can lead to millions in warranty. Hence across the supply chain the emphasis is on defect prevention rather than detection. Various controls are defined, established and implemented for

prevention of defects. For sustenance there is a need of continuous verification; which can be every shift, daily, weekly, monthly and so on. For this reason, the big OEMs like Ford, GM, VW all put LPA requirements into their customer-specific requirements. It helps them to establish Traceability for recalls. For example; LPAs create dated records showing "we checked this process on this day by this manager and it was running within the specified limits." It helps to define vehicles under suspicion precisely. This is critical for 8D and root cause analysis.

Benefits to suppliers

The very purpose of writing this series of articles is to explain the benefits to suppliers; specifically for the Aluminium foundries. The OEMs require that the LPAs to be followed by their Tier I suppliers and their sub-suppliers. Since most of the foundries are sub-suppliers of the Tier I suppliers, this requirement gets percolated to the foundries. Due to lack of clear understanding the LPAs one can not enjoy all the advantages of this LPA system. Apart for giving support to the customer and complying with customer requirements there are multifold gains that a foundry can expect through effective implementation of LPA system. Not all but some benefits are listed below.

- Maintains proper application of standards as defined & achieved through operational readiness process
- Boosts Continuous Improvement throughout the organization.
- Expands ownership beyond the Quality function
- Ensures a high level of process control
- Provides a system to verify compliance to the documented process.
- Improvement in overall quality
- Inculcation of discipline and safety practice
- Improved communication at all levels
- Identification & control of high-risk elements /significant process elements
- Identify opportunities for improvement
- Helps to establish a process for effective follow up

- Involvement of Top Management into process or area responsibility
- Ensures that only qualified people perform the job
- Establish measurable criteria for skills and knowledge level of the operators
- Verification of the sustainability in internal process requirements
- Introduction of regular verification routine and cascade evaluation
- Direct communication between the Management and Operators

Industries from other than automotive sector have now also adopted this system since the advantages are lucrative. They call it “Gemba walks” or “Management layer audits”. Due to wide spread application by the Tier I in automotive sector various formats, and checklists for LPA are standardized to a good level. Many monitoring software are also available. Before going ahead with those, it is important to understand the key principles.

Key principles

- There are only 10-15 questions, and the audit is done in 10-15 minutes.

- They are NOT full system audits
- Precise result recording like Yes or No. No chance for hiding issues with the audit observation like N/A (Not Applicable)
- Provision for placing photo showing the actual situation
- Must be done on the floor, not from the office
- Close the loop. For every “No” needs immediate correction and provide CAR (Corrective action report) in 48 hrs.
- Track and improve. (Top 3 failures/ misses/ repetitions etc.)

It forces management to see problems before QA person or the customer does. A supervisor finding a temperature controller not working is significantly less expensive than a recall after 6 months.

Disclaimer: This is compilation of the information that is available as an open source on internet supported by my analysis. I do not claim any copyright for this. The copyright of images, diagrams, pictures, and other artistic works belongs to the original creators.

Training Programme



Structured Problem Solving, Tools & Techniques Like G8D Methodology and 12 Step Methodology



Held on 23-24 June 2026 at Hotel Kalasagar, Pimpri, Pune.

Total 19 delegates attended the programmes.



The faculty is **Mr. Sanjay Mergal**, Management Consultants



TOPICS COVERED

- Introduction to Problem Solving Frameworks,
- Defining the Problem,
- Data Collection & Analysis,
- Root Cause Analysis Techniques,
- Deriving Solutions & Decision Making,
- Implementation Planning,
- Monitoring & Evaluation,
- Continuous Improvement & Learning
- Team Collaboration
- Real Life Case Studies

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On "Mastering Aluminium Machining" designed by Bhagyesh Lakhota ! This was GDCTECH 's largest ever training program so far! Shri. Bhagyesh Lakhota designed the 2-days program with more than 200 pages training material and inviting 5 different visiting faculties to interact with the trainees !

The training announcement received a whooping response from the industry. We were happy to welcome 35 trainees from different cities like #Delhi, #Chennai, #Nashik, #Ahmedabad and #Pune ! Trainees were extremely happy at the end of 2 days. In addition to learning about machining , they were able to interact and make friends in industries all across India.

Special thanks to GDCTECH's President Shri. Anil Kulkarni Ji, Chairman of Pooja Castings , GDCTECH's Vice-president Shri. Jitendra Lakhota ji , CEO Aakar Foundry Pvt Ltd , Shri. Sagar Kaushik Ji , Chairman of Victory Precisions Pvt Ltd, for their presence, guidance, interaction with the trainees!

- We organize training every month under the guidance of GDCTECH's Chairman of training committee "Shri. Kishor Dukare Ji", CEO at Uno Minda.

