

MTPE3006 MECHANICAL WORKING OF MATERIALS (3-0-0)

Objectives of the Course:

The course aims to provide students with a comprehensive understanding of the principles, mechanisms, and technologies involved in the mechanical working and deformation of materials. It focuses on plastic deformation behavior, hot and cold working processes, and the relationship between processing parameters, microstructure, and mechanical properties. The objective is to develop an understanding of how industrial forming operations — such as rolling, forging, extrusion, drawing, and sheet-metal forming — are designed and optimized for various materials.

Module – I: (06 hours)

Fundamental of metalworking

Classification of forming process, mechanics of metalworking, Flow stress deformation, temperature in metalworking, strain rate effect, metallurgical structure, friction and lubrication, deformation zone geometry, hydrostatic pressure, workability, residual stress, experimental technique for metalworking process, computer-aided metalworking

Module – II: (06 hours)

Forging

Classification of forging process, forging equipment, forging in plain strain, open die forging, closed die forging, calculation of loads in closed die forging. Forging defects, powder metallurgy forging, residual stress in forging.

Module – III: (06 hours)

Rolling and Extrusion Process

Classification of rolling process, rolling mills, Hot and cold rolling , Rolling bars and shape, forces and geometrical relationship in rolling, simplified analysis of rolling load: rolling variables, problem and defects in rolling products, rolling mill control, theories of cold rolling, theories of hot rolling, torque and horsepower, Classification of extrusion, extrusion equipment, hot extrusion, deformation, lubrication and defects, cold extrusion and cold forming, hydrostatic extrusion, extrusion of tubing, production of seamless of pipe and tubing.

Module – IV: (06 hours)

Drawing and Sheet Metal Forming

Wire drawing and tube drawing processes — principle, mechanics, and die design. Sheet metal forming operations: bending, deep drawing, stretching, spinning, and shearing. Forming limit diagrams and spring back behaviour. Deep drawing defects and remedies. Hydroforming and superplastic forming. Influence of material anisotropy and strain rate on formability.

Module – V: (06 hours)

Advanced Working Processes and Industrial Applications

High strain rate forming — explosive, electrohydraulic, and electromagnetic forming. Thermo-mechanical processing (TMP) — concept, objectives, and benefits. Hot working of steels, aluminium, copper, and titanium alloys. Modern metal forming equipment and automation defects, and inspection in worked materials.

Course Outcomes:

After completing this course, the student will be able to:

- CO1: Explain the fundamentals of plastic deformation and the principles of metal forming.
- CO2: Analyze the process parameters influencing rolling, forging, extrusion, and drawing operations.
- CO3: Evaluate the effects of working temperature, strain rate, and microstructure on mechanical behavior.
- CO4: Identify and prevent defects in formed products through proper process design.
- CO5: Apply advanced and thermo-mechanical forming methods in industrial contexts.

Books:

1. Dieter, G. E. Mechanical Metallurgy, McGraw-Hill Education.
2. H. J. Avner. Introduction to Physical Metallurgy, McGraw-Hill Education.
3. K. L. Narayan. Metal Forming Technology, New Age International Publishers.

Reference Books:

1. Hosford, W. F. & Caddell, R. M. Metal Forming: Mechanics and Metallurgy, Cambridge University Press.
2. Polakowski, N. N. & Ripling, E. J. Strength and Structure of Engineering Materials, McGraw-Hill.
3. Kalpakjian, S. & Schmid, S. R. Manufacturing Processes for Engineering Materials, Pearson.
4. Ghosh, A. & Mallik, A. K. Manufacturing Science, Affiliated East-West Press.

Digital Learning Resources:

Course Name: Metal Forming

Course Link: <https://nptel.ac.in/courses/112/105/112105125>

Course Instructor: Prof. S. K. Biswas, IIT Kanpur

Course Name: Principles of Metal Forming

Course Link: <https://nptel.ac.in/courses/112/107/112107297>

Course Instructor: Prof. N. S. Das, IIT Kharagpur