**NATIONAL INSTITUTE OF TECHNOLOGY**

**TIRUCHIRAPPALLI - 620 015**

**M.Tech. DEGREE**

**(MANUFACTURING TECHNOLOGY)**

**4 SEMESTER PROGRAMME**

**CODE : PR**

# SYLLABUS

**FOR**

**CREDIT BASED CURRICULUM**

**OPERATIVE FOR STUDENTS OF 2006 -2007 ADMISSION**


**DEPARTMENT OF PRODUCTION ENGINEERING**

**JUNE 2006**

# M. Tech. MANUFACTURING TECHNOLOGY

## CURRICULUM 2006-2007 FOR FULL TIME STUDENTS (4 Semesters)

Curriculum Structure:
The total minimum credits required for completing the programme is 60

**Semester I**

| CODE | COURSE OF STUDY | L | T | P | C |
|---|---|---|---|---|---|
| MA 609 | Mathematical Methods | 3 | 0 | 0 | 3 |
| PR 601 | Tool Engineering and Design | 3 | 0 | 0 | 3 |
| PR 603 | Casting and Welding Technology | 3 | 0 | 0 | 3 |
| PR 605 | Manufacturing Management | 3 | 0 | 0 | 3 |
| --------- | Elective I | 3 | 0 | 0 | 3 |
| --------- | Elective II | 3 | 0 | 0 | 3 |
| | | 18 | 0 | 0 | 18 |

**Semester II**

| CODE | COURSE OF STUDY | L | T | P | C |
|---|---|---|---|---|---|
| PR 602 | Production Automation & CNC Technology | 3 | 0 | 0 | 3 |
| PR 604 | Mechanics of Metal Forming | 3 | 1 | 0 | 4 |
| PR 606 | Flexible Manufacturing Systems | 3 | 0 | 0 | 3 |
| --------- | Elective III | 3 | 0 | 0 | 3 |
| --------- | Elective-IV | 3 | 0 | 0 | 3 |
| PR 608 | CNC Technology Lab. | 0 | 0 | 4 | 2 |
| | | 15 | 1 | 4 | 18 |

**Semester III**

| CODE | COURSE OF STUDY | L | T | P | C |
|---|---|---|---|---|---|
| PR 647 | Project Work - Phase-I | 0 | 0 | 24 | 12 |

**Semester IV**

| CODE | COURSE OF STUDY | L | T | P | C |
|---|---|---|---|---|---|
| PR 648 | Project Work - Phase-II | 0 | 0 | 24 | 12 |

**List of Electives :**

| Code | Course of Study | L | T | P | C |
|---|---|---|---|---|---|
| **Elective I & II** | | | | | |
| PR 611 | Tolerance Technology | 3 | 0 | 0 | 3 |
| PR 625 | Materials Technology | 3 | 0 | 0 | 3 |
| PR 669 | Project Management | 3 | 0 | 0 | 3 |
| MT 620 | Welding Application Technology | 3 | 0 | 0 | 3 |
| **Elective III & IV** | | | | | |
| PR 672 | Terotechnology | 3 | 0 | 0 | 3 |
| PR 618 | Computer Aided Design and Manufacturing | 3 | 0 | 0 | 3 |
| PR 624 | Manufacturing of Products from Non-metallic Materails | 3 | 0 | 0 | 3 |
| Or any other elective subject from any other department | | | | | |

