Guest Editorial

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SPECIAL ISSUE ON ADVANCED MATERIALS ENGINEERING: SELECTED PAPERS FROM THE INDO-AUSTRIAN SYMPOSIUM 2010

Advanced Materials Engineering is a highly multidisciplinary field that offers exiting opportunities for engineers, physicists, chemists, materials scientists, applied mathematicians as well as researchers from the life sciences. Materials of a quality and functionality unheard of just a few decades ago can now be calculated, synthesised, produced, characterised and tailored. Designed materials such as functional micro- and nanostructures, hierarchical materials and integrated materials are made from metals, ceramics, polymeric materials, and combinations of these in form of structured or unstructured composites.

In the field of Engineering Science, Advanced Materials Engineering has made significant progress in recent years. Once a kind of ''black art'', Advanced Materials Engineering nowadays allows application of causal knowledge and the understanding of structure-function relationships over various levels of hierarchy in the development of new materials for our technology. To a certain degree the understanding of complex materials, structures and processes as used by living nature has been achieved, and a regular transfer of knowledge from biology to engineering becomes a realistic scenario [1,2,3]. The current materials engineer is a person with broad knowledge and interest, and the ability to bridge gaps across fields and applications.

The Nonferrous Materials Technology Development Centre (NFTDC) in Hyderabad, India has close relations to research centres and universities in Austria, especially in the area of materials science and engineering, and in tribology. There are joint projects and active exchange of students and researchers. In December 2010, NFTDC organised the two-day ''Indo-Austrian Symposium on Advanced Materials Engineering'', with Krishnamurty Balasubramanian as chairman, Andreas Pauschitz as co-chairman and Manish Roy as convener.

Focal themes of the symposium were generic technologies in emerging areas comprising:

(i) Energy Materials and Devices;
(ii) Surface Engineering, Tribology & Applied Nanotechnology (as in Micro- and Nanomachining and -fabrication); and
(iii) Materials leading to Biomedical Devices and Sensors.

Seven researchers from Austria and 16 researchers from India gave invited lectures; about 150 students, researchers and policy makers attended the symposium. This special issue of IMechE Part C: Journal of Mechanical Engineering Science contains selected papers from the symposium, five from India and three from Austria, with three review type papers and a representative mixture of theoretical and experimental approaches.

While research in materials *per se* would open new perspectives in terms of potential applications, redesign and new designs, application engineering and functional tests are crucial elements in the chain that render technology and products. It is here that NFTDC has played a pioneering role in bringing advanced materials processing, design, prototyping and

rendering of components, products & systems as well as instrumentation and control engineering solutions under one roof for a wide range of engineering applications.

While symposia in general focus on specific areas, the Indo-Austrian Symposium on Advanced Materials Engineering aimed at bringing a slightly broader range of experts from Austria to India in order to enable the younger Indian scientists to develop working relationships in emerging areas in materials technology leading to products and end to end technology developments. A careful blend of youngsters and senior experts from the Indian side, which are expected to form research groups in specific topics and across institutions in the country, was pooled as invited speakers to enable fruitful interaction.

The focal themes of the symposium were covered by invited lectures by Austrian and Indian scientists and engineers. The selected papers present an overview of the field as well as recent advances in the important aforementioned application areas.

The first paper in this special issue is entitled ''*Review of advances in diamond thin film synthesis*'' [4] and comes from a research laboratory at the University of Hyderabad. It reviews important advances that have taken place in diamond thin film synthesis. Chemical vapour deposition (CVD) techniques like HFCVD, MWCVD, RF-PCVD, DC-PCVD, ECR-MWCVD, combustion flame-CVD etc., and their hybrids are in use. Theoretical explanations as well as prediction of diamond growth and experimentally controlled CVD diamond synthesis processes are available to obtain diamond thin films with desired properties. Microcrystalline (poly), highly oriented, epitaxial, nanoscale and nanocomposite diamond thin films can be routinely synthesized on a wide range of substrates.

