Advanced Lightweight Metallic Materials for Automobile and General Engineering Applications: Present Scenario and Future Prospect

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Lightweight metallic materials are considered to be a potential material primarily in automobile application where high specific strength, specific stiffness, good corrosion resistance in association with lightness are of prime consideration. Replacement of existing heavy components with lightweight would certainly lead to reduction in emission of greenhouse gases like CO_2, NO_2, SO_2. In order to reduce greenhouse gases and improving fuel efficiency in transportation sector, automakers and related agencies invest heavily in developing alternate lightweight materials. The alternate materials such as Aluminium alloys and composites, Magnesium alloys, ultralightweight cellular materials, CNT /graphene based metallic composites, polymer reinforced composites and laminates are the potential materials finding interest among the designers and manufacturers. In aluminium nano particle composites, considerable improvement in properties are reported with limited understanding of improvement in properties, large scatter in properties and decrease in properties above 2-3 % nano-sized reinforcement and the fundamental issues related to solidification structure (movement of nano-sized particles in the melt, effect on nucleation and growth, micro and nano segregation, interface interaction with nano particles. Aluminium/Magnesium alloys reinforced with carbon/alumina fibers, manufactured by melt infiltration technique, despite being expensive on a per kilogram basis offer enormous demand in automobile sectors because of their enhanced strength to weight ratio. The structural Cast Magnesium Development (SCMD) project has successfully shown that redesign of Mg components can reduce weight and savings in weight would around 35% by replacing Al alloys. Another niche area of interest is Metallic Foam (with cellular structure). Materials with cellular structure have interesting combinations of physical and mechanical properties. Presently, due to advent of new technologies in foaming science, metal foams are being produced with low cost. The major setback in using the lightweight materials is their higher cost and considerable research is being carried out to reduce the material cost, innovative low cost forming technologies and manufacturing processes. For achieving lightweight solution in automobile one has to follow through stages of feasibility study i.e., concept, technical and demonstration. Hence, lightweight concept could be implemented either through utilizing direct use of lightweight materials or use of proper design or combination of both.

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A doctorate in Metallurgical Engineering from IIT Kanpur, India, Dr. Das has accomplished in basic as well as applied research in Materials Science and Technology, Metal Matrix Composites, Light alloys, metal foam, and tribomaterials with applications in ranging from automotive components, mining equipment components, farm machinery implements and defense are the main areas. His work embodies a vast pool of knowledge and experience as R&D scientist in Materials Science & Technology.

The academic achievements are manifested in his original research contributions through over 150 papers published in refereed international journals (with high impact factors). These contributions are well reckoned as shown through numerous citations to his papers, an example being his review paper on metal matrix composites published in International Metals Review (1986) that has registered 400 over citations and continues to be cited till very recently. His original work on solidification processing of MMCs, structure property correlations, understanding of dispersion of particulates in metallic melts has made it possible to make tailor-made composites. He has carried out work on tribological studies, mechanical properties, thermo mechanical processing of MMCs. He has guided a number of Ph.D and postgraduate research scholars. His frequent best paper awards, in metallography contests in reputed conferences, invitation from US university as guest faculty bear testimony to his pursuit of academic excellence. His endeavors in applied and industrial R&D are best exemplified in his design of a custom-built stir caster (capacity of 100 kg melt per batch) for particulate dispersed MMCs. Development of prototype automobile components such as brake drums, brake discs, pistons, cylinder liners, with MMCs and performance evaluation has been a major work. Similarly, components for mining and mineral & coal processing equipment have been demonstrated in field applications. A refrax apex insert for hydrocyclones was successfully demonstrated at Hindustan Zinc Limited mines, India.

The recent work consists of development of aluminium foams for different applications where low density and high specific energy absorption is required in automobile, aerospace and thermal management sectors. Recently, a climatizer has been designed and fabricated using open pore Al foam. Water is fed through the Al foam and the heat is extracted from the chamber as latent heat of evaporation. The Climatizer is capable to reduce the chamber temperature to an extent of 15ºC. In the implementation of such varied type of industrial projects, Dr. Das has had a very rewarding interaction with industries such as Tata Motors Limited, Auto Industries, Bajaj auto limited, Maruti udyog, Hindustan Zinc Ltd, coal industries etc., that have given him credentials for knowledge networking and management. He values integrity, quality and efficiency and has been recipient of the Metallurgist of the year - 2003 Award (NMD) instituted by Ministry of Steel and Mines, Govt of India. He has retired as Director CSIR-AMPRI Bhopal India on 31 January 2017 and presently he is serving as a Visiting Professor in Materials Science Engineering at Indian Institute of Technology, Kanpur, India.