ISSN 0972-0480 • Vol. 26 No. 8 • August 2023

IIM METAL NEWS

A monthly publication of The Indian Institute of Metals

77th Annual General Meeting
The Indian Institute of Metals

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Vol. 26 No. 8 August, 2023

Chief Editor
Prof K Bhanu Sankara Rao

Printed and Published by
Brig. Arun Ganguli (Retd.) Secretary General, on behalf of "The Indian Institute of Metals", and
printed at Print Max, 44, Biplabi Pulindas Street, Kolkata-700009
and
published at 'Metal House', Plot 13/4, Block AQ, Sector V, Salt Lake, Kolkata-700091, West Bengal, India

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The Students from IIEST Shibpur attended the 32nd Prof. AK Seal Memorial Lecture on 29th July, 2023

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Editorial Board of IIM Metal News

IIM welcomes Mr Satish Pai, President, IIM, 2023-24

Message

Mr Satish Pai
Managing Director, Hindalco Industries Ltd

Dear Members,

Greetings and warm regards to each one of you. It is my privilege and honour to be President of the Indian Institute of Metals (IIM) for the year 2023-24.

I would like to thank Dr. Samir V Kamat, the outgoing president, for his significant contribution in steering the institute towards improvement in various domains throughout the past year. I would also like to acknowledge the exemplary efforts of our former Presidents who have set high standards, elevating IIM to a unique position among industrial and academic institutions.

As India undergoes a transformative phase and takes on a leading global role, IIM has the unique opportunity to act as a catalyst in bridging the gap between the evolving technology requirements of industries and the research and development efforts of academic institutions.

The rapid adoption of Electric Vehicles (EVs) and the growth of its ecosystem have ushered in new and exciting prospects for the metals and materials sectors to develop indigenous supply chains. This is a great opportunity for IIM. Through knowledge sharing, joint research, and technology transfers, IIM can enable the seamless integration of cutting-edge materials into EV components, supporting India's ambition to become a global player in the electric mobility space.

At the same time, the metal industry is facing major sustainability challenges such as GHG emissions, zero discharge and waste management. Here, the vast knowledge-base of IIM members becomes valuable. The institute can proactively engage with industries and government institutes to develop sustainable practices, leveraging research and expertise to devise eco-friendly processes and waste reduction techniques. By actively contributing to the formulation and implementation of sustainable practices, IIM can help the metal industry attain its environmental goals and contribute to India's broader commitment to combat climate change.

The non-ferrous and ferrous industries, research and educational institutes share a symbiotic relationship that is central to the growth and progress of the manufacturing landscape. By aligning our efforts and expertise, we can together power the Make in India movement - creating a cycle of innovation and collaboration that propels the metal industries forward, making them more competitive and resilient on the global stage.

To achieve this vision of co-creation and industry acceleration, collaboration among research and educational institutions, industry stakeholders, and government bodies is paramount. Through joint research projects, technology transfer initiatives, and knowledge-sharing platforms, we can foster a vibrant ecosystem of innovation. This ecosystem will empower researchers, engineers, and entrepreneurs to translate cutting-edge ideas into practical solutions that benefit the metal industries and society.

I am enthusiastic about working closely with my distinguished Vice-Presidents - Mr. Sajjan Jindal, Prof. B. S. Murty, and Dr. Komal Kapoor, as well as all the Council Members and Office Bearers of IIM, to continue the new initiatives started by my predecessors. As we push these initiatives - encompassing membership drives, the enrolment of younger members, and specialised training programs - we recognize the pivotal role that diversity plays in driving innovation and progress. By promoting diversity within the IIM, we foster an environment where ideas, experiences, and talents converge, propelling us towards novel solutions.

Additionally, I aim to strengthen the ties of IIM with international metal societies like GDMB, JIIM, ASM, and Materials Australia.

I eagerly look forward to your proactive support in our collective mission to establish IIM as a global institute of excellence for the Metallurgy & Materials industry and research and academic institutions.

Regards,

(Satish Pai)
1st August, 2023

Profile of Mr. Satish Pai

Satish Pai has been the Managing Director of Hindalco since August 2016. Headquartered in Mumbai, Hindalco is the metals flagship of the Aditya Birla Group, a diversified global conglomerate with operations spanning 36 countries. In his role as MD, Satish also oversees the operations of Hindalco subsidiary Novelis Inc., which is the world's largest aluminium rolling and recycling company. Mr. Satish Pai took over as the President of The Indian Institute of Metals on August 1st, 2023.

Satish's strengths lie in envisioning and guiding organisation-wide, sustainable transformation. At Hindalco, he has been the driving force behind Hindalco's journey from a metals commodity player to a value-added solutions provider in the aluminium and copper sectors. Under his leadership, Hindalco has evolved into a future-facing company with a Greener, Stronger, Smarter Purpose at its core, and a focus on digitalisation, innovation and high performance.

Some key transitions under Satish's stewardship include adoption of large-scale renewable energy and pathbreaking responsible mining initiatives through India's first Sustainable Mining Charter. He drove global-first circular economy solutions that utilise bauxite residue as an industry input rather than waste. Initiatives for carbon neutrality, water positivity, biodiversity and zero waste to landfill have contributed to Hindalco being recognised as the world's most sustainable aluminium company by the Dow Jones Sustainability Indices in 2020, 2021 and 2022. Beyond operations, Satish has focused on cultural transformation, such as driving gender diversity with a higher intake of women in core manufacturing and leadership roles, improving performance accountability and ownership in mid-management levels, and raising benchmarks for people safety. Satish ushered in the era of digitalisation in Hindalco and encouraged and empowered the R&D function to make it core to Hindalco's functioning. These changes have helped to position Hindalco as a global manufacturing leader in Aluminium, Copper and Chemicals.

At Hindalco, Satish has driven mega greenfield and brownfield projects, such as the Aditya and Mahan smelters, and the Utkal Alumina refinery expansion.

In 2020, he led Novelis' acquisition of global aluminium flat-rolled-producer Aleris, which has enhanced Hindalco's presence in premium market segments such as aerospace.

His interest in R&D has led to new product lines such as lightweight aluminium-intensive battery enclosures for the global EV industry, lightweight commercial vehicles such as aluminium bulkers and trailers, and new housing infrastructure solutions. These innovations have led to the filing of over 75 patents across Hindalco-Novelis. Satish has also directed investments for the development of cutting-edge aluminium alloy sheet manufacturing technology for next-gen automotive panels with lower carbon footprints.

Satish's experience in managing complex, global operations dates back to his 28-year career with oil and gas major Schlumberger, where his roles included Executive Vice President - Worldwide Operations, Vice President - Technology, and President of its software entity.

A highly-regarded influencer and spokesperson for the sector, Satish works to highlight the importance of aluminium and copper as strategic metals for sectors such as defence, automotive, packaging, aerospace and power. He advocates for industry through his positions as the Chairman of the International Aluminium Institute; Chairman, Non-Ferrous Metals at FICCI and President, The Indian Institute of Metals; and Chairman of the Government Affairs Committee of the Aluminium Association of India. He is the Chair on the Vikaasa collation, formed by Xynteo, a purpose-driven organization. He also serves as Director on the boards of Aditya Birla Management Corporation Pvt. Ltd., and BP p.l.c.

Satish holds a mechanical engineering degree from Indian Institute of Technology (IIT) Madras. In his personal capacity, he holds a patent in directional drilling. Satish was conferred the 'Distinguished Alumni Award' by IIT Madras in 2017 and the honorary Doctor of Letters (D. Litt) by Ajeenkya DY Patil University in 2020.

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Technical Article

Additive Manufacturing of Nickel-base Superalloys for High Temperature Applications: A case study with Inconel 718

K Praveenkumar, R J Vikram, Satyam Suwas*

Abstract

Metallic materials are widely used in high-temperature applications despite their decrease in strength with increasing temperature and enhanced susceptibility to aggressive environments that prevail. The specially designed alloys can mitigate or decrease the detrimental effect of temperature. Especially, Inconel 718 (IN718) has been developed for use in hot section of turbine engines of aircrafts and industrial gas turbines due to its exceptional combination of creep and fatigue strength and high oxidation resistance. Recently it has been realised that additive manufacturing processes are most suitable for the manufacturing of gas turbine components used for hight temperature applications. This article presents a short review on additively manufacturing as applied to IN718, its benefits, and the importance of microstructure and texture in the AM-processed nickel-base superalloy IN718.

1. Introduction

The ability to make gas turbine engines with better power ratings and efficiency levels is largely due to the latest advances in the field of materials. The capacity of materials to survive elevated temperatures in service has been a key factor in gas turbine advancements. A few high-temperature materials are especially preferred in for gas turbines due to their better performance against mechanical and chemical degradation at elevated temperatures. Nickel based super alloys are typical examples of such materials. The components from these materials are frequently manufactured using conventional machining process (subtractive machining). However, in subtractive manufacturing processes the buy-to-fly ratios is 10:1 (10% of the initial raw material mass converted to final product) or some times higher [1] and also it takes more time to produce the parts. On the other hand, additive technique such as additive manufacturing (AM) or 3D printing, leads to the manufacturing of parts from powder, wire, or sheets in a layer-by-layer manner and reduces the processing time by approximately 50% compared to conventional manufacturing processes with concomitant reduction in the wastage of the material. Many techniques have been developed that involves melting or solid-state sintering. In directed energy deposition (DED) processes, powder or wire feedstock is introduced into a molten pool. In another AM approach, the powder bed fusion process (PBF) involving Electron Beam Melting (EBM) and Laser Melting (LM), is associated with selectively melting of distributed layers of metal powder to produce a part in a typical bottom-up approach. PBF processes can produce more complex shapes than DED processes [2]. All the AM processes have distinct advantages over casting and subtractive machining in which unique geometries can be manufactured with lower retooling costs, and enhanced cost-effectiveness for small production quantities. The detailed processing and corresponding parameters are well discussed in the literature for each investigated metals [2]. This article mainly focusses on the additive manufacturing of high temperature material IN718, its microstructural feature's and resulting mechanical properties.

2. Additive manufacturing

The ASTM F42 Committee on Additive Manufacturing has established a standard for process terminology [3–5]. Among the seven F42 standard categories, the following four are relevant to various metal additive manufacturing (AM) techniques: powder bed fusion

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(PBF), directed energy deposition (DED), binder jetting (BJ), sheet lamination (SL), and ultrasonic additive manufacturing (UAM). The remaining three categories outlined in the standard do not currently pertain to metal technologies: material extrusion, material jetting, and vat photopolymerization. Each of these processes comes with its unique strengths and challenges.