In the paper entitled ''*High-resolution wear analysis of a ball-on-disc contact by using low activity radioactive isotopes*'' [5] researchers coming from the Austrian Center of Competence for Tribology report the application of an advanced wear volume measuring technique by the radioisotope concentration (RIC) method to a ball-on-disc experiment, allowing for highly precise online wear volume measurements and for distinguishing among different wear regimes. Furthermore, the adhesive transfer of material from the activated specimen to the counteracting body can be investigated with this method. Results show a frequency dependent running-in behaviour though the applied load was identical and constant. Through this precise online technique a more accurate lifetime prediction can be estimated for applications such as rolling bearings to which ASTM D 6425 (the standard test method for measuring the friction and wear properties of extreme pressure lubricating oils using the SRV test machine) refers.

The paper entitled ''*Nanofinishing techniques*'' [6] provides a comprehensive literature review of the magnetorheological (MR) finishing process in terms of rheological characterization of the MR fluid, experimental investigation, theoretical analysis, and applications. It deals with various advancements in abrasive flow finishing and hybrid processes. The developments in magnetorheological abrasive flow finishing (MRAFF) and its allied processes are discussed in detail.

The paper ''*Green nanotribology*'' [7] by an Austrian researcher who now works in Malaysia defines the emerging field as the utilization of nanotechnology to establish specific conditions regarding friction, wear, and lubrication of interacting surfaces in relative motion to achieve minimum environmental impact. Agents, surfaces and processes are identified as the three basic aspects of green nanotribology and are analysed regarding their potential to go green. Green nanotribology focuses on sustainable solutions; in lubrication, for example, ultimately, not the perfect lubricant counts, but the development/usage of finished surfaces that do not need lubricants at all. Various examples of biotribological systems (such as the hip joint) illustrate the expediency of natural tribosystems.

The paper entitled ''*Dynamics of virial stress in gold lattice after crack initiation*'' [8] by Indian researchers from Punjab and the USA tried to measure virial stress in atomistic models by appropriate spatial and temporal averaging that are known to be representations of continuum stresses in bulk materials. Using molecular dynamics simulations, this effort shows that some local and dynamic features of the continuum stress exist in the dynamic response of the virial stress. The spatially averaged but temporally fluctuating behaviour of the hydrostatic component of the virial stress is observed in both time and frequency

domains at a mean stress-free state for a nanostructure at a target temperature. An atomistic-scale model with one finite dimension and two infinite dimensions was utilized to represent a thin single crystal film. Numerical simulations were performed with force fields and lattice parameters corresponding to gold. The initial temperature, pressure, and volume states for the material were determined using two equilibrium procedures that produced convergent energy and stress states. The dynamics of the virial stresses in atomistic ensembles show several dynamic and local characteristics of the continuum stresses.

The paper entitled ''*Recent developments in the reverse micro electrical discharge machining in the fabrication of arrayed micro features*'' [9] by an Indian group from Mumbai discusses recent developments in reverse micro electrical machining techniques. The focus of the discussion is on comparing the process with further micromachining processes that are presently available for the fabrication of arrayed microfeatures. In addition, Reverse Micro Electrical Discharge Machining (R-MEDM) process characteristics in the fabrication of arrayed features on materials that are 'easy' or 'difficult' to erode are presented. It is understood that R-MEDM has comparable or in some cases better performance in the fabrication of arrayed features than processes such as micromilling, micro wire EDM, micro wire electrical discharge grinding (EDG) and block EDG.

The paper entitled ''*Applications of instrumented indentation testing for the characterisation of polypropylene materials*'' [10] is from a research group at the Vienna University of Technology and presents instrumented indentation testing to characterise polypropylene materials. The influence of molecular weight and cooling rate on the hardness was investigated showing that low cooling rates and relatively low molecular weight lead to higher hardness values. In random copolymers of propene with butene and hexene the correlation between hardness and degree of crystallinity is linear and the conversion to the amorphous state could be detected. Blends of polypropylene with an ethylenepropylene elastomer show a strong negative deviation of the indentation modulus from the linear rule of mixture. This behaviour can be described by Kerner's model in the case of a particulate arrangement and by Davies' model in the phase inversion region. The addition of high-density polyethylene to polypropylene results in a synergistic behaviour of the modulus that can be attributed to nucleation effects. Furthermore, the application of indentation testing to detect physical ageing of a surface of an injection moulded specimen and heterogeneity of weld lines was

Delegates of the ''Indo-Austrian Symposium on Advanced Materials Engineering'' that took place at the Nonferrous Materials Technology Development Centre in Hyderabad, India, in December 2010.

shown. Orientations in a biaxially oriented film could be detected using a Knoop indenter.

