

## PMM206: FAILURE ANALYSIS

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**Course Objective:** To understand the different type of materials failure and examine the causes of material failure

**Introduction:** Reliability and durability of materials. Bath tub curve of component failure. Concept of Mean Time Failure and related statistics. Failure Mode Effect Analysis (FMEA), Methodology of failure analysis, Fractography. Distortion failure, Primary and secondary process defects, Effect of defects on service properties, Ductile and brittle fracture. Basic fracture modes (shear mode, cleavage mode, intergranular and transgranular fractures, Fatigue fracture, creep fracture), Factors affecting the ductile brittle relationship.

**Testing Techniques:** Procedural steps for investigation, Non-destructive testing, Fractographic examination, Metallurgical tests, Analysis of service parameters and Simulated tests.

**Mode of Fractures:** Brittle fracture, Brittle fracture of normally ductile steels, Characteristics of brittle fracture, Microstructural aspect of brittle fracture, Combined fracture modes, Ductile fracture, Characteristics of ductile fracture, Microstructural aspects of ductile fracture, Fatigue fracture, Types of fatigue fracture, Stages of fatigue fracture, Microscopic and macroscopic characteristics of fatigue fracture, Relationship of stress to strength in fatigue, Statistical aspects of fatigue.

**Different Type of Failures:** Wear failure, Abrasive and adhesive wear, fretting wear, Wear failures-fatigue, Corrosion failure, Life cycle of a metal, Basic nature of corrosion, Forms of corrosion (Galvanic corrosion, Uniform corrosion, Crevice corrosion, Stress-corrosion cracking), Corrosion fatigue, Hydrogen embrittlement in alloys, Elevated-temperature failure, Creep, Elevated-temperature fatigue, Thermal fatigue, Metallurgical instabilities, environmentally induced failure, Cooling methods.

### Case study and documentation

#### Laboratory Work:

Inspection of surface defects occurred during solidification of a given metallic sample. Detecting the voids and blowholes in as-cast material by UFD, Welding a given metallic sample and observing the HAZ (Heat Affected Zone) defects under optical microscope, Rolling a given metallic specimen and discussing the rolling defects, Forging a given metallic specimen and discussing the forging defect, To Study the fracture surface of brittle and ductile materials under SEM, Studying the fracture surface of a material failed under cyclic loading, Observation of wear surface and subsurface and evaluating the mode of failure, Observation of corroded metallic material to evaluate the form of corrosion.

#### Course Learning Outcomes (CLO):

Student will be able to:

1. Analyze the reasons for failure and suggest remedial actions
2. To document the cause of failure, its effect on the operation / service and mode of failure
3. Prevents further failures by influencing design, material selection, manufacture, testing techniques or operating conditions

***Recommended Books:***

1. *Wulpi, D.J., Understanding How Components Fail, ASM International Technical Books (2004).*
2. *Das A.K., Metallurgy of Failure Analysis, Tata McGraw Hill (1986).*