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Progressive Research Areas of Mechanical and Production Engineering

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Mechanical and Production engineering deals with the design, development, manufacturing of the product with consideration of its performance, service life and other aspects. Various new improvements and methods are developed everyday which may be superior to their previous versions in some way and they should be judiciously selected according to the required properties of the product. There are numerous areas which are being researched at any given time and can be chosen according to the area of interest.

Digital manufacturing combines all the manufacturing processes in a virtual environment using 3-d visualization, simulation and other collaborative tools. Digital manufacturing is based on various collaborative methods of process and product design such as- computer integrated manufacturing (CIM), design for manufacturability (DFM), lean manufacturing, flexible manufacturing etc. It can save a huge amount of time and money as any process, design, layout can be optimized without using them physically. It plays a vital role in the initial manufacturing stages of product introduction. Digital manufacturing uses computer aided design (CAD), computer aided manufacturing (CAM), product data management (PDM) and computer aided engineering (CAE) to optimize product lifecycle management (PLM). The applications of digital manufacturing are unlimited as every manufacturing industry can use it to optimize product design, manufacturing processes, production, layout, material flow etc.

Fracture mechanics is based on the concept that every structure has inherent flaws which may develop in various processing stages of the material and grow in service. These flaws propagate in the form of cracks and ultimately lead to failure. To calculate the driving force and fracture resistance, theories of solid mechanics are used and particularly the theories of elasticity and plasticity. The basic mechanisms which define crack growth are-

- Fatigue
- Stress corrosion cracking
- Creep
- Corrosion fatigue/creep fatigue
- Liquid metal embrittlement

After the crack growth, the fracture is governed by any of these two mechanisms, brittle fracture/cleavage and ductile fracture/rupture. The main aim of fracture mechanics is to understand the causes of failure of real life structures and try to be able to predict these failures to avoid them.

Rapid prototyping is a group of processes which help in creating a 3-D physical object using some computer aided design software. It is becoming an important part of manufacturing process as it saves a lot of time and money by

converting the CAD data to 3-D prototype which can then be studied for further amendments. Highly complicated shapes can be easily made with rapid prototyping and the wastage is also significantly reduced. Stereo lithography is considered as one of the first rapid prototyping techniques. Selective laser sintering, laminated object manufacturing, solid ground curing, fused deposition modeling, ink jet printing techniques are some other rapid prototyping techniques. The application area of rapid prototyping is wide and is going to increase over time as it is the future of manufacturing industry. It is used in product design and development, reverse engineering applications, rapid tooling, modeling etc. Rapid prototyping is used quite effectively in medical field to replicate the body parts. It also has the ability to produce very tiny, miniature parts which makes it useful for jewelry design and crafts.

Thermal barrier coatings *(TBC)* use a thermally non-conductive coat on the material to prevent it from thermal fatigue and enable it to work at higher temperatures. It consists of four layers- metal substrate, metallic bond coat, thermally grown oxide, ceramic top coat. The ceramic top coat has very low thermal conductivity which helps in keeping away a large amount of heat from the lower layers and also from the metal surface. The material used for top coat varies depending upon the need but some common materials are- yttria stabilized zirconia, alumina, mullite, rare earth zirconites/oxides, metal glass composites etc. while NiCrAlY/NiCoCrAlY is commonly used for bond coat. The processes which are used to apply thermal barrier coating are- electron beam physical vapour deposition, air plasma spray, direct vapour deposition, electrostatic spray assisted vapour deposition, high velocity oxygen fuel etc. Solution precursor plasma spray is a new method which creates TBC's with considerably low thermal conductivity. The application areas of TBC are mostly automotive and aviation industry.

Microelectromechanical systems *(MEMS)* are miniaturized devices/machines with mechanical and electronic components. The size of components in MEMS varies from 1 to 100 micrometers. When MEMS is merged with nanotechnology it is termed as nano-electromechanical systems. MEMS use batch fabrication technique to combine micro-sensors and micro actuators. The basic techniques to produce the required shape in fabricating MEMS are–deposition (physical deposition, chemical deposition) of material layers, patterning (photolithography, electron beam lithography, ion beam lithography, x- ray lithography, diamond patterning etc.), etching (dry etching, wet etching). The machining processes include bulk micromachining, surface micromachining and high aspect ratio silicon micromachining. The application of MEMS are found in a wide range of products as in inkjet printers, accelerometers in cars, planes, smart phones, game controllers etc., pressure sensors, ultrasound transducers etc.

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