2.1.1 Powder Bed Fusion Process

Powder Bed Fusion (PBF) is an AM process that uses focused energy, such as laser or electron beams, to precisely melt or sinter layers of powder within a bed. Metals are frequently printed using this method. The key innovation is the capacity to remelt earlier layers while melting the current one, ensuring strong layer bonding. Two primary methods, LM and EBM, have distinct hardware setups, managing powder dispersion differently. Both methods involve machine setup, operation, powder recovery, and substrate removal, with the substrate providing mechanical support. It is essential to stabilise build layers during powder spreading, and machine performance is impacted by scan techniques and processing parameters. Following completion, extra powder is eliminated either by direct filtration (LM) or a recovery system (EBM). The removal of the build substrate depends on the specific PBF material used. In situations like Ti-6Al-4V deposit on a stainless-steel substrate in EBM, the components are frequently simple to separate. As-fabricated (AF), "as-printed" (AP), or "as-built" (AB) are common terms used for parts that come out of the machine directly after printing.

2.1.2 Directed energy deposition

Directed energy deposition (DED) encompasses various techniques where concentrated energy forms a melt pool into which feedstock is deposited, utilizing heat sources like lasers, arcs, or electron beams. Feedstock is available as wire or powder. DED technologies deposit material outside of a controlled environment while enclosing the melt pool with gas. They were originally inspired by welding technology. One prominent DED variant involves melting powder feedstock with a laser (powder-fed), pioneered by Sandia National Laboratories, and patented as the LENS method. Another type feeds wire into a molten pool (wire-fed), an extension of welding technology. Software automates the sensor checks, calls for powder hoppers to be restocked, and places a build substrate, making machine setup comparatively simple. For powder-fed systems, regular verification of powder feed rate and potential nozzle cleaning or maintenance is necessary. The build chamber is enclosed for laser safety, often filled with inert gas for oxidation resistance, especially with reactive metals like titanium. DED components are typically attached to a substrate and undergo thermal post-processing for final geometry, with parts often near net shapes and rough finishes. Excess powder is removed from the machine, with disposal being an expensive choice due to the high cost of powders.

3. Need for Additive manufacturing for manufacturing materials for High-Temperature Applications

Many applications involving high temperature materials demand intricate shapes in the final engineering product; one such application is the turbine blades of jet engines. Additive manufacturing successfully addresses criticalities imposed while manufacturing a component from high-temperature material. In addition, it offers the flexibility in mechanical (design) and metallurgical (microstructural and texture control) aspects. The problem associated with AM is related to microstructural heterogeneities and spontaneously generated defects, which are observed in AM-produced parts. The most challenging aspect of substituting conventionally manufactured parts with additively produced components lies in the metallurgical distinctions between the two. Specific issues such as porosity, cracking, delamination, and residual stress are inherent to AM techniques and require attention, particularly in critical aerospace applications. These applications encompass aluminium, various types of steel, nickel, and titanium alloys [6]. On the other hand, AM processes involve rapid solidification accompanied by significant thermal gradients within the melt pool, resulting in a distinctive morphological and crystallographic texture. This mechanical anisotropy resembles that found in directionally solidified nickel-based superalloys within the columnar-grained material [2,7]. These issues undermine the benefits of AM leading to hesitation in adapting of this technology by industrial manufacturers. Most of the current metallurgical studies are focused pre-processing aspects (optimizing processing parameters to generate a defect-free material). Limited research has been performed on the post processing of materials.

4. Additive Manufacturing of IN718

4.1 Microstructure of AM INCONEL 718

A number of investigations have been carried out on microstructure of IN718 for different AM processes under as-printed and post-heat treated conditions [8–14]. The microstructure of the as-printed SLM IN718 shows a columnar structure throughout the build [15]. The columnar structures extend across many deposited layers as a result of partial remelting of the previous layers and heterogeneous nucleation of γ dendrites, resulting in epitaxial development [16]. The texture obtained after the AM process is determined by the local heat flow directions and competing grain development in one of the six ⟨001⟩ preferred growth orientations of the fcc structure. [17]. Commonly, one of the crystallographic ⟨001⟩ directions align with the orientation of the building process. By regulating various processing parameters, such as laser power, scanning speed, and scanning strategy, researchers have reported a comprehensive band of textures in AM IN718, ranging from a strong cube texture [18] to a fibre texture to a random texture [19]. It has been noted that the preference for a ⟨001⟩ texture is observed in applications involving high-temperature creep and fatigue, and this texture can be employed as a design factor for tailoring material properties specific to particular loads [20]. Fig. 1 shows typical SLM microstructures in built and heat-treated conditions.

The microstructure of IN718 is influenced by the cooling rate, which varies for different manufacturing methods. Fig. 2 shows the typical microstructure that evolved during the DED of IN718. In a direct metal deposition process, the deposition parameters and laser-specific energy in DED systems have a considerable impact on the height-to-width ratio of the deposited zone. Because of the different thermal gradient along its height, the microstructure of AM IN718 generally alters towards the build direction [21]. The lower layers, in direct contact with the substrate plate, experience a higher cooling rate, resulting in finer columnar dendrites in the bottom layers compared to the coarser ones in the top layers [22,23]. Micro-segregation in AM IN718 is primarily observed in the form of Nb and Mo-rich Laves phases [24]. The reduced cooling rate at the top layer often leads to a higher proportion of Laves phases and the formation of a thick, continuous Laves network [25].

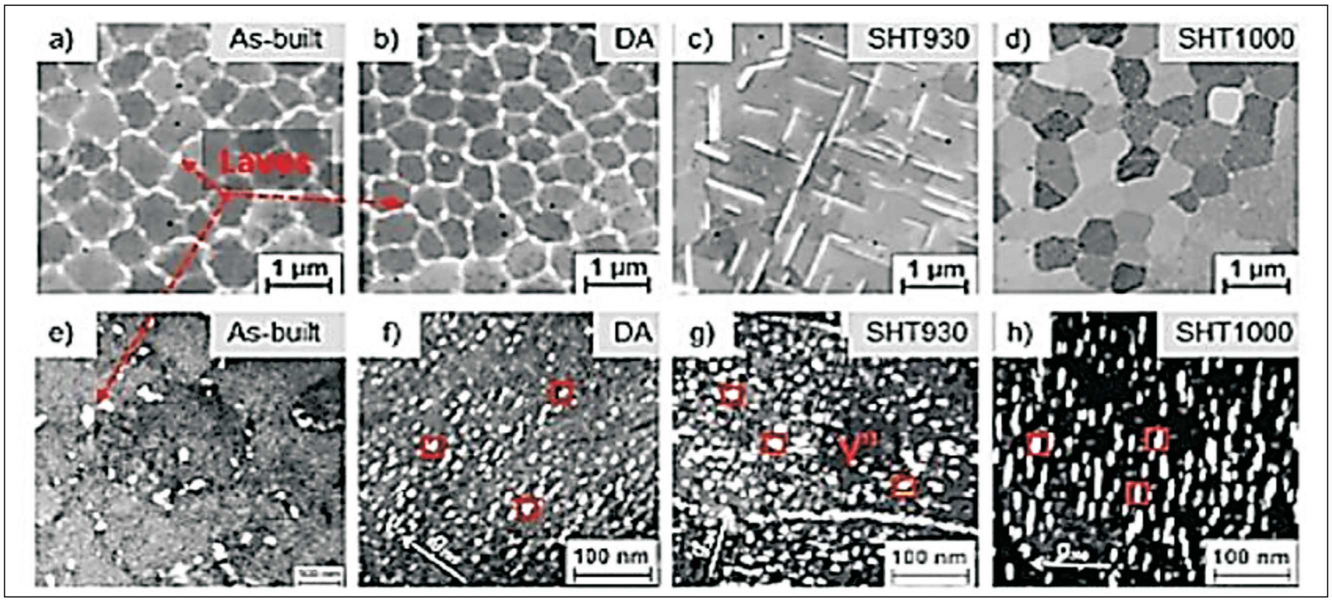

Fig. 1 : Microstructure of SLM IN718 (a-d) SEM images and (e–h) TEM DF after various heat treatment processes (DA: direct aged, SHT930: 930 °C solution heat treated and aged, SHT1000: 1000 °C solution heat treated and aged) [7, 12] (reproduced with permission).