The final paper in this special issue on Advanced Materials Engineering is entitled ''*Dry tribology and nanomechanics of gaseous flame soot in comparison with carbon black and diesel soot*'' [11]. It is from an Indian research group and deals with carbon soot particles that are collected thermophoretically from burning ethylene gas. The physical and mechanical properties and tribological performance of such soot are compared with those of carbon black and diesel soot. The physical-crystalline structures of the nanometric particles generated in the flame are shown to vary from the flame root to the exhaust. As the particle journeys upwards the flame, through a purely amorphous coagulated phase at the burner nozzle, it leads to a well defined crystalline phase shell in the mid-flame zone and to a disordered phase consisting of randomly distributed short range crystalline order at the exhaust.

This special issue intends to stimulate the debate and help give further motivation for collaborative experimental, theoretical and conceptual research in Austria and in India, as well as to provide an impulse for further global scientific cooperation. In-depth understanding of the basic principles and their complex relationships will grant the required foundation for greatly accelerating progress in Advanced Materials Engineering.

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REFERENCES

1 **Dowson, D.** and **Neville, A.** Bio-tribology and biomimetics in the operating environment. *Proc. IMechE, Part J: J. Engineering Tribology*, 2006, **220**(J3), 109–123.
2 **Neville, A.** Special issue on biomimetics in engineering. *Proc. IMechE Part C: J. Mechanical Engineering Science*, 2007, **221**(C10), i, 1141–1230.
3 **Gebeshuber, I. C.** and **Drack, M.** An attempt to reveal synergies between biology and engineering mechanics. *Proc. IMechE, Part C: J. Mechanical Engineering Science*, 2008, **222**(C7), 1281–1287.
4 **Srikanth, V. V. S. S.** Review of advances in diamond thin film synthesis. *Proc. IMechE, Part C: J. Mechanical Engineering Science*, 2012, **226**, 303–318.
5 **Corniani, E., Jech, M., Wopelka, T., Ditroi, F., Franek, F.,** and **Pauschitz, A.** High-resolution wear analysis of a ball-on-disc contact by using low activity radioactive isotopes. *Proc IMechE, Part C: J. Mechanical Engineering Science*, 2012, **226**, 319–326.
6 **Jain, V. K., Sidpara, A., Sankar, M. R.,** and **Das, M.** Nanofinishing techniques: A review. *Proc. IMechE, Part C: J. Mechanical Engineering Science*, 2012, **226**, 327–346.
7 **Gebeshuber, I. C.** Green nanotribology. *Proc. IMechE, Part C: J. Mechanical Engineering Science*, 2012, **226**, 347–358.
8 **Kumar, N.** and **Pochiraju, K.** Dynamics of virial stress in gold lattice after crack initiation. *Proc. IMechE, Part C: J. Mechanical Engineering Science*, 2012, **226**, 359–366.
9 **Mastud, S. A., Garg, M., Singh, R.,** and **Joshi, S. S.** Recent developments in the reverse micro electrical discharge machining in the fabrication of arrayed micro features. *Proc. IMechE, Part C: J. Mechanical Engineering Science*, 2012, **226**, 367–384.
10 **Koch, T.** and **Seidler, S.** Applications of instrumented indentation testing in the field of polymer science using the example of polypropylene materials. *Proc. IMechE, Part C: J. Mechanical Engineering Science*, 2012, **226**, 385–393.
11 **Bhowmick, H., Majumdar, S. K.,** and **Biswas, S. K.** Dry tribology and nanomechanics of gaseous flame soot in comparison with carbon black and diesel soot. *Proc IMechE, Part C: J. Mechanical Engineering Science*, 2012, **226**, 394–402.