Pressure Vessel Design and Analysis

Target Audience

This course is designed for mechanical engineers, design analysts, and professionals in the process and manufacturing industries who want to gain practical skills in **pressure vessel design, analysis, and validation**. It is ideal for learners working with storage tanks, reactors, heat exchangers, and industrial process equipment requiring compliance with design codes and safety standards.

Course Outcomes

By the end of this course, participants will be able to:

- Understand fundamentals of pressure vessel design and industrial applications.
- Apply engineering principles including stress, strain, and material behavior.
- Perform code-based design calculations for shells, heads, nozzles, and supports.
- Conduct structural analysis and finite element analysis (FEA) for verification.
- Apply design-by-analysis methods for stresses, buckling, and fatigue.
- Understand fabrication, welding, inspection, and testing procedures.
- Implement safety systems including relief devices and integrity assessments.
- Execute complete pressure vessel design workflows with industrial case studies.

Course Outline

The course comprises **5 days (40 hours)** of theory and labs and is divided into **15 modules**. Each module will be followed by hands-on exercises to reinforce learning and gauge understanding of the topics covered.

Table of Contents

Module 2: Engineering Fundamentals

- Stress and strain
- Material behavior
- Thin and thick cylinder theory
- Failure theories
- Factor of safety

Module 3: Materials and Design Conditions

- Material selection
- Mechanical properties
- Design pressure and temperature
- Corrosion allowance
- Design loads

Lab/Exercise: Pressure vessel component identification, basic design calculations

Day 2 – Pressure Vessel Components and Code-Based Design

Module 4: Shell and Head Design

- Cylindrical shells
- Head configurations
- Thickness calculations
- Internal pressure design
- External pressure considerations

Module 5: Openings and Nozzles

- Nozzle design
- Reinforcement requirements
- Local stresses
- Junction design
- Opening calculations

Module 6: Flanges and Supports

- Flange types

- Gasket selection
- Bolted joints
- Saddle supports
- Skirt and leg supports

Lab/Exercise: Manual design calculations, design verification examples

Day 3 – Structural Analysis and FEA Fundamentals

Module 7: Introduction to Structural Analysis

- Stress analysis concepts
- Load paths
- Stress categorization
- Deformation
- Design verification

Module 8: Finite Element Analysis Fundamentals

- FEA methodology
- Model idealization
- Mesh concepts
- Boundary conditions
- Result interpretation

Module 9: Design by Analysis

- Primary stresses
- Secondary stresses
- Peak stresses
- Buckling concepts
- Fatigue basics

Lab/Exercise: Sample stress evaluation, FEA result interpretation

Day 4 – Fabrication, Inspection and Safety

Module 10: Welding and Fabrication

- Welding processes

- Weld joints
- Heat treatment
- Manufacturing tolerances
- Fabrication sequence

Module 11: Inspection and Testing

- Visual inspection
- Non-destructive testing
- Hydrostatic testing
- Pneumatic testing
- Acceptance criteria

Module 12: Pressure Relief and Integrity

- Safety philosophy
- Relief systems
- Corrosion mechanisms
- Fitness-for-service
- Remaining life assessment

Lab/Exercise: Inspection planning, defect evaluation

Day 5 – Integrated Design and Industrial Applications

Module 13: Complete Pressure Vessel Design Workflow

- Design methodology
- Design documentation
- Quality assurance
- Compliance review
- Engineering deliverables

Module 14: Industrial Applications

- Storage vessels
- Reactors
- Heat exchangers

- Columns and towers
- Process equipment

Module 15: Case Studies and Final Project

- Design case study
- Stress assessment
- Code compliance review
- Design optimization
- Project presentation

Final Assessment: Design review, technical discussion, Q&A session, best practices, course wrap-up