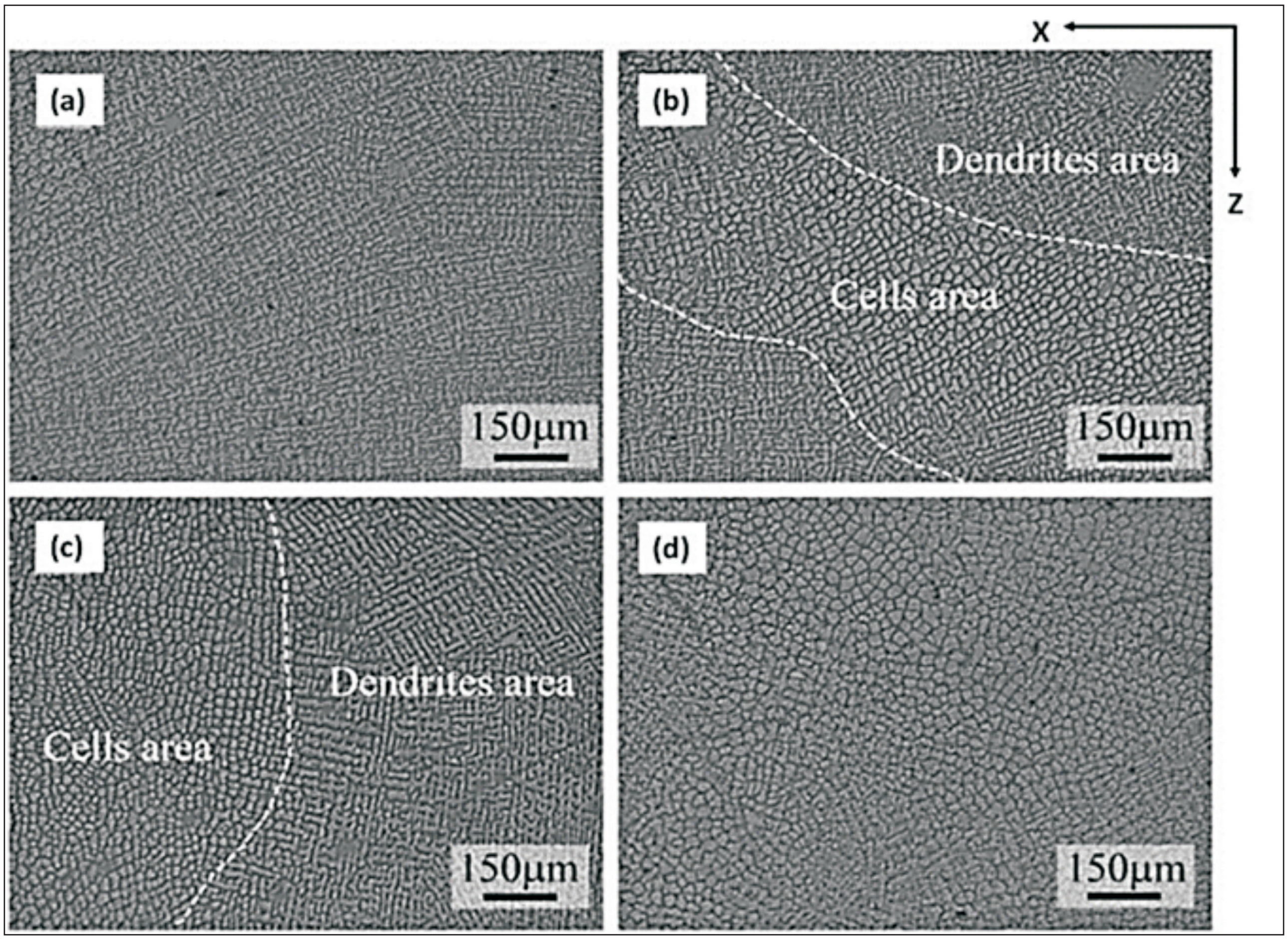

Fig. 2 : Optical micrographs of as-built DED IN718 sample on horizontal section (X–Y plane) for various energy inputs (EV): EV of (a) 176 J/mm³, (b) 248 J/mm³, (c) 350 J/mm³ and (d) 600 J/mm³ respectively. The angle θ is the angle between laser scanning velocity (V) and solid-liquid interfacial growth velocity (Vs); the blue dashed lines indicate the tangent of the solid-liquid interface [7,26] (reproduced with permission).

4.2 Mechanical properties

4.2.1 Tensile properties

Numerous studies have investigated the tensile behaviour of AM IN718 [27–29]. Fig. 3 illustrates the reported room temperature yield/tensile strengths and elongations for both as deposited and heat-treated AM IN718, compared to cast and wrought alloys. It is worth noting that while there are numerous reports on the properties of as-built IN718, its application without undergoing precipitation hardening treatment is uncommon. Consequently, the properties of the alloy after heat treatment hold greater significance. It can be observed that the strength of as-built AM IN 718 is lower, and its ductility is higher compared to the heat-treated alloy. This disparity is attributed to the absence of precipitation hardening from γ' and γ" phases in the as-built AM alloy. On comparing the strength values of as-built SLM and EBM IN718, the EBM alloy exhibits higher strength, primarily due to higher processing temperature, which allow for in-situ precipitation hardening during the EBM process [30]. For both as-built and heat-treated conditions, the most commonly reported strength values for AM IN718 fall within the range between those of cast and wrought alloys. The enhanced strength of AM IN718, compared to its cast counterpart, is mainly credited to the fine microstructure achieved through AM process [31]. On the other hand, the presence of porosity has been identified as the primary reason for comparatively inferior properties of AM IN718 when compared to the wrought alloy [32].

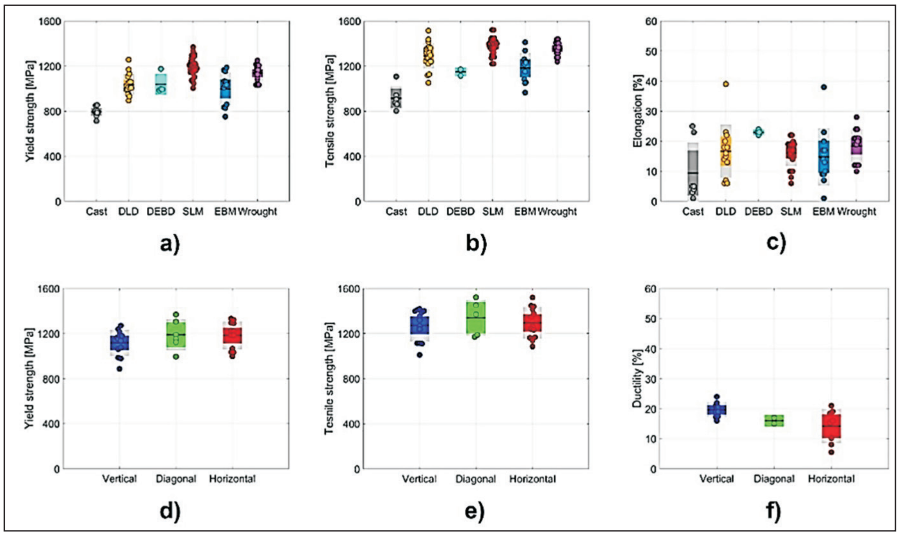

Fig. 3 : Fully heat-treated yield strength, (ultimate) tensile strength, and elongation of Inconel 718 manufactured with different MAM processes compared to the cast and wrought alloys. The graphs present the mean of reported data, SD, and SE quantities. Anisotropy is observed in tensile properties for AM samples printed vertically, diagonally (45°), and horizontally. The plots present the mean of reported data, SD, and SE quantities [7,27–29]. (Reproduced with permission)

4.2.2 Hardness

Numerous studies have delved into the hardness of AM IN718, encompassing various techniques such as DLD [33], SLM [34–36], and EBM [17]. Fig. 4 illustrates the reported hardness values of the as-deposited IN718 for different AM processes in comparison with cast and wrought IN718 (without the standard solution annealing and aging heat treatment). Numerous studies have investigated the distribution of hardness throughout the build height. Like tensile properties, the spatial variation in hardness hinges on the specific AM technique and the process parameters employed. Some investigations have reported negligible variations in hardness [27, 37–40], while others have pointed out a decline in hardness as you move through the build height. The higher hardness at the bottom of the build can be attributed to enhanced precipitation hardening, arising from the repeated heating cycles experienced by the lower regions during the AM process [41]. In addition, the presence of a narrow band with elevated hardness at the very top layer of the build samples has also been reported [42].

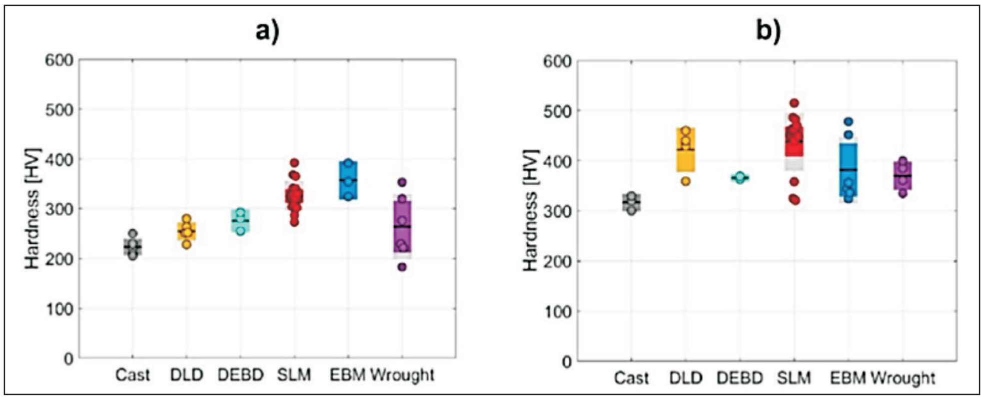

Fig. 4 : a) Hardness values for as-built IN 718 manufactured with different MAM processes compared to cast and wrought alloys without solution annealing and precipitation hardening treatment. The graph presents the mean of the reported data, SD, and SE quantities. b) Hardness values for full heat-treated IN 718 for different MAM processes compared to the cast and wrought alloys [7,27]. (Reproduced with permission)

In contrast to the differences observed in tensile properties, studies have reported a minimal disparity in hardness between planes parallel and perpendicular to the building direction [43]. The hardness is profoundly influenced by AM process parameters, such as input energy and scanning strategy, which have a substantial impact on the temperature profile during AM and consequently affect the resulting hardness. For instance, an increase in input energy leads to a higher proportion of Laves phase and a reduction in available Nb for γ" phase formation, which has a moderating effect on hardness [44]. Undoubtedly, the fine microstructure developed due to the rapid heating and cooling cycles in AM processes contributes to the hardness of AM IN718. However, a post-processing heat treatment remains essential to further enhance hardness [45]. The minimum requirement for the hardness of wrought IN718 after heat treatment is typically in the range of 36-38 HRC, which is approximately equivalent to 355-385 HV [46]. Interestingly, most of the reported hardness values for heat-treated AM IN718 and the as-built AM IN718 exceed those of conventionally manufactured IN718 [47].

4.2.3 Fatigue

The fatigue behaviour of AM IN718 has been studied and reported in [43,48–51]. Fig. 5 represents the S-N (stress vs number of cycles) curve for AM IN718 in comparison with wrought alloy. Most reports [52] consistently reveal that AM IN718 exhibits lower fatigue limit compared to wrought alloy, and in some cases, even cast IN718. This inconsistency is especially pronounced at lower stress amplitudes, where the initiation of fatigue cracks is influenced by stress concentrations caused by the presence of pores in AM IN718 [45]. It has been reported that while the fatigue endurance remains comparable in the low cycle regime, the fatigue life of AM IN718 is at least an order of magnitude shorter than that of wrought counterparts in the high cycle regime [53]. The presence of process-induced pores, particularly the lack of bonding between built layers, reduces the fatigue endurance of AM IN718 [16]. Another consequential factor is the residual stress induced by the AM process, which can significantly impact fatigue properties, both in terms of crack initiation and propagation. The fatigue behaviour of AM alloys correlates reasonably well with their surface condition. Particularly for low-stress amplitudes, machined specimens have demonstrated considerably longer endurance compared to those with an as-build surface condition. from the investigation of Kelley et al. [54] the difference in lifetimes was observed to be between 100–1000 times. In another study, for notched fatigue specimens, Witkin et al. [55] revealed that surface machining doubled the fatigue strength of fully heat-treated SLM samples.