**List of reserve Electives :**

| Code | Course of Study | L | T | P | C |
|---|---|---|---|---|---|
| PR 612 | Robotics | 3 | 0 | 0 | 3 |
| PR 613 | Intelligent Industrial Systems | 3 | 0 | 0 | 3 |
| PR 614 | Machine Tool Technology | 3 | 0 | 0 | 3 |
| PR 615 | Quality Engineering | 3 | 0 | 0 | 3 |
| PR 617 | Product Analysis and Cost Optimisation | 3 | 0 | 0 | 3 |
| PR 619 | Modeling and Simulation | 3 | 0 | 0 | 3 |
| PR 620 | Computer Integrated Manufacturing | 3 | 0 | 0 | 3 |
| PR 621 | Finite Element Method | 3 | 0 | 0 | 3 |
| PR 622 | Finite Element Analysis in Manufacturing | 3 | 0 | 0 | 3 |
| PR 623 | Finite Element Plasticity and Metal Forming Analysis | 3 | 0 | 0 | 3 |
| PR 626 | Fracture Mechanics and Mechanisms | 3 | 0 | 0 | 3 |
| PR 627 | Press Tools in Metal Forming | 3 | 0 | 0 | 3 |
| PR 628 | Mechanics of Composite Materials | 3 | 0 | 0 | 3 |
| PR 629 | Theory of Plasticity | 3 | 0 | 0 | 3 |

## MA 609 MATHEMATICAL METHODS

Calculus of variations - Euler's equation - Variational problems in parametric form - Natural boundary condition – Conditional Extremum - Isoperimetric problems.

Direct methods in Variational Problems - Euler's finite difference method - Rayleigh -Ritz method - Galerkin's method - Kantorovich's method.

Integral equations - Conversion of BVP to integral equations using Green's Function - Fredholm equation with separable kernels – Solution of Fredholm and Volterra equations by the method of Successive approximations.

Finite difference scheme for elliptic, parabolic, and hyperbolic partial differential equations.

Introduction to Finite Element Method - Rules for forming interpolation functions - Shape functions Application to fluid flow and heat transfer problems.

**REFERENCES**


1. *DESAI, C.S., and ABEL, J. P., Introduction to Finite Element Method, Van Nostrand Reinhold.*
2. *ELSEGOLTS, L., Differential Equations and the Calculus of Variations, Mir Publishers.*
3. *GREWAL, B.S. , Higher Engineering Mathematics, Khanna Publishers.*
4. *HILDEBRAND, P.B., Method of Applied Mathematics, Prentice Hall.*
5. *VENKATARAMAN, M. K., Higher Mathematics for Engineering and Science, National Publishing Company.*


## PR 601 TOOL ENGINEERING AND DESIGN

Introduction to manufacturing processes – objectives, organization and role of tool engineering – role of materials in tooling.

Tooling for material removal process like traditional machining processes, nontraditional machining processes automats and NC and CNC machines.

Tooling for forming processes.

Tooling for casting and metal joining processes – molding and pattern design mechanization of foundries Design of welding fixtures – tooling for mechanical joining processes.

Tooling for inspection and gauging – design and manufacturing of gauges – CMM – CAD in tool design.

**REFERENCES**

*1) Hoffman E.G, "Fundamentals of tool design", SME, 1984.*
*2) Kalpakjian S., "Manufacturing Engineering and Technology", Addision Wesley, 1995.*
*3) HMT "Production Technology", Tata McGraw Hll, 1991.*

## PR 603 CASTING AND WELDING TECHNOLOGY

Core making processes - design for moulding and casting - use of CAD in the design of gating and risering systems – different moulding and casting processes.

Melting and quality control of various steels and non-ferrous alloys - casting defects - fettling, inspection and testing of castings - Manufacturing of Cast irons - Design for casting.

Different arc welding processes.

Welding metallurgy – weldability criteria - design of weldments and joints.

Inspection and testing of welding and casting – Defects, Destructive tests - Non destructive testing techniques - techniques for the production of defect free casting.

**REFERENCES**

*1) Scrope Kalpakjian,, "Manufacturing processes for Engineering Materials", Addision Wesley, 1997.*
*2) Khanna O.P., "Text book for welding Technology", Dhanpat Rai & Sons, 1997.*
*3) Srinivasan N.K., "Foundry Technology", Khanna Publishers, 1991.*

## PR 605 MANUFACTURING MANAGEMENT

Inventory management systems - Strategic Planning: facilities design - general discrete location - allocation problems - Facility location - analysis and models.

Tactical Planning - Aggregate production planning and models - Operational control - Inventory management - EOQ decision rules – cost model in inventory system - EOQ decision rules - EOQ for multiple items under constraints - ABC analysis - review systems.