In August our training will be "on the floor" with the topic "Know Your #DieCastingMachines", planned by Shri. Avinash patil, LK Machinery.

If you want to sign-up, kindly connect with Advait Athavale on LinkedIn or on +91-9373171391 call-sms-whatsapp.

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8007286560

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THIS IS WHAT MAKES Great Die Casting Technology Forum (GDCTECH) UNIQUE !!!

We are so happy to announce WINNERS of our 2026 QUIZ COMPETITION... !!

Mr. Darshan Mundale and Mr. Ankit Dandale an from @pooja casting !!!

Congratulations, Both the winners get a FREE DELEGATE ENTRY worth ₹ 10,000/- each, to the GDCTECH's Annual Conference in October this year!!!

Is this Quiz just another competition?? NO !

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- It promotes science and technology
- It boosts skill development
- It's participation is FREE !
- It offers amazing prizes
- Top of all... it's FUN !!!





Great Die Casting Technology Forum (GDCTECH)

Reflecting on an Inspiring Coffee Talk & Looking Ahead to a Historic Milestone!

I am delighted to share that I had the opportunity to be a part of the 97th GDCTECH's Coffee-TALK on **"Beyond Booths & Brochures: The New Age of Foundry Marketing."**

The session, led by Mr. Sanjay Landge and Mr. Anoop Budhlay from Ekspans - The B2B Network, was highly interactive and filled with practical insights on how businesses can rethink their marketing strategies. From digital transformation and strategic networking to market expansion and building meaningful partnerships, the discussion highlighted how modern marketing goes far beyond traditional methods. It was truly an eye-opening session for anyone looking to upgrade their marketing approach in today's competitive landscape.

This event was particularly special for me because it marked the first Coffee-TALK managed entirely by our Gen Z team after the responsibility was handed over to us. Seeing months of planning come together successfully and witnessing the enthusiastic participation from industry professionals made the experience incredibly rewarding. A heartfelt thank you to everyone who attended, supported, and contributed to making this session a success.

And now, the journey continues...

We are excited to announce that the **100th GDCTECH Forum CoffeeTALK** is just around the corner—a landmark

event that promises to be our biggest and most memorable Coffee Talk yet!

If you've been thinking about attending a GDCTECH's Coffee-TALK, this is the one you don't want to miss. Join us as we celebrate this incredible milestone with insightful discussions, valuable networking opportunities, and an unforgettable experience.

Register now and be a part of the grand 100th Coffee Talk before the seats fill up!

Shravan Katkade

Member of GDCTECH's Coffee-TALK team
Engineering Student
Business Development Intern
CASTAL DIES AND TOOLS, Pune

Our Coffee-TALK team...

Bhagyesh Lakhota, Akshay Bhagwat, Sahil Kaushik, Tanay Sapre, Chetan Patil, Anurag Patil, Deepak Patil, Hrushikesh Lokhande, Jitendra Lakhota, Nitin Bhagwat, Ravindra Ghogare, Jitendra Parekh, Advait Athavale.



GREAT DIE CASTING TECHNOLOGY FORUM



Reflecting on a Transformative Coffee-TALK on Theory of Constraints

I am delighted to share that I had the opportunity to be a part of the 98th GDCTECH's Coffee-TALK on "How to Make More Money from Existing Investments and Resources," an insightful session on applying the Theory of Constraints to unlock better profits, profitability, and cashflow within our businesses.

The session was led by CA Aniruddha Joshi, Director and Co-founder of Yagna Entrepreneur Success Services, whose depth of experience in delivering financial and operational results through Theory of Constraints made the discussion both practical and thought-provoking. Mr. Joshi began by aligning the audience on the true goals of any business, reminding us that profitability and cashflow are equally important as the absolute profit figure. He then introduced the concept through a simple but sharp analogy, that a chain is only as strong as its weakest link, which set the foundation for everything that followed.

From there, he explained why so many improvement activities we undertake fail to move the needle on profit, profitability, or cashflow. The reason, quite simply, is that these activities are often not focused on the weakest link in our business or manufacturing chain. It was a powerful lesson in prioritisation, directing our energy and attention toward the true constraint, resolving it thoroughly, and then repeating the exercise to identify and tackle the next one. This iterative discipline, he emphasised, is what compounds into meaningful results over time.

What made the session especially engaging was a hands-on exercise where each of us stepped into the shoes of a production planner for a company with a mix of four products, each demanding different resources and offering different profits. The challenge was to arrive at the production combination that maximised profit within the available resources. The energy in the room during that pen and paper exercise was remarkable, a clear sign of just how relevant and exciting the topic was for everyone present. Mr. Joshi rounded off the session by sharing some of the astonishing results he had achieved with client firms by applying these very principles.