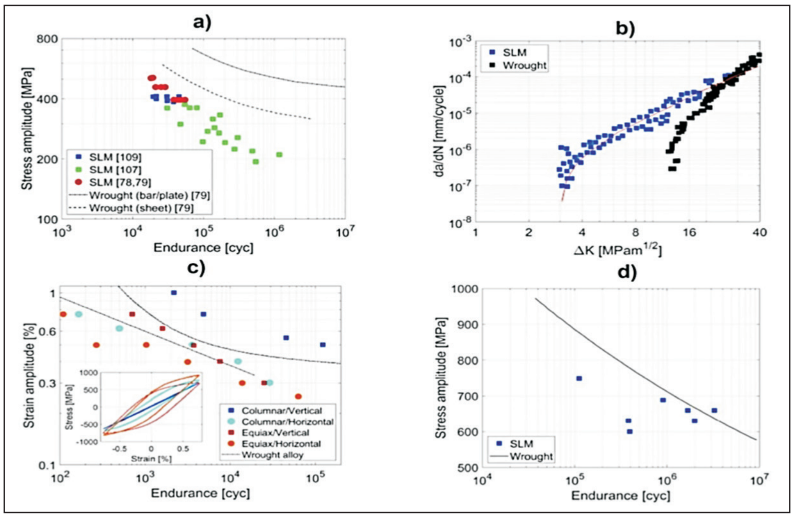

Fig. 5 : a) Room-temperature fatigue (endurance) behaviour of fully heat-treated AM IN 718 for constant-strain amplitude fatigue. b) Fatigue crack growth behaviour of SLM IN718 compared to the data for wrought alloy. (c) constant-strain amplitude fatigue and d) constant-stress amplitude fatigue [7,48]. (reproduced with permission)

Furthermore, it has been demonstrated that the utilization of advanced surface modification techniques, such as laser peening [56], ultrasonic nanocrystal surface modification (UNSM) [57], and shot peening [58], leads to the generation of substantial compressive residual stresses at the surface of AM IN718. This, in turn, enhances the fatigue performance of the alloy [54]. However, it's important to note that one of the major advantages of the AM process is its ability to create intricate geometries with internal features where surface finishing operations may not be feasible. Therefore, the impact of the as-fabricated surface quality on fatigue behaviour should be considered in AM design of components. Besides surface roughness, the presence of internal (subsurface) pores has a detrimental effect on the fatigue response of AM IN718. The Hot Isostatic Pressing (HIP) process is commonly employed to close these internal pores. Observations from studies conducted by Kelley [54] and Witkin et al. [55] indicate that properly HIP-processed, heat-treated, and surface-machined AM IN718 can exhibit fatigue properties comparable to those of wrought IN718. However, it is worth noting that surface defects are recognized as the primary reason for the inferior fatigue response of AM alloys, and the effect of HIP (without surface finishing) on fatigue endurance is relatively minor.

4.2.4 Creep

Creep behaviour in AM IN718 has been the subject of numerous studies [59–61]. These investigations have yielded varying results when compared to wrought IN718. Some studies [62] have reported inferior creep properties, while others [63] have indicated a superior creep response for AM IN718. The discrepancies in reported data can be attributed to the use of different processes, heat treatments, and surface conditions for the tested specimens, as illustrated in Figure 6. For instance, Pröbstle et al. [61] delved into the compressive creep behaviour of SLM IN718. They attributed the superior creep properties of AM IN718, at least in the primary creep regime, to the presence of numerous processing-induced sub-grains. Other factors, such as the availability of more niobium for γ" precipitation hardening, solid solution strengthening, and a smaller and thinner morphology of δ precipitates, were also cited as responsible for the improved creep performance of the AM alloy under compressive loading conditions [64]. Rogers [65] noted a better creep performance for AM IN718 and observed that, in contrast to cast and wrought alloys, AM IN718 did not exhibit a transition in the creep mechanism with stress variation. Dislocation glide was identified as the dominant creep mechanism, potentially due to the difficulty of diffusional creep and grain boundary sliding in the AM alloy. Strondl et al. [13] reported significantly shorter creep rupture times for EBM alloy, primarily attributed to the presence of process-induced pores that led to premature failure.

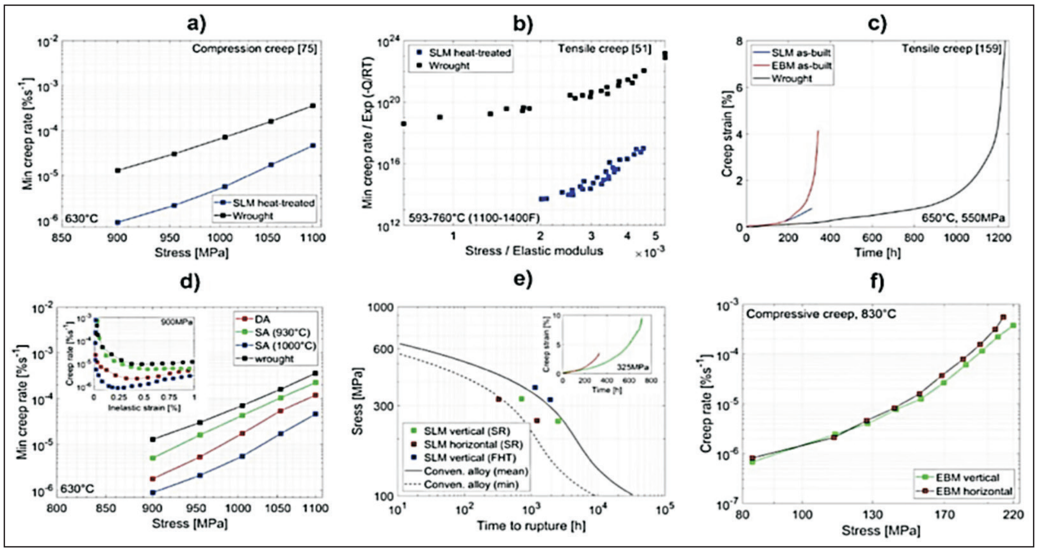

Fig. 6 : Creep behaviour for AM Inconel 718 compared to that for the wrought alloy. Anisotropy of creep behaviour of AM Inconel 718 (SR: stress relived, FHT: full heat treatment) [7,65]. (reproduced with permission)

Interestingly, Zhao et al. [27] highlighted the substantial impact of powder quality on the porosity levels in AM builds and demonstrated a significant improvement in creep rupture duration when using PREP powders instead of GA powders. Xu et al. [62] conducted a series of creep tests on miniature specimens of as-built SLM IN718 and reported poor creep performance attributed to surface defects and an unfavourable microstructure. Although the application of heat and surface treatments improved creep rupture times by a factor of four, they still remained significantly below those of the wrought alloy [61]. Similarly, Kuo et al. [66] compared the creep response of as-built SLM and EBM IN718 with that of the wrought alloy and found short rupture durations for both AM alloys. Heat treatment, as investigated in [66], significantly enhanced the creep response of AM IN718, resulting in superior performance. Several studies underscored the crucial role of the δ phase in the creep performance of AM IN718. While a small amount of needle-shaped δ precipitation at grain boundaries controls grain boundary sliding and improves performance at low-stress, high-temperature creep regimes, Kuo et al. [66] demonstrated that suboptimal heat treatment might lead to extensive transformation of γ" to δ and the formation of precipitation-free zones, particularly near grain boundaries. Such areas allowed for the localization of creep strain and accelerated the formation of creep voids at grain boundaries. The anisotropy of creep behaviour in AM IN718 was explored in several studies. Some reported negligible creep anisotropy, while others indicated better creep performance for specimens loaded parallel to the building direction. Inferior creep responses were observed for samples loaded perpendicular to the loading direction, primarily due to the presence of the δ phase at grain boundaries, which were mostly oriented perpendicular to the stress direction. This δ phase acted as sites for rapid creep cavity formation, consequently accelerating rupture [67]. The extent of anisotropy was more pronounced for EBM builds than those manufactured using the SLM process. EBM's higher penetration depth and slower solidification and cooling rates led to the formation of large grains elongated in the build direction and with a strong ⟨001⟩ texture [68].

5. Concluding remarks

AM produces complex aerospace parts precisely using minimal buy to fly ratio and lower lead time than conventional manufacturing process. However, major challenges of AM are the generation of tensile residual stresses, porosity, and high surface roughness. The critical applications such as turbine disc and blade often require more extensive post-processing to meet stringent quality and performance requirements. Proper post-processing can significantly enhance the overall quality and reliability of AM parts. Hot Isostatic Pressing is a post-processing technique commonly used in additive manufacturing (AM) to improve the properties of printed metal parts, particularly those produced using powder bed fusion technologies like selective laser melting (SLM) or electron beam melting (EBM). HIP is especially valuable for ensuring the structural integrity, density, and material properties of metal AM components. One of the primary goals of HIP is to eliminate internal porosity and voids in the printed metal part. However, it's important to note that the HIP process may encounter challenges when attempting to address surface cracks.

To effectively overcome this challenge, a proactive approach involves minimizing porosity and addressing lack-of-fusion defects by controlling printing parameters (such as laser power, scanning speed, and layer thickness). By carefully regulating these factors, it is possible to enhance the quality and integrity of the printed metal components, reducing the occurrence of surface cracks and other defects.

On the other hand, in conjunction with HIP processing, surface modification techniques must be employed to eliminate the surface and sub-surface defects. The surface modification techniques such as shot peening, ultrasonic shot peening, and laser peening enhances the surface properties by eliminating the surface cracks and defects and reduces the roughness. In addition, these processes induce the compressive residual stress at surface and sub-surface that are beneficial for mitigating premature failure. Especially, laser peening induced compressive residual stresses are thermally stable and enhance the fatigue properties at higher temperatures, suitable for high temperature materials. It is important to note that while shot peening induces compressive stress at the surface and sub-surface, it is not thermally stable and may relax when exposed to higher temperatures. By combining, additive manufacturing with HIP and suitable surface modification technique to reduce the chance of porosity and surface defects could lead to better mechanical properties.

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Obituary Dr V S Arunachalam, Former President, IIM, 1987-88

Late Dr V S Arunachalam
[10 November 1935 –16 August 2023]
Former President, The Indian Institute of Metals

With a deeply pained and heavy heart we convey that Dr. V S Arunachalam, Former President (1987-88) and Honorary Member of IIM had left for the heavenly abode. The IIM fraternity deeply mourns his sad demise.

Dr. V S Arunachalam's distinguished career spanned across Bhabha Atomic Research Centre, National Aeronautical Laboratory, and the Defence Metallurgical Research Laboratory. Dr. Arunachalam was the Secretary, Department of Defence Research and Development (Ministry of Defence, Government of India, the Director General of Defence Research and Development Organisation (DRDO) and the Scientific Adviser to Raksha Mantri, Government of India, from 1982 to 1992. It was under his guidance that the Light Combat Aircraft program (TEJAS) and the Integrated Guided Missile Program of the DRDO was initiated, amongst many others. He was conferred the Shanti Swarup Bhatnagar Award, Padma Bhushan, and Padma Vibhushan for his contributions to engineering science and technology. He has been conferred with The Lifetime Achievement Award of the Indian Institute of Metals in 2007. In 2011, INAE recognised his contributions with its Lifetime Achievement Award in Engineering. He was awarded DRDO's Lifetime Achievement Award in 2015.