Operations Scheduling and Assembly Line Balancing - Project Scheduling.

MRP I, MRP-II and ERP.

JIT, kanban system, Quality management - SPC - Taguchi method - quality circles – ANOVA– Lean Manufacturing.

**REFERENCES**

*1) H.G. Menon,, "TQM in New Product Manufacturing", Mc Graw Hill, 1992.*
*2) Hax and Candea., "Production and Inventory Management", Prentice Hall, 1984.*
*3) Buffa., "Modern Production Management", John Welley, 1983.*

## PR 602 PRODUCTION AUTOMATION AND CNC TECHNOLOGY

Concept and scope of industrial automation – automation strategies - devices, drives and control circuits in automation - Semi-automats, automats and transfer lines.

Concepts, features, fundamentals, advantages and classification of NC systems - input media - Design consideration of NC machine tools - machining centre - MCU functions.

Controls and System devices - Control loops of NC system - CNC concepts, reference pulse and sampled data techniques - microprocessor and CNC adaptive control – ACO and ACC systems.

Graphical Numerical Control - part programming - design of post processor..

Manual part programming. Computer aided part programming - post processor - APT programming – programming for CNC turning center, Machining center and CNC EDM.

**REFERENCES**

*1) Scrope Kalpakjian,, "Manufacturing processes for Engineering Materials", Addision Wesley, 1997.*
*2) Radhakrishnan, P., "Computer Numerical Control Machines", New Central Book Agencies, 1997.*
*3) Yoram Korem., "Computer control of Manufacturing systems", Mc Graw Hill, 1986.*

## PR 604 MECHANICS OF METAL FORMING

Basics of metal forming - Mohr's circle - isotropic elasticity - yield theories - plastic stress-strain relationship - plastic work - the principle of normality - incremental plastic strain.

Constitutive relationships - mechanical properties - work hardening - compression test, bulge test, plane strain compression test - plastic instability in tension tests.

Strain rate - super plasticity - slab analysis for sheet drawing - Extrusion and forging - upper bound solution for Extrusion - Indentation and plane strain forging.

Slip line field theory and its solution - Formability and its testing.

Sheet Metal forming - Bending theory, Cold Rolling theory - Hill's anisotropic plasticity theory - Hill's general yield theory, CAD/CAM applications in Extrusion, Forging and sheet metal Forming - Localized necking in biaxial stretching.

**REFERENCES**

*1) Hosford W.F and Caddell, R.M,, "Metal Forming Mechanics and Metallurgy", Prentice Hall, 1983.*
*2) Narayanasamy R., "Theory of Plasticity", Ahuja Publications, 2000.*
*3) Scrope Kalpakjian,, "Manufacturing processes for Engineering Materials", Addision Wesley, 1997.*

## PR 606 FLEXIBLE MANUFACTURING SYSTEMS

Introduction to FMS - concepts, advantages, components and examples of FMS, Distributed Numerical Control (DNC) - Communication between DNC computer and MCU.

Distributed data processing in FMS - Computer network protocols - Interfacing of CAD and CAM - Part programming in FMS tool data base - Clamping devices and fixtures data base, tool management system part alignment and work mounting errors, surface description method for automated design and robotized assembly.

Material Handling systems - ASRS - AGVs – features of industrial robots - robot cell design and control.

Inspection - CMM - incycle gauging - Sensors for robots.

Interfacing of computer - machine tool controllers and handling systems: communications standards - programmable Logic Controllers(PLC's) – Interfacing - Computer aided Project planning - Inventory control

**REFERENCES**

*1) Mikell P Groover, "Automation Production systems, Computer Integrated Manufacturing", Prentice Hall,1987.*
*2) Paul Ranky., "The design and operation of FMS", IFS publication.,, 1983.*
*3) Viswanathan, N & Nahari, Y, "Performance modeling of automated manufacturing systems", Prentice Hall,1992.*

## PR 608 CNC TECHNOLOGY LABORATORY

Experiments in EMCO PC TURN 55 (SinumeriK), HMT STC-15 TURNING CENTRE (SinumeriK), T5 TURNING CENTRE (Fanuc – OT), TRIAC 3AXES CNC MILLING MACHINE, EMCO PC MILL 55 (SinumeriK), VMC 3 AXES CNC MACHINING CENTRE (Fanuc – OM)

## PR 611 TOLERANCE TECHNOLOGY

(Use of approved design data book is permitted in the examination)

Limits, fits and tolerance - hole basis and shaft basis system, quality engineering based product development process.