As I reflected on the session, I could not help but see how deeply relevant this is to our casting industry. Our processes are long and multi step, inventory piles up between stages, and our attention naturally gravitates toward the most visible operations, even as the inefficiencies of the hidden or overlooked steps quietly erode our profits and profitability. Theory of Constraints offers us a lens to see through this fog and act with focus.

Process of Ongoing Improvement is based on "5 steps" :

1. One Goal
2. One Constraint (weakest link)
3. One Problem (biggest reason for wasting the capacity of weakest link)
4. One Conflict (preventing the solution to the one problem)
5. One Innovative Solution & Implementation (win-win solution which breaks the conflict) and repeating this cycle can help all die casting companies to make more money.

A heartfelt "thank you" to

Mr. Aniruddha Joshi for such an enriching session, and to the GDCTECH's team for once again curating a topic that speaks directly to what our MSME businesses need.

And the journey continues...

We now look forward to the 99th & 100th Coffee-TALK, another opportunity to learn, connect, and grow together as a community. If you have been considering attending a Coffee-TALK, do join us. These sessions have a way of leaving you with ideas you can put to work the very next morning.

Chetan Patil

Member of GDCTECH's COFFEE-TALK team
Business Development Manager
MAP Alloys, Pune



Upcoming Conference



GREAT DIE CASTING TECHNOLOGY FORUM

7th - 8th October 2026
(Wed - Thu)

Venue - Hotel Kalasagar
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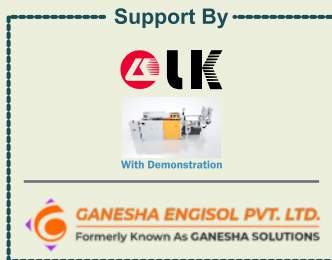
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Upcoming Training Programmes



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Topics to be covered

Maintenance of Pressure /Gravity Die Casting Machine

A. Functional aspects of pressure die casting machine

1. Die Closing system
2. The injection system
3. Ejection and corepull system
4. Automation accessories

B. Maintenance of Pressure /Gravity die casting machine.

1. Preventive maintenance
2. Planned maintenance

3. Predictive maintenance
4. Break down maintenance
5. Spare Parts

C. Control Systems

1. Hydraulic circuits
2. Operating sequence of pressure/gravity die casting machine.
3. Safety interlocks
4. Servo Hydraulic Pump System, working concept and Maintenance

D. Troubleshooting

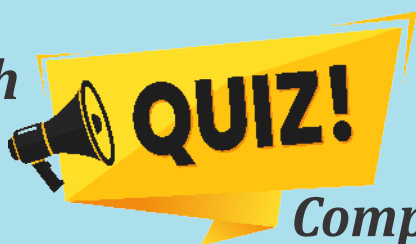
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Why the Same Customer Complaint Keeps Coming Back... Even After We Closed the Corrective Action

Welcome to the first article...

Every component dispatched from our factory carries something much more valuable than metal, dimensions, or specifications—it carries our customer's trust. Protecting that trust is the true purpose of Manufacturing Excellence.

The greatest lessons in manufacturing are not learned in conference rooms—they are learned beside machines, on production lines, during customer visits, and while solving real shop-floor challenges.

PAGE 1 –Welcome to the first article of the Sohaum Manufacturing Excellence Series – Practical Insights from the Shop Floor.

The greatest lessons in manufacturing are not found in textbooks—they are **learned on the shop floor**.

The purpose of this series is simple:

The purpose of this series is to share practical experiences, proven manufacturing practices, and lessons learned from real shop-floor situations so that together we can build stronger systems, develop capable people, delight our customers, and create sustainable manufacturing excellence.

Happy Reading!

SOHAUM MANUFACTURING EXCELLENCE SERIES

Practical Insights from the Shop Floor

ARTICLE 1

Manufacturing Excellence Begins with One Question...

Will My Customer Receive the Same Quality Every Time?

The article is about Manufacturing Excellence, and corrective action becomes one chapter within it.

World-class manufacturing organizations do not depend on individuals—they build systems capable of delivering consistent results regardless of who is operating the process.

The Journey Towards Manufacturing Excellence

Whether you manufacture castings, forgings, machined components, fabricated assemblies, plastic parts, or complete systems, every organization shares one common dream—to become a trusted supplier and a preferred business partner to its customers..

Yet, one question continues to challenge every organization:

Why do the same problems keep returning?

The answer is rarely hidden inside the defective component. It is hidden inside the process that created it.

Manufacturing Excellence is not achieved by eliminating every problem. It is achieved by building systems that learn from every problem.

Through this monthly series, I invite you to join me on a journey—not through standards and clauses—but through real shop-floor experiences, practical lessons, and continuous improvement ideas gathered over nearly three decades in casting, forging, machining, and automotive manufacturing.

If each article inspires one improvement in your organization, this journey will have served its purpose."