From 1990-2005, he served as the Distinguished Service Professor (Engineering and Public Policy) at Carnegie Mellon University, Pittsburgh. On his return to India, he founded the Center for Study of Science, Technology and Policy (CSTEP), a not-for-profit think-tank, with a mission to enrich policymaking with innovative approaches using science and technology for a sustainable, secure, and inclusive society.

He was a Fellow of the Indian National Science Academy, the Indian Academy of Sciences and the Indian National Academy of Engineering along with being the first Indian Fellow of the Royal Academy of Engineering (UK). He served on INAE's first ad hoc council after it was founded.

He championed the notion of "Atma Nirbhar Bharat" throughout his life. He will be missed dearly by his family, friends, and the scientific community at large, and the nation.

On Board | Dr Komal Kapoor, Vice-President (NF Division), IIM

Dr. Komal Kapoor

Outstanding Scientist and Chairman & Chief Executive, Nuclear Fuel Complex (NFC), Hyderabad

Dr. Komal Kapoor obtained Bachelor's degree in Metallurgical Engineering from Punjab Engineering College, Chandigarh. Subsequently he completed a one year Post Graduate Course in Nuclear Science & Engineering from (BARC) Training School, Mumbai. He received Ph.D. in Materials Science and Metallurgical Engineering from the Indian Institute of Technology Bombay, Mumbai. He has rich experience in the fields of processing of Zirconium, Titanium and Nickel-based superalloys for in-core and-out-of-core applications in nuclear reactors, fuel fabrication for Pressurized Heavy Water and Boiling Water Reactors, manufacture of core sub-assemblies and advanced alloys for Fast Breeder Reactors, Development and processing of Seamless Tubes for Nuclear, Defense and Space applications, Quality Assurance and Characterization of Nuclear Materials. He has over 100 Peer Reviewed publications in national and international journals and conference proceedings. He has been the recipient of Scientific & Technical Excellence Awards of DAE for his excellent contributions as Group Leader/ Member (9 times), and Young Metallurgist Award from the Ministry of Steel, Govt. of India. The professional affiliations he received include : Director (Board) Uranium Corporation of India Limited (UCIL); Director (Board) Indian Rare Earths Limited (IREL); Council Member, Atomic Minerals Directorate (AMD); Chairman, ISNT Hyderabad Chapter; Vice President, Hyderabad Chapter of Society for Failure Analysis (SFA)-India; Adjunct Professor Homi Bhabha National Open University; Visiting Professor University of Hyderabad and Engineering Staff College, Hyderabad; Consultant IAEA for publication of Tecdoc and Guide book; member Board of Research in Nuclear Sciences (BRNS); Life Member of The Indian Institute of Metals (IIM), Indian Society for Non-destructive Testing (ISNT), and Indian Nuclear Society (INS).

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Achievements of Members | Dr Jaiteerth R Joshi

DRDL scientist conferred with Prestigious Fellowship of Royal Aeronautical Society

Dr. Jaiteerth R Joshi, a Fellow Member of IIM, is an Outstanding Scientist and Programme Director with over 32 years of proven track record of strong decisive leadership in Defence Research & Development Laboratory.

Dr. Joshi has contributed immensely in the fields of missile technology, NDT, welding & skill development of industry professionals. As AICTE- INAE Distinguished Visiting Professor, he has significantly contributed in skill development of engineering students to make them industry-ready engineers. As the Chairman of Indian Society for Non-destructive Testing, trained and certified large number of candidates in Level-I and Level-II of Radiography, Ultrasonic, Magnetic Particle and Penetrant Testing and trained welding professionals as a part of his Chairmanship of IIW.

His contribution in public policy and management as **Member Secretary of** National Strategic Materials Policy, **Governing Council Member** of **Dept. of Science & Technology, Member** of National Innovative Manufacturing Policy, stand as a living example. He has been bestowed with fellowships of various academia and institutions, notably among them are Telangana Academy of Sciences, Indian Society for Non- destructive Testing, Institution of Engineers India, Indian Society for Mechanical Engineers.

He has harnessed Industry, Academia & R&D Labs in deep and outcome based Research. He is very well established & decorated scientist for which he has been conferred with galore of significant awards and honours, few of them are **Distinguished NDT'ian of the decade** by ISNT, **National Technology Day Award** by DRDO, **IIM SAIL Gold Medal** by IIM, **DRDO Performance Excellence Award, Scientist of the Year Award** by DRDO, **Bharat Ratna Sir Mokshagundam Vivesvaraya Award** by Institute of Engineers, **Sir C V Raman Endowment Lecture Award** by IWWA, **Manager of the Year Award** by HMA, **Dr. N. Kondal Rao Memorial Award** by ISNT.

Dr. Jaiteerth R Joshi has succeeded in building one of the most illustrious group of technicians, engineers & scientists in the field of welding & NDT by applying his techno-managerial skills. He has published several research papers in leading journals and delivered keynote address and lectures in many conferences & academic institutions. For his contributions in the field of Defence & Aerospace sector The **Royal Aeronautical Society, UK** & Indian National Academy of Engineering has bestowed him with fellowships of their Academy.

Achievements of Members Dr L Rama Krishna

Dr. L. Rama Krishna received the first Dr. Elaya Perumal National Award of ECSI

Dr. L. Rama Krishna is currently serving as Scientist-G & Head-Centre for Engineering Coatings and the Chairman of Aerospace Working Group at International Advanced Research Centre for Powder Metallurgy and New Materials ARCI has been awarded Dr. K. Elaya Perumal National Award for Excellence in Industrial Electrochemical Science and Technology on 17 Aug, 2023 in recognition of his outstanding contributions in the area of Surface Engineering, Tribology and Corrosion. Over the past two and half decades of his professional services at ARCI, Dr. L. Rama Krishna, conceptualized and executed numerous fundamental and sponsored R&D projects leading to the development of applications pertaining to automotive, energy, aerospace, textile, electrical, electronics and pharmaceutical sectors, filed 12 patent applications out of which 10 patents were already granted in India and abroad, 50+ products developed, delivered and demonstrated, several technologies were transferred and implemented for the benefit of the Indian industry. Besides, he has contributed over 80 scientific articles including 2 Encyclopedia articles, 6 invited book chapters, fetched over 3050 citations with a h-index of 28 and i-10 index of 46, supervised 5 Doctoral thesis awarded till date.

In recognition of the outstanding contributions of Dr. L. Rama Krishna to the broader inter-disciplinary fields of surface engineering, tribology and corrosion, he has received numerous honors and awards including Young Engineer Award of Indian National Academy of Engineering, BOYSCAST Fellowship of DST, Government of India. He was appointed as a Research Faculty of Materials Science & Engineering, Northwestern University, Illinois, USA during 2008-09, won Silver Medal at ICMCTF, San Diego, USA. In addition, he was part of the Indian delegation at the Indo-US Frontiers of Engineering Symposium, Washington DC, USA.

Dr. L. Rama Krishna is a Fellow of Institution of Engineers (India), and Life Member of IIM, ECSI, MRSI, Defense and Aerospace Panel of Confederation of Indian Industry. In recognition of his multi-faceted achievements, he was conferred with Distinguished Alumni Professional Achievement Award by NIT-Warangal. Further, in recognition of his impactful research, Dr. L. Rama Krishna was also conferred Thomson's Highly Cited Author Award by Web of Science, Singapore.

Over the past two decades, The Indian Institute of Metals is proud to have Dr. L. Rama Krishna associated in multiple capacities namely Editor of the Transactions of The Indian Institute of Metals (TIIM) Journal from 2017-23, Life Member of IIM (LM 37699), Secretary IIM Hyderabad Chapter (2020-23) and served as the council member of the chapter multiple times. IIM wishes Dr. L. Rama Krishna all the best in his future endeavors.

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AGM of IIM — 77th Annual General Meeting

The 77th Annual General Meeting [AGM] of The Indian Institute of Metals, was held on Saturday, 29th July 2023, in hybrid mode at Tollygunge Club, Kolkata.

Mr. Bhaskar Roy, Acting Secretary General, IIM welcomed all members present at the Meeting and requested the President, Dr. SV Kamat to preside over the meeting.

At the outset, the President welcomed all members and requested Mr. Bhaskar Roy to transact the following business:

ORDINARY BUSINESS

1. To approve and adopt the Report of the Council for the year 2022-23 (1st April 2022 to 31st March 2023).
2. To approve and adopt the Financial Statement for the year ended 31st March 2023 and the Report of the Auditors thereon.
3. To appoint the Council and the Office Bearers for the period 1st August 2023 to 31st July 2024.

SPECIAL BUSINESS

To confirm appointment of the Secretary General by the Council of The Indian Institute of Metals w.e.f. 1.8.2023 and handing over charge by the Acting Secretary General, Mr. Bhaskar Roy and if thought fit, to pass the special resolution as indicated later.

Condolences

The members present during AGM the following resolution to express their condolences to the bereaved families of :

	Member	Category
1.	Dr. Arun Kumar Bhaduri	Life Fellow
2.	Dr. J J Irani	Honorary Member & IIM Former President
3.	Shri P N Shali	Life Member
4.	Prof. Somnath Misra	Life Fellow

"**RESOLVED** that the President, and, the Members of IIM present at the 77th AGM at Tollygunge Club through hybrid mode deeply mourn the sad demise of the IIM Members during the Council Year 2022-23."

Proceedings

[1] The minutes of the 76th Annual General Meeting [AGM] held through hybrid mode were circulated to all Members of the Institute. No comment was received. The minutes were confirmed through voice vote. Proposed by Dr. Vilas Tathavadkar and seconded by Mr. Bibhu Mishra.

[2] The report of the Council for the period 1st April 2022 to 31st March 2023 was circulated earlier amongst members via email dated 14th July 2023 for subsequent adoption during the 77th AGM.

Dr. S V Kamat, President, IIM requested the Acting Secretary General to present the Council Report (2022-23).

The Acting Secretary General apprised the members regarding the following initiatives & happenings for the Year 2022-23 under various heads as given below.

a. Organizational
- ACFP
- IIM National Council
- IIM National Committees

b. Significant Deliberations of the Council
- Financials
- General

c. IIM Buildings & Premises.

d. IIM Events & Happenings
- Memorial Lectures
- Chapter Divisional Activities
- MOUs signed between HO & Chapters
- Webinars & Lectures
- Quiz & Technical Talks
- Flagship Events

e. Publications & Library

f. Associate Membership Examination

g. IIM Memorial Lectures

h. Membership: A way forward

i. Chapter Relations Committee: Meetings & Deliberations

j. Accolades

k. From President's desk

l. Postface & Conclusions

No comments were made. Members passed the following resolution.