Interpretation, inspection and application of form tolerances - datum system and targets – tolerance of position.

Fundamentals of descriptive statistics and inferential statistics - use of distributions - Taguchi approach - tolerance analysis.

Tolerance stack analysis and allocation - linear and non-linear stack analysis - worst case tolerance analysis - computer aided tolerance technique – cost based optimal tolerance analysis - tolerance allocation methods.

Tolerance charting - blue print dimensions - machining allowances - datum features - functional and manufacturing datum - exercises.

### REFERENCES

*1) ASME "study manual on tolerance stacks ", Vol I, Second edition 1994.*
*2) ASME self study workbook on GD & T second edition 1994.*
*3) Spotts,, "Dimensioning and tolerancing of mass production", Prentice Hall, 1983*

## PR 625 MATERIALS TECHNOLOGY

Classification of materials – mechanical properties of metals.

Plastic instability – strain hardening / work hardening – strengthening mechanisms – cold working and recrystallization.

Plastic working of metals – formability of sheet metals – Forming Limit Diagram (FLD) –super plastic forming.

Workability of bulk metals – workability diagrams – necking and fracture of metals.

Machinability of carbon steels and nonferrous metals – machinability index.

**REFERENCES**


1) *Geller Y.A and Rakhshtadr "Science of Materials", MIR Pub, 198.6*
2) *Narayanasamy R., "Theory of Plasticity", Ahuja publications, 2000.*
3) *S.Kalpakjian, "Manufacturing Processes for Engineering Materials", Addision Wesley Pub Co, 1997.*


## PR 616 TEROTECHNOLOGY

Probability concepts – Probability distributions – density and distribution functions for uniform, exponential, razeligh, weibull, normal distribution

Non-maintained systems – Reliability definition and its important

Method of improving reliability redundancy techniques

failure data analysis – Reliability models –

Maintenances systems and economics of reliability - Maintenance and spares management - preventive replacement - Condition monitoring & analysis.

**REFERENCES**


*1) Srinath L S,, "Reliability Engineering", East West Press Pvt Ltd, 1991.*
*2) Collact, "Mechanical Fault Diagnosis and Condition Monitoring", 1997.*
*3) Balagurusamy, "Reliability Engineering", Tata Mc Graw Hill,1984.*


## PR 618 COMPUTER AIDED DESIGN AND MANUFACTURING

Basic concepts of CAD - CAD workstation - principles of computer graphics - graphics programming - mechanical drafting package.

Advanced modeling techniques - surface modeling - solid modeling, rendering methods. CAD/CAM data base development and data base management systems.

Principles of optimum design - CAD optimization techniques, Application of CAD - computer-aided process planning - post processing - NC code generation - principles of computer aided engineering and concurrent engineering.

Computer aided manufacturing, programming and interface hardware – computer aided process monitoring - adaptive control, on-line search strategies.

Production systems at the operation level - computer generated time standards - machinability data systems - cutting conditions optimization - production planning - capacity planning - shop floor control - computer integrated manufacturing systems, system components, application.

**REFERENCES**

*1) Radhakrishnan P & Kothandaraman C.P, "Computer Graphics and Design", Dhanpat Rai & Sons, 1990.*
*2) Groover M P, "Automation, Production System and Computer Aided Manufacture", Prentice Hall, 1984.*
*3) William M Newman & Robert Sproul,, "Principle of Interactice Computer Graphics", Mc Graw Hill, 1984.*

## PR 624 MANUFACTURING OF PRODUCTS FROM NON METALIC MATERIALS

Polymers - molding of thermoplastics - plastic sheet forming process - machining of thermoplastics - Thermosetting plastics - properties, molding processes and machining - other processing methods for plastics - plastic component design.