— Sanjay Mergal



Manufacturing Excellence is a Journey...Not a Destination

Many manufacturing organizations believe excellence begins with:

- New Manufacturing Technologies
- Advanced Production Equipment
- Better Process Capability (Cp/Cpk)
- Zero Customer PPM
- Successful Customer Audits
- IATF 16949 Certification
- Digital Manufacturing & Industry 4.0
- Lean, TPM & Six Sigma Projects
- Skilled Workforce
- Higher OEE & Productivity
- Implementing Lean, TPM, Kaizen or Six Sigma Projects

All these initiatives certainly contribute to business success.

But they do not guarantee Manufacturing Excellence.

These certainly help.

But true excellence begins with something much simpler:

True Manufacturing Excellence begins with a culture of ownership, disciplined processes, data-based decisions, and the courage to learn from every failure.

Great organizations don't ask:

Who made the mistake?

They ask:

What allowed the mistake to happen?

That single question changes the culture.

Shop Floor Reflection

Every rejection, customer complaint, machine breakdown, process deviation, and near miss carries an opportunity to improve the system. Manufacturing Excellence begins when organizations start listening to those opportunities.

The challenge is not finding the rejection.

The challenge is understanding what the process is trying to teach us.

Think Before You Read

Pause for a moment... Think about the last customer complaint received by your organization. What was discussed first?

- What would your organization discuss first?
- The customer
- The operator
- The inspection report
- The process (We'll revisit this at the end.)

A production supervisor and operator walking through the shop floor while discussing a process—not looking at a laptop.



Excellence begins with conversations at the Gemba.

Every Problem is an Opportunity to Improve the System

Let us consider a practical situation experienced by many organizations in the casting and machining industry. Although the product and customer may differ, the learning remains the same.

The organization immediately:

- Sorted the stock
- Replaced the parts
- Initiated a Cross Functional Team (CFT) and structured 8D problem-solving process
- Retrained operators

The customer appreciated the quick response. The report was closed. Internally everyone believed the problem had been eliminated.

But six months later...
the same complaint returned.

The question was not:

- Why did the customer complain?
- The real question became:
- What did our system fail to learn?

That is the difference between problem solving and Manufacturing Excellence.

Excellence Framework

Instead of reacting to problems, high-performing organizations strengthen five pillars:

1. Customer Focus

Every improvement begins with understanding customer expectations—not merely meeting specifications.

2. Process Stability

A capable process consistently produces conforming products.

Inspection cannot replace process capability.

3. People Engagement

Operators, supervisors, maintenance, and quality engineers all see different parts of the process.

When they work together, they see the whole picture.

4. Learning from Every Failure

Tools such as 8D, 5 Why, Fishbone Diagram, Layered Process Audits, and PFMEA are not objectives.

They are simply methods to help the organization learn.

5. Improvement and & Organizational Learning

Excellence is built through hundreds of small improvements—not one major project.



Facilitator's Thought

Manufacturing Excellence is achieved when every problem becomes an opportunity to strengthen the system - not merely to close a report.

A cross-functional team standing around a component, discussing it together.



Great solutions are built through teamwork—not departments.

Turning Problems into Competitive Advantage

Customer complaints are expensive—but losing customer confidence is far more expensive. Every customer complaint gives an organization two choices.

Choice 1

Fix today's defect.

- Move on.
- Hope it never happens again.

Choice 2

Understand the process.

- Improve the system.
- Prevent recurrence.
- Strengthen customer confidence.
- World-class organizations always choose the second path.

The Manufacturing Excellence Cycle

Customer Feedback



Problem Identification



Root Cause Understanding



Process Improvement



Standardization



People Development



Customer Confidence



Continuous Improvement

This is a cycle—not a one-time activity.

Five Questions Every Manufacturing Leader Should Ask

Before closing any problem, ask:

- What did we learn?
- What changed in the process?
- How will we prevent recurrence?
- Have we shared this learning with others?
- Will this improvement increase our customer's confidence in us?

Golden Rule

Correction solves today's issue.

System Improvement prevents tomorrow's issue.

Key Takeaways

- Manufacturing Excellence is built through people, processes, systems, and continuous learning—not by solving one problem at a time..

Next Month

Quality is Built in the Process... Not at Final Inspection

- Why inspection cannot create quality
- Prevention vs Detection

About the Author

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Final Message from the Author

Manufacturing Excellence is not a destination that an organization reaches one day. It is a journey that begins with a single decision—to learn from every problem, improve every process, and earn the customer's trust every single day. I look forward to walking this journey together through every article in this series.