"RESOLVED that the Institute's Report of the Council for the year 2022-23 is hereby approved and adopted by the Members."

Proposed by: Dr. AK Ray

Seconded by: Dr. U Kamachi Mudali

[3] Appointment of the Council for 2023-24

In accordance with Clause 18 of the Articles of Association of the Institute, the Council Slate for 2023-24, constituting the Office Bearers & Council Members was announced by the Acting Secretary General. The council slate has been kept as 60 for the time being. Two members, one under the R&D and Academia segment and one from Chapter will be co-opted in the Council during its next meeting, sometime in September 2023.

Mr. Satish Pai, Managing Director, Hindalco Industries Ltd was appointed the President of the Institute for 2023-24 and Dr. Komal Kapoor, Chairman & Chief Executive, NFC as the Chairman & Vice President, Non-Ferrous Division.

The following resolution was passed unanimously by the members present.

"RESOLVED that pursuant to Clause 18 of the Institute's Articles of Association, 60 members are hereby approved as Office Bearers and Members of the Council to the year 2023-24."

Proposed by: Mr. Lohitendu Badu

Seconded by: Dr. SVS Narayana Murty

[4] Institute's Financial Statement: FY 2022-23

The Acting Secretary General requested Mr. Somnath Guha, Hon. Treasurer, IIM to apprise the Council regarding the audited Financial Statements for FY 2022-23. Mr. Guha placed the following as was earlier approved by the Council, for necessary ratification by the Members.

Table I

Summary: Income/Expenditure Statement (Rupees)

Particulars	2022-23	2021-22
Total Revenue	9.63 Cr	4.93 Cr
Total Expenditure	8.55 Cr	2.76 Cr
Total Surplus	1.08 Cr	2.16 Cr

Major Highlights:

a. Rs 3.5 Cr revenue earned from IIM-ATM 2022 is the highest till date. Previous year, the earnings from IIM-ATM was Rs. 2.66 Lakhs.

b. Rs 3.97 Cr earned from Chapter Seminars is also significantly high in comparison to previous years. In FY 2022-23, Chapters like Bokaro, Rourkela, Jamshedpur & Delhi [MMMM] were the major Revenue earners. All these Chapters organised the events in physical mode and through paid registrations, unlike in earlier years when the events were mostly organised virtually and through free registrations.

c. It was observed that the Income for FY 2022-23 was close to double that for FY 2021-22 and the expenses wear close to triple. As a result, the surplus was approx. Rs.1 Cr, which was half of that of last year.

Analysis of Other Accounting Heads

a. Earnings from Membership subscriptions in 2022-23 was Rs 6.28 Lakhs against Rs 13.47 Lakhs which is not an apple-to-apple comparison. Last year, a cumulative figure was derived adding up earnings from both one time and annual membership subscriptions. However, based on Auditors comments, the earnings from annual subscriptions were placed under Revenue Income while the earnings from Lifetime Membership category have been kept under Capital Head.

b. The Income from Student, Ordinary & Sustaining Membership under annual categories has been dwindling. Council has advised to carry out a holistic study of various reasons behind the steep decline in the number of enrolments. This has been a burning issue and should be a primary agenda of discussion by the Chapter Relations Committee. However, on comparison with budget, the performance was found not too alarming.

c. Last year many old accounts/liabilities appearing in the list have been cleaned up with Council's approval. All these have been considered by the Auditors and records have been updated.

The Balance Sheet for FY 2022-23, Income/ Expenditure Statements & Cash-flow are principal yardstick of the Institute's financial health. There has been an increase in assets over the last year.

Table II

Balance Sheet for FY 2022-23 in comparison to the previous year [Rupees]

Particulars	2022-23	2021-22
Equity & Liabilities	25.33 Cr	24.31 Cr
Assets	25.33 Cr	24.31 Cr

Forty Chapters annual audited accounts have been incorporated in the Annual Audited Accounts of the Institute for FY 2022-23.

Auditors' Opinions [FY 2022-23]

Mr. Somnath Guha, Hon. Treasurer, IIM presented the following Auditors opinions for information of the Members whose extract is as given under :

(A) Old observations being Carried Forward from Previous Years

i. We did not audit the Financial Statements of 38 Chapters (Actually 40), 2 Events & 2 Funds accounts (Actually 4) included in financial statements of Head Office as on 31st March 2023 and for 8 Chapters & 2 funds, we have not been provided with the signed accounts /partially complete accounts for review. The financial statements of these Chapters have been audited by the Chapter auditors duly approved by the Council, whose reports have been furnished to us. Details of financial Statements received from chapters have been stated in Note no 20 (a) and also the detail of Financial Statements received from Chapters have been stated in Note no 20 (a) and also the detail of financial statements not at all received from the Chapters, including 2 Chapters where such statements are due over many years, have been stated at Note no. 20 (b).

ii. Since the consolidated accounts of the Chapters were not homogeneous (i.e. not including the financial information of common Chapters in all cases) the previous year's figures in the accounts are not comparable with the same of the Current year.

iii. In absence of receipt of audited accounts from some of the Chapters the cash & bank balances of those Chapters at the year ended 31st March 2022 added with any transfer of fund during 2022-23 to those Chapter(s) were considered as the cash & bank balances as 31st March 2023 as was detailed at Note no.21.

iv. As stated at Note no.25 of the Financial Statements the GST liability for FY 2022-23 is under reconciliation.

v. We draw attention to note no 28 of the Financial Statements in relation to balance shown under trade receivables short loans & advances, trade payables, bank balances, fixed deposit and other current liability are subject to reconciliation / confirmation and respective consequential adjustment.

vi. We also draw attention to note no 29 of the Financial Statements, wherein disclosure given for unreconciled accrued interest to due non-receipt of all chapters' /funds/events audited accounts of Rs 29,64,281.17.

vii. The Institute is following Cash basis in accounting of Membership income instead of Mercantile basis which is not as per statute.

viii. We also draw attention to note no 5 & 11 of the financial statements and state that due to non-availability of appropriate information we are unable to comment on ageing of trade payable and trade receivables.

(B) New Opinions for FY 2022-23

ix. From the Chapter auditor's report, it is noted that in one Chapter, 3 fixed deposits receipts, are not in the name of IIM, but in the name of some other concern having remark in Duplicate.

x. Attention is also drawn to note no.6 of the financial statements where in absence of production of relevant document, we are unable to comment whether land and building under property, plant & equipment in are under lease hold or free hold one and as a consequence required lease accounting, has not been done.

xi. Though the company has maintained one 'Fixed Assets' register but there exists substantial differences between the Original costs shown under that Register and the same appearing in the financial Statement.

xii. In absence of production of relevant reports we are unable to comment whether any physical verification of 'Property, Plant & Equipment's was conducted during this year. As a result, no adjustment in the Financial was made during this year. We are also not able to comment on whether the title deeds of Land & Buildings are in the name of the Company.

Mr. Somnath Guha provided suitable clarifications to some of the above observations, wherever possible.

The Members ratified the Annual Audited Accounts of the Institute for FY 22-23 and adopted the following Resolution:

"RESOLVED that the Institute's Audited Income and Expenditure account and the corresponding Balance Sheet for the year ended 31st March 2023 and the Auditor's report thereon be and is hereby approved & adopted by Members."

Proposed by: Mr. Arnab Banerjee

Seconded by: Mr. L Pugazhenthy

5. Appointment of the New Secretary General wef 1st August 2023.

Mr. Bhaskar Roy, Acting Secretary General placed the following Special Resolution under Special Business, incorporating the terms & conditions of appointment of Brig Arun Ganguli (Retd), for confirmation.

SPECIAL BUSINESS :

To confirm appointment of the Secretary General by the Council of The Indian Institute of Metals w.e.f. 01. 08. 2023 and handing over charge by the Acting Secretary General Mr. Bhaskar Roy, and if thought fit to pass the following resolution as a **special resolution**.

"RESOLVED that the appointment of Brig. Arun Ganguli (Retd.) as Secretary General by the Council of The Indian Institute of Metals, be and is hereby approved as per terms & conditions set out below:

i) Period:

Initially for a one-year term on probation, with effect from 1st August 2023, and then for four more years on confirmation, which may be extended further at the discretion of the Council.

ii) Nature of Duties:

The Secretary General will function as Chief Executive Officer of The Indian Institute of Metals (IIM) and report to the President. He will carry out his duties under direction of the Council and under the supervision and control of the Council and the President. He will be responsible to carry out all related functions, as well as perform all duties of the Secretary as defined in the 'Memorandum and Articles of Association' of the Institute and would endeavour to enhance the image and the functioning of the Institute. He will coordinate, promote and enhance the objectives with robust communications, skills and imagination.

iii) Remuneration:

(a) Honorarium: Consolidated amount of Rs 84,500/- [Rupees Eighty-Four Thousand Five Hundred only] per month, subject to deduction of tax at source as per prevailing Income Tax Act.

(b) Conveyance: In addition to the honorarium, re-imbursement of local transport expenses subject to a maximum limit of Rs 13,500/- [Rupees Thirteen Thousand Five Hundred only] per month.

(c) In addition, re-imbursement of all telephone charges relating to the Institute's activities at actuals but not exceeding Rs 2,000/- [Rupees Two Thousand only] per month.

iv) The appointment shall be subject to termination by the employer by giving 1[One] Month notice in writing. The incumbent may wish to resign from his position by giving 3 [Three] Months' notice to the employer.

The Special Resolution was unanimously adopted by the Members and the appointment was confirmed.

Proposed by: Mr. Atish Mandal

Seconded by: Dr. R Balamularikrishnan

Further to the appointment of Brig Arun Ganguli (Retd) as the Secretary General of the Institute, the following resolutions were passed by the Council Members.

'FURTHER RESOLVED THAT as the Secretary General of the Institute, Brigadier Arun Ganguli (Retd) is empowered to carry out all actions, accomplishments, matters, and things considered necessary, appropriate, or beneficial, and to sign and start executing all required documents, implementations as and when required'.

Proposed by: Mr. Atish Mondal

Seconded by: Dr. Biswajit Basu

6. Revamped Website of IIM :

The Acting Secretary General informed that the revamped website of IIM is in the final stages of development and shall go live shortly. The project is undertaken by M/s Lowe Lintas at a cost of approximately Rs 20 Lakhs, inclusive of GST. M/s Tata Steel had sponsored Rs 10 Lakhs towards designing and development of the Website.