Rubber: Manufacturing process - Manufacturing techniques, materials design, sizing, components, building, moulding and vulcanising of tyres - Belting – manufacture and types of hose.

Types, processing and manufacturing techniques of Glass vessels.

Ceramic materials - Processing of ceramic products.

Composite matearials, Fiber, particulate, whisker reinforced ceramics, properties of reinforcements and matrix. Manufacturing Techniques and applications of different Composites namely PMC, MMC and CMC.

**REFERENCES**

*1) Blow C M,, "Rubber Technology and Manufacturing", Newman Butterworths, 1977.*
*2) Hasle Hurst, "Manufacturing Technology", ELBS, 1973.*
*3) Vanviack L.H, "Physical Ceramics for Engineers", Addision Wesley Publicxation, 1964.*

## PR 612 ROBOTICS

Fundamentals of robotics – wrists design - end effectors – actuators - modular robots.

Robot and its peripherals - sensors, machine vision - image processing & analysis - application of artificial intelligence, voice communication - robot control units - motion controls.

Robot kinematics - homogeneous transformations - forward & inverse kinematics - problems of dynamics - differential relationships - motion trajectories - dynamics of a robot control of single & multiple link robot - static force analysis.

Robot Programming - different languages - expert systems.

Robot applications in manufacturing - material transfer & machine loading/unloading - processing operations – inspection - automation - robot cell design – control – recent developments and special applications.

**REFERENCES**

*1) Richard D Klafter, Thomas A Chmielewski & Michael Negin, "Robotic Engineering – An Integrated Approach", Prentice Hall, 1994.*
*2) Deb, S.R., "Robotic Technology and Flexible Automation", Tata Mc Graw Hill, 1994.*
*3) Fu & Gonzales,, "Industrial Robotics", Tata Mc Graw Hill, 1988.*

## PR 613 INTELLIGENT INDUSTRIAL SYSTEMS

Basic concepts of Artificial intelligence and expert systems - System Components - System architecture and Data flow – System Operations

Knowledge based systems - knowledge representation – knowledge acquisition and optimization - Knowledge based approaches to design mechanical parts and mechansims and design for automated assembly

Knowledge based system for material selection – Intelligent process planning system.

Intelligent system for equipment selection - Intelligent system for project management & factory monitoring. Scheduling in manufacturing – scheduling the shop floor – Diagnosis & trouble shooting

The role of Artificial Intelligence in the factory of the future – Intelligent systems.

**REFERENCES**

*1) Andrew Kussiak,, "Intelligent Manufacturing Systems", Prentice Hall , 1990.*
*2) Simons, G.L, "Introducing Artificial Intelligence", NCC Pub, 1990.*
*3) Rich,E., "Artificial Intelligence", Mc Graw Hill, 1986.*

## PR 614 MACHINE TOOL TECHNOLOGY

Metal cutting machine tools and their specifications - machine beds and columns - relative merits of different types of beds and columns - design of beds and columns -force on cutting tool.

Types and design of slideways - wear adjustments.

Design of spindles and bearings – example for lathe, drilling machine and milling machine, choice of bearings.

Types of drives for machine tool – step and stepless – speed and feed mechanisms – kinematic diagrams.

Machine tool vibration – types - effect of undeformed chip thickness variations, rake and clearance angle variations - stability of cutting operation - regenerative chatter - testing of machine tools for alignment and accuracy - standard test charts.

**REFERENCES**

*1) Sen and Bhattacharya,, "Principles of Machine Tools", New Central Book Agencies, 1975.*
*2) Boothroyd,G., "Fundamentals of Metal Machining and Machine Tools", Mc Graw hill, 1985.*
*3) Acherkan,, "Machine Tool Design", Vol 2 & 3, MIR Pub, 1973.*

## PR 615 QUALITY ENGINEERING

Basics of quality – process capability analysis – quality gurus and their philosophies.