— Sanjay Mergal



Author Disclaimer

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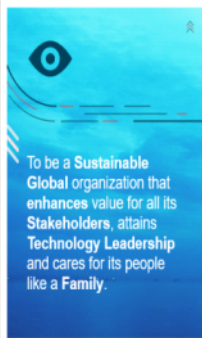
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Pavan Ajay Raj

Lightweight Automotive Alloy Wheels: A Comparative Study of Magnesium and Aluminum Alloys

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ABSTRACT

The increasing demand for lightweight vehicles has accelerated the adoption of advanced materials that improve fuel efficiency, reduce emissions, and enhance overall vehicle performance. Magnesium alloys have emerged as a promising alternative to conventional Aluminum alloys for automotive applications due to their low density and excellent strength-to-weight ratio. This study presents a comparative analysis of Magnesium and Aluminum alloy wheels to evaluate the feasibility and advantages of material substitution.

The simulation results indicate that magnesium alloys exhibit superior casting quality, with improved feeding characteristics, lower defect formation and reduced solidification time compared with Aluminum alloys. In addition to achieving significant weight reduction, magnesium alloy wheels demonstrated improved casting quality, making them well suited for lightweight automotive applications.

Keywords: Magnesium alloys, magnesium die casting, casting quality, Alloy wheel, casting simulation, ADSTEFAN, porosity, shrinkage, solidification.

Introduction:

The automotive industry is continuously striving to reduce vehicle weight to improve fuel efficiency, lower emissions, and enhance overall vehicle performance. Lightweight components have become a key focus in modern vehicle design, particularly with the rapid growth of electric vehicles (Evs), where reducing mass directly contributes to extended driving range and improved energy efficiency. Among various automotive components, alloy wheels play a significant role in vehicle dynamics because they contribute to the unsprung mass, which influences acceleration, braking, handling, and ride comfort. Consequently, selecting suitable lightweight materials for alloy wheels has become an important area of research.

Aluminum alloys have long been the preferred material for automotive alloy wheels due to their excellent castability, corrosion resistance, good mechanical properties, and cost-effectiveness. Low-pressure die casting (LPDC), and gravity die casting (GDC) are widely employed to manufacture

Aluminum wheels with high dimensional accuracy and productivity. However, the increasing demand for lighter vehicles has encouraged researchers and manufacturers to explore alternative materials that offer further weight reduction without compromising structural integrity.

Why Magnesium alloy:

Magnesium alloys have emerged as one of the most promising lightweight engineering materials for automotive applications. With a density of approximately 1.8 g/cm^3 , magnesium is nearly 35% lighter than Aluminum, making it an attractive choice for reducing vehicle weight. In addition to their low density, magnesium alloys exhibit excellent vibration damping characteristics, high specific strength, and good machinability. These advantages make magnesium alloy particularly suitable for high-performance vehicles, motorsports, and next-generation electric vehicles. Nevertheless, magnesium casting presents several manufacturing challenges, including oxidation, limited fluidity under

certain processing conditions, and stringent process control requirements, which have restricted its widespread adoption.

Alloy wheel for 4 wheelers:

Alloy wheels are lightweight and durable wheels made from a blend of metals, typically aluminum or magnesium. They are widely used in cars for their functional and aesthetic advantages. The reduced weight improves fuel efficiency, handling, and acceleration while putting less strain on the suspension system. Their superior heat dissipation helps keep brakes cooler, enhancing brake performance and reducing wear. Additionally, alloy wheels are resistant to corrosion, making them durable in various weather conditions. They also offer a sleek, stylish appearance, enhancing the overall look of the car. While more expensive than steel wheels, their benefits often justify the cost.

Comparison between Al alloy wheel and Mag Alloy wheel

Aspect	Aluminum Alloy Wheels	Magnesium Alloy Wheels
Material Composition	Aluminum mixed with metals like silicon, copper, or magnesium.	Predominantly magnesium with aluminum or zinc additives.
Weight	Heavier than magnesium but lighter than steel.	30% lighter than aluminum.
Strength	Strong and impact-resistant, durable for everyday use.	Less impact-resistant, prone to cracking under stress.
Heat Dissipation	Good heat dissipation for brake cooling.	Superior heat dissipation, ideal for performance vehicles.
Corrosion Resistance	Highly resistant to corrosion.	More prone to corrosion unless specially coated.
Cost	More affordable and widely available.	More expensive due to lightweight properties.
Usage	Common in standard passenger vehicles.	Used in high-performance or racing vehicles.
Durability	Long-lasting and suitable for various conditions.	Requires careful handling, less durable under stress.

Table 1 - Comparison between Al alloy wheel and Mag Alloy wheel

For experiments we have considered 17- inch alloy wheel as shown in below figure and run FEA analysis for Functionality qualification of wheel design.

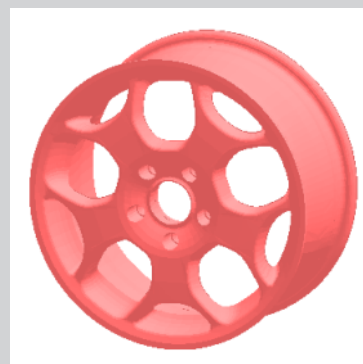


Fig 1 – Alloy wheel design considered.