The Acting Secretary General requested Mr. Tamal Goswami to apprise the Members regarding the additional features which have been incorporated in the revamped website.

Mr. Goswami emphasized the following for information of all members:

New Secondary Menu
Allows to link multiple Content and Pages on the Homepage itself without disturbing the structure of the existing menu.

Dedicated Updates Page
Includes latest Updates and other relevant Sections like examinations, events and webinars etc.

New Laravel Based CMS
An improved Solutions to manage and update our Website compared to the existing one.

Related Pages
Dynamic functionality of seeing other relevant Pages to explore on the Website.

Improved Hierarchy and Navigation
Websites includes dedicated Sections for Membership and Community and separate Functional Key Pages like Resources.

Use of Brand Elements
An improved Identity via use of a new color palette, tonality of images and identity via Membership Badges. This allows the Website to be consistent and semantically sound for intuitive user experience.

Floating Action Button
A sticky Button at the bottom right that takes user to six Key Pages and is available at all times at a Single Tap/Click.

Dynamic Events Page
Dynamic Cards with information, clear indication of attached File Type and Pagination.
Legibility Use of Fonts, Sizes and Color allows for maximum Legibility and Readability on the Website.

7. Conclusion : The AGM ended with a vote of thanks to the Outgoing President, Dr. SV Kamat for his invaluable contributions to IIM.

While passing on the Baton to Mr. Satish Pai, Dr. S. V. Kamat thanked and expressed gratitude to all Members of Apex, Council, Office Bearers and Chapters for their able support during his tenure and reiterated the dynamicity of IIM in being able to offer meaningful services to Industry, Institutes & Research Organisations at the same time.

He added here that the Hon'ble Prime Minister of India has given a target that by 2047 our country has to become a developed country, and to make it happen, we have to become self-reliant in producing all types of Metals & Minerals, including Ferrous, Non-Ferrous and others. IIM can play a critical role in fostering interactions, cooperations, and dialogues between various agencies and people working in different areas of materials and metals. He emphasized on the strengths of the Institute and envisaged that the next 25 years will be going to be the Golden Period (Amrit Kaal) for India and IIM can effectively contribute its might in making this happen for the Country.

Dr. Kamat thanked once again the Apex & Council Members for their immense contributions & support extended to him in the Council Year 2022-23, and, welcomed Mr. Satish Pai as the President, IIM for 2023-24.

Mr. Satish Pai, President (Elect) thanked the Members & Council for giving him the opportunity to serve as the President of IIM and be at the helm of affairs of such an august body.

8. There being no other points for deliberation, Meeting was closed with words of appreciation and thanks to all the Attendees of the AGM meet.

32nd Professor A K Seal Memorial Lecture


IIM President Mr. Satish Pai presenting a silver plaque to Dr. Sandip Ghosh Chowdhury

Dr. Sandip Ghosh Chowdhury, F.N.A.E., Chief Scientist and Head, Materials Engineering Division, CSIR National Metallurgical Laboratory, Jamshedpur, has delivered the lecture on "Nano-Pearlite formation: a pathway to design high speed rails", following the Annual General Meeting on 29th July, 2023. The Memorial Lecture was well attended by Students of IIEST, Shibpur and IIM Members.

Mr. Satish Pai, the newly elected President of The Indian Institute of Metals, presided over the function and introduced the speaker to the assemblage.

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Chapters' Conclave — CRC Meeting

The Chapters' Conclave was hosted in hybrid mode on 12-July-2023 at 1530 hrs, chaired by Mr. S. S. Mohanty, Chairman, Chapter Relations Committee (CRC). Representatives from CRC, IIM Chapters and IIM Head Office were present.

A. The Chairman, Chapter Relations Committee (CRC) welcomed all members and initiated the proceedings with a request for points arising from the previous meeting in Nov-2022 and actions taken thereof. These were presented by Shri Tamal Goswami from IIM Head office. Dr. Sudhanshu Shekhar Singh (Co-chairman, CRC) briefed about the number of chapters presenting in the CRC meeting and the overview of the chapter's representation for last few years. A total of 29 chapters (11: Large, 8: Medium, 11: Small) participitated in the CRC Meeting held on 12 July 2023. This is the highest number of Chapters attending CRC meeting since 2017.

- ✓ Regarding membership drive, HO informed that it had been suggested to the chapters to conduct membership drive in a regular interval and encourage the professionals to be the IIM Member. In recent years, IIM HO has visited 36 chapters for membership drive. In the year 2022-2023, 290 new life members were added. The total number of members in IIM (as on 31st March) is 7848 (life member: 6619).

B. Chapters presentations and Deliberation

- ✓ Each chapter presented on six headings, namely, (i) Activities completed, (ii) Financials, (iii) IT / networking strategies, (iv) Future plans and long-term vision, (v) major success and (vi) area in which excellence is wished to be attained. Most of the attending chapters have done lots of activities and were observed to be sound in terms of finances.
- ✓ Jamshedpur Chapter suggested that Behind the Teacher's Desk (BTTD) has been a very successful event and it can be made IIM event.
- ✓ IIM Hazira Chapter informed about the delay in new bank account opening. IIM HO informed that it will be done soon.
- ✓ A few events, such as MMMM (Delhi) and IIM-ATM (Bhubaneshwar) will be organized. Chairman CRC suggested that all chapters should help in organizing these events and also participate.
- ✓ IIM HO informed that a couple of chapters have used different IIM logo while conducting events. Chapters were advised to use the IIM logo as provided in IIM website. In addition, it was informed by HO that chapters need to inform about their events beforehand for wide publicity.
- ✓ Mr. Tamal from HO informed that IIM Roorkee chapter has been revived and student affiliated chapters at IIT Hyderabad and GEC-Jamunalia have been formed. No further dormant chapter has been reported. A total of 36 chapters are registered for GST (two in 2022-2023). In addition, Mr. Tamal informed about IIM publication, IIM examination, e-library (As on 31st March, 9.45 L pages have been uploaded to the internal server).
- ✓ IIT Roorkee Chapter informed that although the chapter has been revived, EC was not able to carry out activities due to unavailability of funds from IIM HO. Mr. Roy informed that IIM HO will coordinate with IIM Roorkee Chapter.

C. Suggestions from the Chairman, CRC

Suggestions from the chairman included further increase in the IIM membership by conducting activities. In addition, the Chair suggested that IIM Chapters should get connect to local industries (MSMEs) and bring them the gambit of IIM.

Mr. Mohanty, Chairman CRC concluded the meeting by thanking everyone for their active participation.

Chapter's Conclave - Participants

CRC: Mr. S. S. Mohanty, Dr. S. S. Singh, Shri Bhaskar Roy

Participating Chapters : *Baroda, Bhubaneshwar, Pune, Kalpakkam, Durgapur, Rourkela, Delhi, Bhilai, Jamshedpur, Mumbai, Kolkata, Coimbatore, Bokaro, Sambalpur, Varanasi, Vijayanagar, Trichy, Chennai, Trivandrum, Bharuch, Hazira, Roorkee, Jaipur, Nagpur, Kharagpur, Dolvi, Kanpur, Sunabeda, Bhopal*

IIM Head Office : *Mr. Tamal Goswami, Ms. Rita Banerjee*

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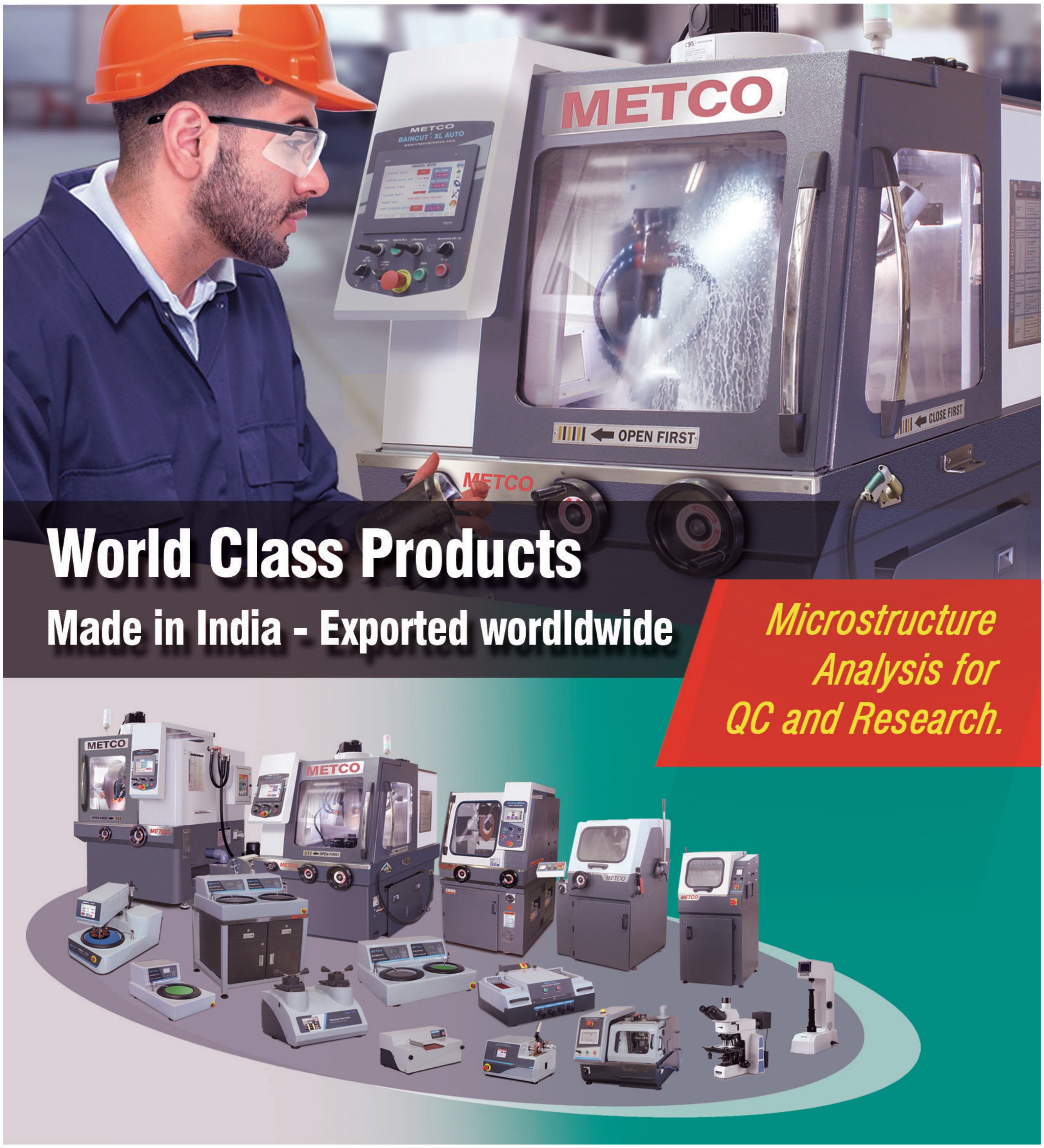
METCO
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CLOSE FIRST
World Class Products
Made in India - Exported worldldwide
Microstructure Analysis for QC and Research.

