Selective Laser Melting is a powder bed fusion process in which the metal and/or alloy powder is melted and fused, fabricated layer by layer using a scanning laser energy source, as dictated by the computer aided design (CAD) data.

Small parts, complex shapes and good surface finish.
• Beam as power source (Laser or Electron Beam)
• Reflectivity of the material influence the process.
• Process parameters and scanning strategies influence the material structure and property.

Wire Arc Additive Manufacturing deposits layers of metal from a wire in a technique derived from welding. Items produced by this method are subsequently machined to a conventional finish but the time taken to manufacture such pieces from steel, aluminium, titanium, copper & metallic alloys and composite materials is significantly shorter than using conventional methods, with considerable cost savings.

Surface Roughness Studies of Poly-Jet Rapid Prototyping System

Poly-Jet technology is a rapid prototyping (RP) technology that utilizes a high precision 3D printing process. The surface quality of objects fabricated using RP is generally poor due to the stair-stepping effect, which results from stacking layers with some level of thickness. This study has attempted to investigate and model surface roughness on parts printed using poly-jet rapid prototyping system.

Low-cost 3D printing system for Tin-Silver alloys

Direct Metal Deposition Technique (LENS™ process)

Optimization of WAAM (GMAW – CMT) process parameters to manufacture Mg alloy:
• Single bead performed at different parameters
• Current value: 60 A to 140 A
• Travel Speed: 100 mm/min to 500 mm/min
• CMT & CMT Pulse

For further details contact: Prof. R. Jayaganthan email: edjay@iitm.ac.in
Topology optimization was integrated with fused deposition modelling (additive manufacturing process) for producing parts with optimal material layouts. The topology optimization was performed using finite element model based on classical laminate theory assumption.

Optimized design for MBB beam and C-bracket manufactured using Fused Deposition Modeling process

Optimization of Custom Cementless Hip Implant for reducing Stress-shielding effect

Stiffness optimization was done for subject-specific cementless hip implant design based on finite element analysis for reducing stress-shielding effect. This formulation enables designs that could be fabricated using additive manufacturing to make porous implant with varying levels of porosity.

Flow chart of stiffness optimization of custom implant stem and cross section of optimized implant with elastic modulus distribution

Optimization of Spiral Casing Design of Hydraulic Turbine

Numerical simulation of complex three-dimensional flow through three different configurations of spiral casing viz., decelerated, free vortex and accelerated flow types has been studied using a finite element method. Framework for optimization is being evolved.
Geometric Design

During the process of design and manufacturing, there are several issues that require geometric design thinking. Part-in-whole retrieval (PWR) is an important problem in the field of computer-aided design (CAD) with applications in design reuse, feature recognition and suppression and so on. Part clustering is a process of grouping geometrically similar models into the same cluster and assigning them a cluster label. This in turn requires segmenting a CAD model.

Feature Recognition

It is an important area in the field of CAD/Engineering with applications in model retrieval, creating an analysis model by defeaturing of the designed model for FE applications, etc.

Shape Reconstruction

Given a point cloud, our objective is to reconstruct the surface that best captures the shape of the point cloud.

Virtual Reality and 3D Printing

It may be too expensive to 3D print (additive manufacturing) a design and then find it is not satisfactory. In this work, a virtual 3D printing simulation has been developed and can be viewed using goggles such as oculus rift.

Model Abstraction for FEA

In the finite element analysis, a CAD model is then reduced to a CAE model. A CAE model is created first by suppressing some of the small features and then approximated using medial surfaces or midsurfaces.

Image-Based Visual Inspection System

Mixing of various geometries is a common problem in coating industry that has varying manufactured geometries and the inspection is carried out manually. The model abstraction medial axis was used in this automatic inspection system.

Fractal Rational Splines CAGD

Fractal interpolation through iterated function systems (IFS) constitute an advanced technique in approximation. This work extends IFS to rational splines for use in CAGD.

Geometric Modelling for Next Generation Heat Exchangers

Complex geometric design suited for enhanced heat transfer, and it’s optimization and additive manufacturability.

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Collaborators: Autodesk, Dr. Chand A.K.B, Professor, Department of Mathematics, IIT Madras
Developed and validated Suzhal Management System (SMS)  
Design thinking and creative problem solving for innovation  
Implementing lean operations sustainably  
SMS helps identifying latent problems and address them optimally  
Human factors approach to increase man and machine productivity  
Results in lean processes with low cost automation  
Various industries and public enterprise have benefited using this model  
Examples of SMS usage  
Development of variety of products and processes within various companies of M/s Anand Automotive  
Development of TN model of integrated approach to road safety. TN model is being implemented nation wide currently by the Ministry of  
Started Tamil Nadu Accident and Emergency care Initiative (TAEI) resulting in an overall improvement of emergency care nation wide  
Developed with Indian Railways for sustainable solutions to variety of problems and built technical leadership in problem solving
Materials