As wheel design is qualified, we are proceeding for manufacturing in Low Pressure Die casting process for both Aluminium and Magnesium material.

Low Pressure Die Casting Process:

Low-pressure die casting is a cyclic process used to produce identical components by injecting molten metal into a metal die under low pressure, typically up to 1 bar. The applied pressure keeps the liquid metal in the die until it solidifies and falls back to crucible. Afterward, the component is allowed to solidify within the mold before being ejected. The process is then repeated.

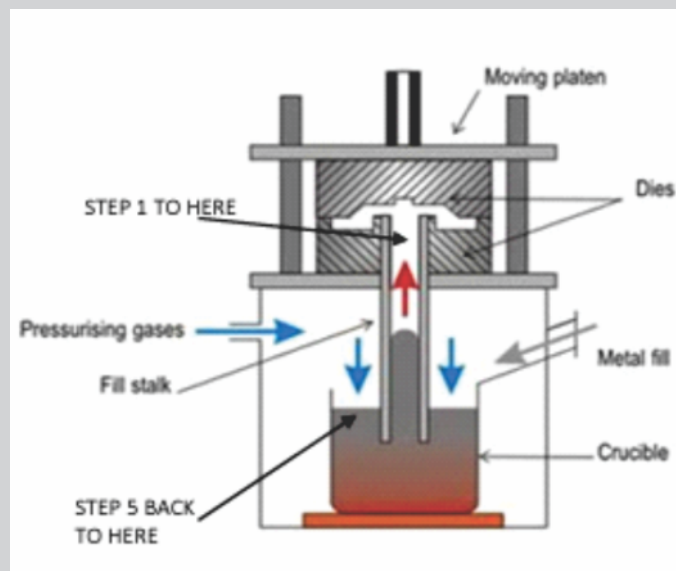


Fig 2 – Typical representation of LPDC process

For LPDC process, filling of mold cavity is controlled by parameter – Pressure vs Time graph. Typical P vs T consists of 5 step as below:

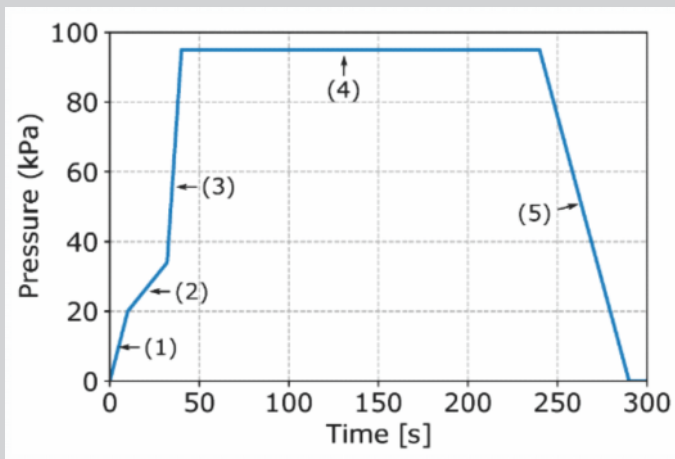


Fig 3 – Understanding Pressure Vs Time Graph in LPDC

Step 1 – Raise - Air Pressure applied to raise molten aluminium steadily to just below die cavity.

Step 2 – Fill - Pressure increased to fill the mould to the top of the cavity. This needs to undertake steadily to avoid turbulence, but fast enough so that all casting cavity is filled.

Step 3 – Intensification - Once die is filled the pressure is raised to the maximum to ‘squeeze’ the casting helping to accelerate solidification and reduce risk of internal voids. 1000mBar is possible, but factors such as use of sands cores.

Step 4 – Hold - The pressure is maintained until the casting has solidified

Step 5 – Drop - Pressure dropped to zero. The feed drops back down the riser tube into the holding furnace. Once the casting has solidified the die is opened and the casting ejected.

Advantages of LPDC process:

- Good die filling control/characteristics.
- High yield.
- Good progressive solidification.
- Minimal finishing requirements.
- Stable and repeatable process.