Recent Developments National

Proud moment for India! LEHIPA at BARC heralds a new era in the field of high-current and high-energy proton accelerators in the country.

The Low Energy High Intensity Proton Accelerator #LEHIPA at the Bhabha Atomic Research Centre reached the target energy of 20 MeV on August 4, 2023, with an intensity of around 2 mA. LEHIPA consists of a 50 keV ECR ion source, a 3 MeV Radio-Frequency Quadrupole (RFQ), and four Drift-Tube Linac structures (DTLs) from 3 to 20 MeV, besides other systems like high-power and low-level RF, beam diagnostics, control electronics, etc.

A large number of scientists and engineers from DAE have collaborated in realising LEHIPA. All major sub-systems of LEHIPA have been designed indigenously by DAE scientists, and most have been developed indigenously in Indian industry, mainly in MSMEs. LEHIPA is the highest-intensity proton accelerator developed in the country, and it opens up a new era in the field of high-current and high-energy proton accelerators in India.

DAE's expertise in proton accelerator technology is also being leveraged in the collaboration with the Fermi National Accelerator Laboratory, USA, on the PIP-II proton accelerator (presently tested to 17 MeV, 2 mA), for which Hon. Prime Minister Shri Narendra Modi ji has recently announced a US$ 140 million in-kind contribution.

This technology can be used in the development of proton synchrotrons for radiation therapy for cancer treatment, the production of radioisotopes, basic research using radioactive ion beams, and also as the first step towards future accelerator-driven reactor systems (#ADS).

Dr. A. K. Mohanty, Secretary, DAE & Chairman, AEC, met and inspired the team in the #LEHIPA Control Room after the successful achievement of the 20 MeV energy target.

- PMO India Dr Jitendra Singh

India's first cathode active materials plant inaugurated by Altmin-ARCI

From left to right: Dr. V K Saraswat, Hon'ble Member, NITI Aayog, Dr. Anil Kakodkar, Chairman, Governing Council, ARCI, Tata Narsinga Rao, Director, ARCI, and Mourya Sunkavalli (right extreme), Founder & MD, Altmin, at the inauguration ceremony of the CAM facility.
Source: Ashok Thakur (ETN)

Battery materials firm Altmin and ARCI, under the Union Ministry of Science and Technology, have launched a 10 MW pilot plant for producing Cathode Active Material (CAM) - first of its kind in India - at the latter's campus in Balapur, Hyderabad.

The facility is poised to make 100 kilos of CAM per day, marking India's foray into the local production of CAM meant for the manufacturing of advanced chemistry Li-ion battery cell. The maiden product under the partnership would be Lithium Ferrous Phosphate (LFP) that has humongous market demand for making electric vehicle batteries.

The International Advanced Research Centre for Powder Metallurgy and New Materials (ARCI) is supporting Altmin as a technology partner and has backed the company's R&D endeavors as well. Altmin strives to to become a leading producer of indigenously developed battery materials and develop its own cell chemistries.

https://etn.news/
Author : Dhiyanesh Ravichandran

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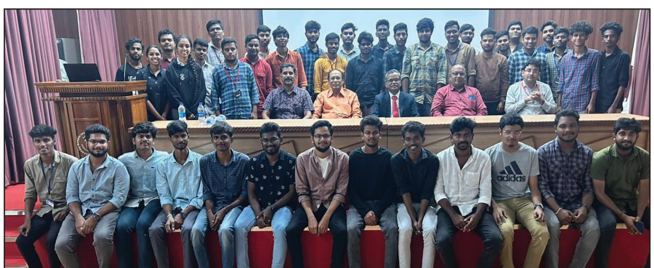
Chapter Activities | Hyderabad Student Affiliate Chapter

Hyderabad Student Affiliate Chapter

1) IIM MGIT Hyderabad Students' Chapter : The Department of Metallurgical and Materials Engineering in association with the Indian Institute of Metals, Hyderabad Chapter has organised an Expert Talk on Education 4.0 on August 01, 2023 in the A-Block Auditorium. Professor U. Kamachi Mudali, Vice Chancellor, Homi Bhabha National Institute (a Deemed to be University), Mumbai delivered the talk for the benefit of the Students community and the Faculty Fraternity of the MGIT HYDERABAD. The talk emphasised the significance of Artificial Intelligence into the Education System and in particular National Education Policy-2020. Professor G Chandramohan Reddy, Principal, MGIT has given opening remarks. Dr. RVSM. Ramakrishna has introduced the Resource Person to the Audience and proposed vote of thanks to conclude the session. Professor K Bhanu Sankara Rao, former Chair Professor (MGIT), Ministry of Steel, Government of India had also been a part of the session and inspired the faculty and students.



Students with the dignitaries @ the event on Education 4.0

2) IIM IITH Students' Chapter : On the Department Day of Materials Science and Metallurgical Engineering at IITH (MeSMErize 2023), the IIM Student Affiliate Chapter organised a technical event on 18th August 2023. The event began with a formal welcome address delivered by Prof. Suhash Ranjan Dey (HOD), who gave a quick glimpse of the journey of making the MSME department at IITH. Prof. B S Murty (Director IITH and Vice President IIM) and Prof. Bhanu Shankar Rao (Distinguished Professor, IITH) addressed the gathering by sharing their memories of their career path. This was followed by Dr. I Srikanth's IIM-MSME Department Day Lecture on "COMPOSITE MATERIALS FOR MISSILES AND AIRCAFTS: PRESENT STATUS." While addressing the gathering, Prof. K. Bhanu Sankara Rao announced his willingness to contribute Rs. 10,000 to the IIM Student chapter at IITH. Dr. I Srikanth was one of the first Ph.D. scholars of the MSME department, working as Scientist F and Technology Director, Advanced Systems Laboratory, Hyderabad. Office bearers for the present academic year were introduced as a part of this event. The present student team comprises Mr. Valasa Siri Chandra (Chairperson), Miss. Ambe Radha (Vice Chairperson), Mr. Akhil Antony Sebastian (Treasurer), Mr. Vikram Soni (Secretary), Miss. Dhanushikaa S (Event Head, Lecture series), Miss K S Geetha Bhavana (Event Head, Visits), Mr. Amandeep Saha (Head, Sponsorship Team), Mr. Anubhav Singh (PR Head, social media), Miss. Avantika (PR Head, Multimedia) and Mr. Aashish Mandavi (Head, Membership team). The MeSMErize 2023 event was concluded with a vote of thanks delivered by Prof. Deepu J Babu (Assistant professor, IITH).

Following this event, IIM Student Affiliate Chapter organised a career guidance lecture by Dr. Surendar Maddela (Senior Technical Specialist, Automotive and Aerospace Solutions Division, 3M Center, USA) on 21st August 2023. Dr. Maddela is celebrated for his pioneering work in Surface Technology, Bonding and Joining Technology, Conversion Coatings, and Material Characterization, and his leadership in multimillion-dollar auto electrification projects. Dr. Maddela delivered an engaging talk, focused on career development within multi-national sectors.

Dr. I. Srikanth is delivering the lecture

Dr. I. Srikanth receiving Memento from Prof. Suhash Ranjan, HOD, MSME, IIT Hyderabad

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News Updates Domestic

NMDC's Nagarnar steel plant in Bastar starts production

NMDC's Nagarnar steel plant (NSP) in Chhattisgarh's Bastar district has commenced production, company officials said. The plant achieved the feat of producing its final product - HR (hot rolled) Coil just nine days after the production of hot metal, they said.

The 3 million tonne per annum capacity steel plant of the National Mineral Development Corporation -a central PSU, has been built at a cost of approximately Rs 24,000 crore over an area of 1,980 acres in Nagarnar village, more than 300 km away from capital Raipur.

"On August 12, Amitava Mukherjee, acting CMD and Director Finance of NMDC had blown in the plant's blast furnace and set the ball rolling for the final commissioning. The production of the final product - HR Coil - was started from Thursday, just nine days after production of Hot Metal in the unit," Rafique Ahmed Jinabade, the plant's General Manager and Chief of Communications said in a statement.

Nagarnar Steel Plant's competitive advantage also stems from its iron ore supply linkage with Bailadila mines (in Dantewada district), barely 100 km from Nagarnar. The plant will also be producing special types of steels to be used in manufacture of generators, motors, transformers and automobiles at a later stage, it added.

The Times of India (26.8.23)

No 'silver bullet' for green transition, needs govt support: Tata Steel CEO

There is "no silver bullet" for green transition in hard-to-abate sectors, including steel, Tata Steel global CEO & MD T V Narendran said, noting it's a complex challenge and needs government support.

The statement from the industry leader comes amid growing concerns across economies over emissions, and need to increase usage of green energy.

Steel is the most commonly used metal in the world and one can do nothing without steel. Even for the transition, steel will be needed whether to hold solar panels up, windmills, storage and pipelines, he said addressing a session at B20 Summit India 2023.

"You need to find a solution and there is no silver bullet for that...India is alone going to add 100-150 Mt steel capacity every decade...for the next few decades you will have these hard-to-abate sectors growing, cement production is twice the amount of steel production globally...you need to find solutions which are technical, which don't get solved by just finding another energy source," he said.

Supply chain in steel sector has been built over 100 years, so transitioning from coal to gas to hydrogen even from supply chain point is a very complex challenge, Narendran, who is also the chairman of Manufacturing Council of industry body CII, said.

Business Standard (18.8.23)

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Non-Ferrous Metals Statistics Domestic Scenario

Prices in India (as on 4th August, 2023)

(Mumbai Local Price in Rs. / kg)

Product	Rs. / kg	Product	Rs. / kg
Copper Armature	703	Aluminium Ingot	207
Copper Cathod	756	Aluminium utensil	174
CC Rod	766	Zinc Ingot	225
Copper Cable scrap	730	Lead ingot	187
Brass Sheet Scrap	512	Tin Ingot	2363
Brass Honey Scrap	497	Nickel Cathod	1845

Source : https://mtlexs.com/


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29.7.2023
COUNCIL MEETING