Electromagnetic material design
- Space applications
- Sensors
  - Level measurement
  - Partial discharge detection
- Nondestructive Evaluation
  - Metals
  - Dielectrics
Electromagnetic material design
- Spatial separation using Frequency selective surface (FSS)
- Return loss for (a) TEM horn (b) Conical horn with lens
- Noncontact multilayered liquid level measurement
- Partial discharge measurement setup

Sensors
- FSS unit cells
- FSS material for X-band (8-12 GHz) with 2400 elements
- Return loss of UHF sensor
- Partial discharge signals

Material characterization
- Material characterization at room temperature using free space method by spot focusing antenna
- Polypropylene properties: (a) Dielectric constant, (b) Loss tangent
- Material properties: room temperature
- Material properties: high temperature
- Lissajous plot for defect B
- CT scan of the sample: 3, 6, and 9 mm deep notches in 15 mm thick Aluminum plate
- Illustration of experimental setup for subsurface defect detection using ECT
- Lissajous plot of the GMR lock-in output for 30% defect depth in 15 mm thick Aluminum plate.

Material Modeling for Design

The properties of materials depend strongly on fine scale microscopic features called microstructure. Examples are grains in wood and metals, dislocation density and cracks. Mechanical behaviour is well understood if the microstructure is static and does not change during operation. Under high temperature and loads microstructure does evolve causing changes in material properties. Designs based on initial microstructure may not be sufficient in such problems. An important open question in such cases is to understand how the material behaviour is influenced by the microstructure. We are developing new models accounting for the effect of microstructure and its evolution on material behaviour. The other areas of focus is in modeling material deformation during machining and modeling the material behaviour in additively made parts.

Discrete Particle Model (DPM)
- DPM describe the material in terms of lumped masses interacting through constitutively prescribed forces (Mostly through springs)
- Parwise interactions (Springs) lead to Cauchy relations on elastic moduli C_{ij} = C_{ji} (Poisson’s ratio to a constant 1/3)
- Existing DPM formulations have following shortcomings:
  - Very difficult to correlate the microscopic interactions with macroscopic behaviour
  - Dependence of constitutive behaviour of the model on the mesh configuration
- So we propose,
- Multibody interaction based on continuum constitutive theory
- Incorporate this novel interactions, in DPM for material behaviour originating from its micro-structures
Applications: Crack Branching, Phase transformation, Composite failure.

Phase Field Model of Abnormal Grain Growth

- Few grains can grow rapidly during high temperature annealing leading to abnormal grain growth (AGG) in polycrystalline material
- AGG can have both beneficial and detrimental effect on material properties
- For Silicon steel AGG improves specific magnetic properties which are beneficial for transformer core usage
- A novel phase field model has been developed to simulate abnormal grain growth
Product Design

PD Lab

The projects mentioned here are outcome of the product design lab sessions conducted in the Department of Engineering Design over years. The Product Design (PD) lab complements a number of theoretical courses, ranging functional and conceptual design to detailed design. The purpose of the lab is to expose the students to the practical aspects of development of a product as an embodiment of a set of coherent components satisfying a set of identified functions needed in the product.

The PD lab helps the students to become competent in facing the real-life challenges in product development. It inspires creativity, promotes team-work and professional discipline. The training in this lab, as well as the facilities available have helped the students participate with confidence in various design-related competitions, such as the Robocon, and the Brunel Design Show.

Important Outcomes

HuMotor
- 2011 Anti-drudgery challenge award from the National Innovation Council, Govt. of India
- Indian provisional patents: 3633/CHE/2012; 4252/CHE/2012
- Commercialisation being taken up by Building Matl & Tech. Promotion Council, Govt.

PageFlipper
- Indian provisional patent: 2597/CHE/2010

Tricycle
- Evaluation for Commercialisation being taken up by Artificial Limbs Manufacturing Corporation of India (ALIMCO) in Kanpur

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- Prof. Ramanathan M., ED, IIT Madras

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HuMotor

HuMotor, an acronym for “Human-powered Motor”, is a machine designed to improve the efficiency of human effort by effectively utilizing the strongest of the human muscles. The concept of HuMotor is to convert the stair climbing motion of a person into rotary output, similar to a motor.

PageFlipper

The PageFlipper is a simple, economical and effective device that can flip pages of any book, one at a time, in both directions and without the use of hands. It is economical, easy to use and caters to a wide variety of books with different dimensions and paper textures.

Tricycle

A novel design, which can be configured according to the user’s requirement and comfort. The features that are adjustable are the driving mechanism, seat height, and inclination, back-rest inclination, and foot-rests. Telescopic tubes are used in all the modular features.

Savonius Wind Turbine

Savonius wind turbines are an excellent solution for low wind speeds and can power a rural household for about 8 hours. In designing the optimal blade geometry, CFD was used accounting for uncertainties in wind speeds.

Mechanism for Noise Reduction

Solution for noise reduction when long stainless steel tubes fall on each other.