Quality standards – ISO 9000 series and 14000 series – Design of experiments – Anova analysis

Reliability – MTBF – MTTR - Acceptance sampling by variables and attributes – ASN – ATI – AOQL

IS2500 plans – MIL STD 105E – Control charts for variables and attributes - Taguchi methods, cases Concurrent engineering.

Quality function deployment – FMEA – Quality circles - Total quality management –Kaizen.

**REFERENCES**

*1) Juran J.M and Frank MGryna "Quality Planning and analysis", Tata Mc Graw Hill,1990.*
*2) Genichi Taguchi et all., "Quality Engineering in Production System", Mc Graw Hill, 1989.*
*3) Gabriel A Pall,, "Quality Process Management", Prentice Hall,1987.*

## PR 617 PRODUCT ANALYSIS AND COST OPTIMISATION

New product strategy, market definition - idea generation - design process - forecasting sales potential - product engineering, manufacturing planning - selection of economical process - standardisation - implification – specialization - break even analysis.

Value engineering – evaluation of function determining function - classifying function - evaluation of costs - evaluation of worth - determining worth - evaluation of value - value engineering.

Job plan information phase - speculation phase - analysis phase - development phase - presentation phase - implementation phase - follow up phase - fast diagramming - cost models - life cycle costs.

Cost accounting - cost estimation

Cost calculations for machined components, welding, casting and forging components - calculation of selling price - activity based cost analysis.

**REFERENCES**

*1) Samual Eilon, "Elements of Production Planning and Control",Universal Book Co, 1984*
*2) Miles L.D, "Techniques of Value Engineering and Analysis", McGrawHill, 1972.*
*3) Narang, C.B.S and Kumar V, "Production and Costing", Khanna publishers ,1983.*

## PR 619 MODELING AND SIMULATION

Introduction to systems and modeling - discrete and continuous system - Limitations of simulation, areas of application - Monte Carlo Simulation. Discrete event simulation and their applications in queueing and inventory problems.

Random number generation an their techniques - tests for random numbers.

Random variable generation.

Analysis of simulation data. - Input modeling – verification and validation of simulation models – output analysis for a single model.

Simlation languages and packages - FORTRAN, C , C++, GPSS, SIMAN V, MODSIM III,ARENA,QUEST,VMAP - Introduction to GPSS – Case studies - Simulation of manufacturing and material handling system.

**REFERENCES**

*1) Jerry Banks and John S, Carson II "Discrete Event system Simulation", Prentice Hall, 1984.*
*2) Geoffrey Gordon., "System Simulation", Prentice Hall, 1978.*

*3) Francis Neelamkovil, "Computer Simulation and Modelling", John Willey and sons, 1987.*

## PR 620 COMPUTER INTEGRATED MANUFACTURING

CIM - Evaluation, hardware and software of CIM - concurrent engineering - advance modeling techniques.

NC, DNC, CNC, Adaptive Control Machining - Automated Inspection and Testing - sensor technologies - CMM - Machine Vision.

Robotics technology - Control Systems - Programming and applications - Automated Materials Handling and Storage Systems - Types of Material Handling Equipment - Conveyer Systems - AGV systems - Storage system performance - ASRS, Carousel Storage Systems - Work-in-process Storage - Interfacing Handling and Storage with Manufacturing.

Group Technology - Machine Cell Design - Flexible Manufacturing Systems: Introduction, Workstations, Planning, applications and Benefits - Control Systems –

Artificial intelligence and CIM systems,

**REFERENCES**

*1) Paul Ranky, "Computer Integrated Manufacturing", Prentice Hall, 1986.*
*2) Donatas T I junclis, Keith E Mekie, "Manufacturing High Technology Hand Book", Marcel Decker.*
*3)Mikell P Groover,, "Automation, Production Systems and Computer Integrated Manufacturing", Prentice Hall,1996.*

## PR 621 FINITE ELEMENT METHOD

Basic concepts - Different approaches in Finite Element - Various methods in Finite Element Methods - Steps involved in FEM.

