Approval: 10th Senate Meeting

Course Number:	EN 611
Course Name:	Durability Behavior of Energy Materials
Credits:	3-0-0-3
Prerequisites:	None
Intended for:	UG/M.Tech./ MS/ PhD
Distribution:	Compulsory for M.Tech. in Energy Engineering with specialization in Materials, and Elective for others
Semester:	Second

Preamble: The course examines the durability of materials employed in energy engineering; the challenge to durability comes from the ability of the material to resist deformation at room and elevated temperature under static and dynamic loading prevailing under a given circumstance of application. In addition, there is corrosion, wear and erosion limiting the life of components. The course aims to offer a holistic view of the durability to indicate the directions of materials development for application in energy technology.

Course Outline:

The course will start with test of deformation behavior to identify the material parameters governing durability under static load and then proceeds to understand the instantaneous deformation behavior under static and dynamic loading and thereafter, focuses on high temperature time dependent deformation behavior prevalent in high temperature to follow the development of alloys for ultra super critical boilers and turbines. At the end the course focuses on durability threats to components employed in energy generation from corrosion, hot corrosion, erosion and cavitation as well as the strategies to counter them. The course will be delivered in the following modules.

Module 1: Static loading and Deformation behavior

Distinctive load – elongation behavior of different types of materials under uni-axial loading, definition of stress and strain, stress-strain diagram, elastic behavior, yielding and plastic behavior of ductile materials; necking instability, Important design criteria based on stress and strain at ambient temperature; strain rate and its influence of stress-strain diagram at elevated temperature; (**4L**)

Module 2: Durability under static loading

Defects in materials; linear defects or dislocations – types, burgers vector, slip, slip planes and slip directions, cross slip and climb, movement of dislocations leading to plastic deformation, stacking fault and partial dislocations, strain hardening, grain boundaries, strengthening mechanisms; recovery, recrystallization and grain growth during heating of deformed materials. (**6L**)

Module 3: Durability under Creep Deformation

Deformation under static loading at elevated temperature - creep curve, mechanisms of creep, temperature dependence of creep, deformation mechanism maps, cavitations, stress rupture versus creep, extrapolation schemes; Development of materials for ultra supercritical boilers for application in furnace panels, super-heaters, thick section components and steam lines. (**8L**)

Module 4: Durability under Cyclic Loading

Deformation under cyclic loading, high cycle fatigue – S-N curve, effect of mean stress, Miner rule, cyclic stress-strain curve, low cycle fatigue, strain life equation, effect of stress concentration and size of component, Design for fatigue, effect of temperature on fatigue; development of turbine materials. (**8L**)

Module 5: Durability under corrosion

Overview of corrosion, corrosion in water and steam, High temperature corrosion; corrosion under boiler flue gases, hot corrosion in gas turbine components, materials protection by coating (**6L**)

Module 6: Durability under Erosion and Cavitation

Overview of wear, erosion and cavitation wear, thermally sprayed coatings and weldings for repair of hydro-turbines and pumps. (**6L**)

Text Books:

1. George E. Dieter, Mechanical Metallurgy, McGraw Hill Book Company 1986
2. J. Lecomte-beckers, M. Carton, F. Schubert and P.J. Ennis (Editors), Materials for Advanced Power Engineering 2006, Vol.53, Part-1, Forschungszentrum Jülich GmbH, Institut für Energieforschung
3. Zaki Ahmed, Principles of Corrosion Engineering and Corrosion Control,Elsevier Science & Technology Books, 2006
4. Peter J. Blau, Friction and Wear transitions in Materials, Noyes Publications, 1989