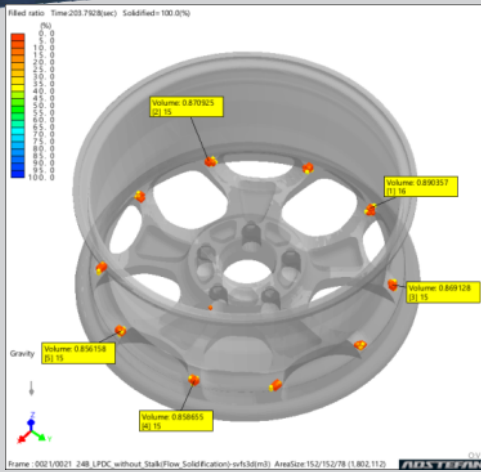
Design consideration for LPDC – Al and Mg alloy:

Aspect	Aluminum LPDC	Magnesium LPDC
Material Properties	Higher density, good strength, and corrosion resistance.	Lower density, excellent strength-to-weight ratio, moderate corrosion resistance.
Melting Point	Higher melting point (~720°C),	Lower melting point (~690°C)
Fluidity	Good fluidity, enabling casting of complex shapes.	Excellent fluidity, better for thin-walled and intricate designs.
Wall Thickness	Typically requires slightly thicker walls for structural integrity.	Allows thinner wall designs due to lower density and excellent flowability.
Thermal Conductivity	High thermal conductivity, suitable for heat-dissipating components.	Lower thermal conductivity compared to aluminum.
Strength	Higher ultimate tensile strength, ideal for heavy-duty applications.	Adequate strength for lightweight and medium-duty applications.
Draft Angle	Requires slightly higher draft angles (2-3°) due to higher shrinkage during solidification.	Can use lower draft angles (1-2°) due to lower shrinkage and better flow characteristics.

Table 2 - Design consideration for LPDC – Al and Mg alloy

Considerations for Aluminium alloy wheel simulation:

For above alloy wheel model, we have considered Aluminium – A 356.2 alloy grade and die material is H13. Pouring temperature is considered 700 °c and die temperature as 350°c. The density of the alloy at room temperature is 2680 kg·m⁻³, the liquidus is 624 °C, and the solidus is 557 °C. By providing these inputs, we have executed simulation in ADSTEFAN to observe potential shrinkage porosity defects in casting.



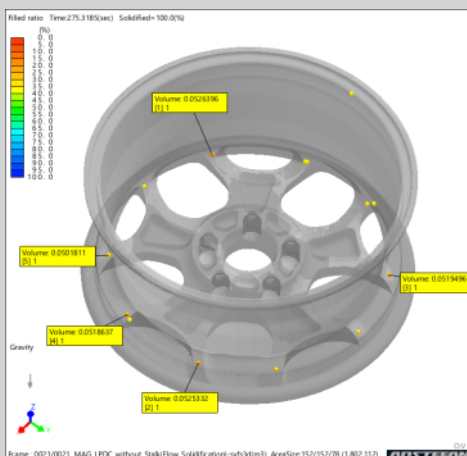
No.	Elements	Volume(cm ³)	Surface(cm ²)	X Length(cm)	Y Length(cm)	Z Length(cm)
1	16	0.890357	8	1.6	1.2	1.2
2	15	0.870925	7.04	1.2	1.2	1.2
3	15	0.869128	7.04	1.2	1.2	1.2
4	15	0.858655	6.72	1.2	1.2	1.2
5	15	0.856158	6.72	1.2	1.2	1.2

Fig 4– Shrinkage porosity results for Aluminium alloy

Fig 4 represents shrinkage porosity distribution for aluminium alloy wheel project. Observed shrinkage in rim spoke joint of wheel further by using cooling lines, we can control shrinkage porosity defect in component.

Considerations for Magnesium alloy wheel simulation:

For above alloy wheel model we have considered Magnesium alloy – AZ91D alloy grade and die material is H13. Pouring temperature is considered 690 °c and die temperature as 380°C. The density of the alloy at room temperature is 1,820 kg·m⁻³. By providing these inputs, we have executed simulation in ADSTEFAN to observe potential shrinkage porosity defects in casting.



No.	Elements	Volume(cm ³)	Surface(cm ²)	X Length(cm)	Y Length(cm)	Z Length(cm)
1	1	0.0526396	0.96	0.4	0.4	0.4
2	1	0.0525332	0.96	0.4	0.4	0.4
3	1	0.0519496	0.96	0.4	0.4	0.4
4	1	0.0518637	0.96	0.4	0.4	0.4
5	1	0.0501811	0.96	0.4	0.4	0.4

Fig 5– Shrinkage porosity results for Magnesium alloy

Fig 5 represents shrinkage porosity distribution for magnesium alloy wheel project. Observed shrinkage in rim spoke joint of wheel which can be further controlled by implementing cooling lines to achieve directional solidification and reduce shrinkage porosity.

Conclusion:

A comparative casting simulation study of aluminium (A356.2) and magnesium (AZ91D) alloy wheels was conducted using ADSTEFAN under their respective process conditions to evaluate shrinkage porosity and casting quality. The simulation results indicate that both materials exhibit shrinkage porosity at the rim–spoke junction, identifying this region as the most critical location for solidification-related defects. This suggests that optimized cooling/heating line design and thermal management are essential for improving casting quality, irrespective of the alloy used.