Interpolation Polynomials - Linear elements Shape function - Element and Global matrices - Two dimensional elements, triangular and rectangular elements - Local and Natural Co-ordinate systems.

Field problems, Steady state problems - Torsional problem - Fluid flow and Heat transfer problems - Acoustic vibrations – Application in manufacturing problems – metal cutting and metal forming.

Finite element Solution of structural problems - Two dimensional elasticity problems.

Higher Order Elements and Numerical Methods - Evaluation of shape functions - Numerical Integration, Gauss Legendre quadrature - Solution of finite element equations - Cholesky decomposition, Skyline storage - Computer implementation- Use of FEM software.

**REFERENCES**

*1) Larry J Segerlind,, "Applied Finite Element Analysis", John Wiley, 1984..*
*2) Bathe KJ, "Finite Element Procedures", Prentice Hall, 1994.*
*3) Huebner K H & Thornton E A, "The Finite Elment Methods for Engineers", John Wiley, 1982.*

## PR 622 FINITE ELEMENT ANALYSIS IN MANUFACTURING

FEM – elements and coordinate system – interpolation polynomials – element and global matrices – local and natural coordinate systems.

FEA - discretization - selecting the proper elements - elements, nodes, degree of freedom – preprocessing - executing the model – postprocessing -design optimization - Fundamentals of Applied finite element analysis – hardware requirements for doing FEA

Finite Element Analysis in production design - Minimising the product design cycle by interfacing CAD and FEA – FEA of maximum fatigue life and minimum weight – vehicles aerodynamics studies.

Application in metal casting, cutting, metal forming and welding, moulds and dies.

FEA in automotive industries - Finite element Models –Finite Element Analysis Results and Discussions.

**REFERENCES**

*1) Edward R Champion Jr,, "Finite Element Analysis in Manufacturing Engineering", Mc Graw Hill, 1992.*
*2) K.J. Bathe and Wilson E L., "Finite Element Procedures", Prentice Hall, 1994.*
*3) Huebner K H & Thornton E A, "The Finite Elment Methods for Engineers", John Wiley,1982.*

## PR 623 FINITE ELEMENT PLASTICITY AND METAL FORMING ANALYSIS

Basics of Metal Forming and Finite-Element Method - Comparison of Finite-Difference and Finite Element Methods with Analytical Solutions - Spatial Discretization - Shape Functions - Assembly of the Stiffness Matrix.

Finite Elements for Large Deformation - Solution of Linear Finite-Element Systems and Nonlinear Finite-Element Systems, Typical Finite Elements.

Classification of Finite-Element Formulations, Auxiliary Equations - Thermomechanical Principles.

Steady-State Forming Problems - Slab Analysis Versus the Finite-Element Solution in forming processes.

Sheet Forming Analysis and Sheet-Metal Formability Tests - Elements Used in SHEET-S and SHEET-3, General Considerations, Consistent Full Set Algorithm, Performance of SHEET-3 in International Benchmark Tests, Meshing and Remeshing - Error Estimation, Adaptive Remeshing.

**REFERENCES**

*1) Shiro Kobayanshi, Soo Ik oh and Taylan Atlan , "Metal Forming and Finite Element Method", Oxford pub, 1992.*
*2) R.H. Wagoner, Jean Loup chenot "Metal Forming Analysis", Cambridge Publications, 1994.*
*3) G.W. Rowe, C.E.N. Sturgess, P.Hartley, I. Pillinger "Finite Element Plasticity and Metal Forming Analysis", Cambridge publications,1992.*

## PR 626 FRACTURE MECHANICS AND MECHANISMS

Introduction sources of micro and macro cracks fracture criterion based on stress concentration and theoretical strength Griffith's energy - various approach - Stress Analysis for Members with Cracks.

Crack tip Plastic Zone: Plastic zone estimation - yielding fracture mechanics.

Elastic–Plastic Fracture Mechanics - Path-independent integrals, J-integral , J-integral fracture criterion, crack opening displacement(COD), experimental determination of J-integral and COD - Fatigue and Fatigue crack growth rate.