Compared with the aluminium alloy, the magnesium alloy demonstrated significantly lower shrinkage porosity, with a substantial reduction in porosity volume. These findings highlight the potential of magnesium alloys as a suitable alternative for lightweight automotive alloy wheel applications, offering the combined benefits of weight reduction and improved casting integrity.

The study also demonstrates that casting simulation is an effective engineering tool for evaluating material substitution, predicting casting defects, and optimizing process parameters during the design stage. By enabling virtual validation before production, simulation helps reduce development time, tooling modifications, manufacturing costs, and the need for extensive shop-floor trials, thereby supporting the development of high-quality and lightweight automotive components.

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ABOUT AUTHOR:

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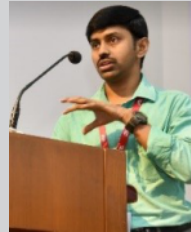
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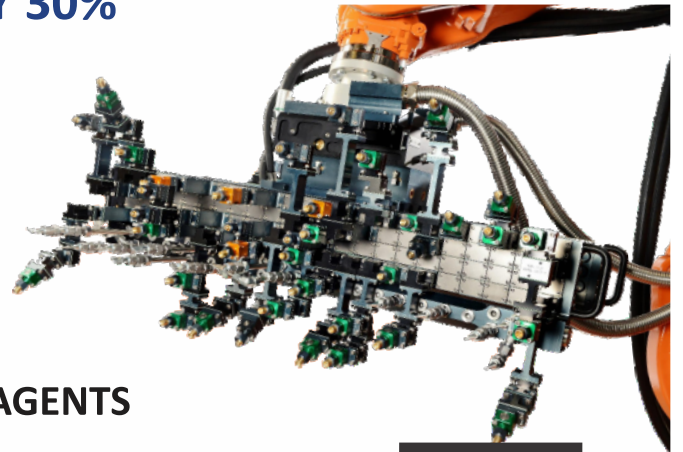
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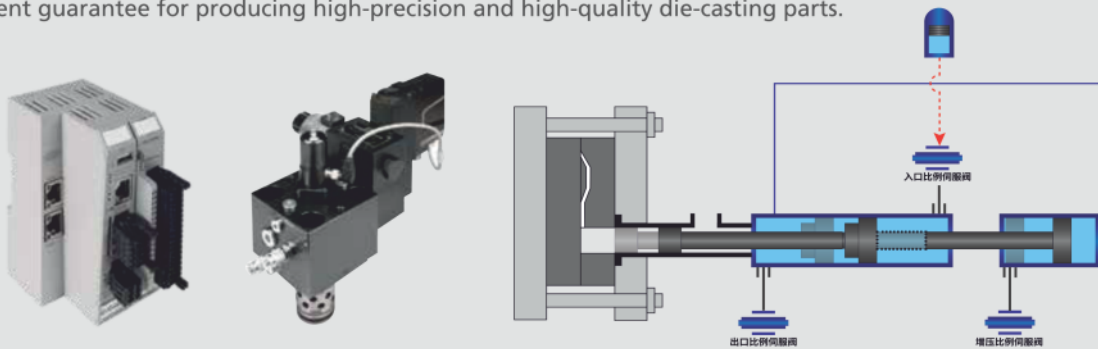
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- Excellent high speed repetition accuracy and slow speed repetition accuracy
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Injection technology comparison

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- Open loop control
- 3 phases injection
- Meter-in control
- Injection speed controlled by proportional/motor valve
- PLC controller

Closed loop from Other Chinese makers

- Only speed is controlled
- Multi-phase speed settable
- Meter-out control
- Injection speed controlled by servo valve
- PLC controller

Haitian dual closed loop real time control system

- Both speed and pressure are real time controlled
- Multi-phase both injection speed and intensify pressure
- Meter-in and meter-out
- 3-5 servo valves control
- Real time controller

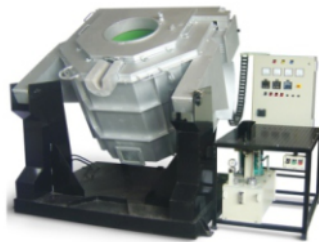


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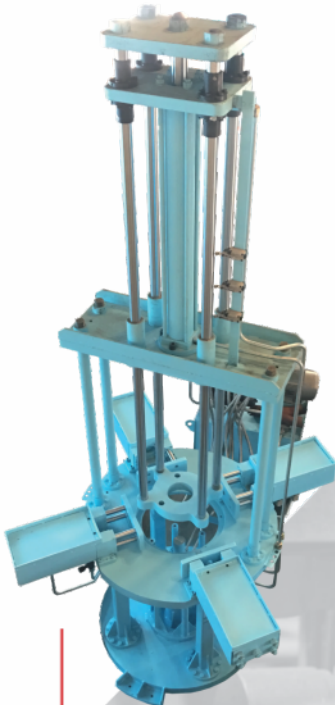


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