Linear static fracture Mechanics Design Concepts - Introduction, the stress criterion, strain energy density, 2-D linear elastic crack problems.

Dynamic Fracture: Mohr's model, strain energy release rates, crack branching, practical applications of crack arresting techniques. Experimental determination of dynamic SIF. -NDT and Fracture Mechanics

**REFERENCES**

*1) S.A. Maguid,, "Engineering Fracture Mechanics", Elsevier, 1996*

*2) David Broke., "Elementary Engineering Fracture Mechanics", Noordhoff, 1995.*
*3) Karen Hellan, "Introduction to Fracture Mechanics", Mc Graw Hill, 1982.*

## PR 627 PRESS TOOLS IN METAL FORMING

Elements, classification of press tools - clearance between punch and die, shut height and daylight, press tonnage calculation - Strip layout, Basic rules, economic layout, bridge size, calculation of plug point/center of pressure.

Types of Press tools

Types and Role of tooling in the deformation system - Tools for cold extrusion, force analysis, analogue method, nomograms - Tool design - Punch pressure significances - Tolerancing cold extrudes based on VOl data - Design chart for a complete sequence of producing a cold extrude.

Forging Tools - Design of Upsetting tools.

Bending and Forming tools, Dies for headers, transfer mechanisms. Design of tool for deep drawing Cutting tools - methods of reducing forces, die pillar set, fine blanking tools.

**REFERENCES**

*1) Paquin Jr,, "Die Design Fundamentals", New York Industrial Press, 1987.*
*2) Dallas, B. Daniel,, "Progressive Dies", Michigan-SME, 1994.*
*3) Smith A David, "Die Design Hand Book", SME, 1990.*

## PR 628 MECHANICS OF COMPOSITE MATERIALS

Classification, Types, characteristics & selection of composites, prepegs, sandwich construction.

Micro and Macro mechanics of a lamina**:** four elastic moduli – Rule of mixture, ultimate strengths of unidirection lamina - Hooke's law - number of elastic constants - Two – dimensional relationship of compliance & stiffness matrix. Hooke's law for two dimensional angle lamina, Engineering constants - Theories of failure.

Macro Mechanical analysis of laminate - Kirchoff hypothesis – CLT, A,B,& D matrices - Engineering constants - Special cases of laminates, Failure criterion.

Manufacturing processes and Quality assurance of composites.

Metal matrix composites, Application developments - future potential of composites.

**REFERENCES**

*1) Mein Schwartz,, "Composite Materials Hand Book", Mc Graw Hill, 1984.*

*2) Autar K. Kaw, "Mechanics of Composite Materials", CRC Press, 1994.*
*3) Rober M Joness, "Mechanics of Composite Materials", Mc Graw HIll,1982.*

## PR 629 THEORY OF PLASTICITY

Iinvariance in terms of the deviatoric stresses, representative stress - Engineering and natural strains, cubical dilation, finite strains co-efficients, Octahedral strain, strain rate and the strain rate tensor.

Yield criteria for ductile metal - Yield criteria for an anisotropic material. Stress – Strain Relations – Plastic stress-strain relations, Prandtl Roeuss Saint Venant, Levy – Von Mises, Yield locus, symmetry convexity, normality rule.

Application to problems, simple forms of indentation problems using upper bounds. Problems of metal forming.

Crystal Plasticity, the crystalline state, crystallographic indices, the preferential planes and directions, critical shear stress, theory of simultaneous slip, slip bands, the plastic bending in crystals, dislocations and crystal growth, polycrystals and grain boundaries,

Plane plastic strain and the theory of the slip line filed, two dimensional problems of steady and non steady motion, plastic anisotropy.

**REFERENCES**

*1) Narayanasamy R, "Theory of Engineering Plasticity", Ahuja Publications, 2000.*
*2) Johnson and Mellor, "Plasticity for Mechanical Engineers", Ban Nostrand, 1973.*
*3) R.Hill , "The Mathematic theory of Plasticity", Oxford Publication, 1982.*