Approval: 10th Senate Meeting

Course Number: EN 612

Course Name: Structure - Property correlation in materials for Energy Applications

Credits: 2-0-2-3

Prerequisites: IC241 (Materials Science for Engineers)/ Instructor Contest

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 goal of this course is to understand the structure of materials at different scales and correlate the observed properties particularly in the context of design of alloys for application in energy systems.

Course Outline: The course begins with understanding of structure at atomic, micro and macro length scales in alloys and then employs the same to design of high temperature superalloys used in turbines. The correlation of microstructure with tensile and creep properties are discussed in the concrete context of nickel, iron and cobalt based superalloys. The relation between structure and properties are discussed in the context of solar photovoltaic materials.

Course Modules:

Module – 1:

Structure of Materials – Crystal structure, micro structure and macrostructure; Determination of crystal structure by X-ray diffraction and microstructure by optical, scanning and electron microscopy, selected area diffraction; Phase diagram of binary alloys and distribution of phases in microstructure of cast and wrought alloys (**10L**)

Module 2

Ni-based super-alloys – Austenitic Ni-Cr binary alloys, Ni-based superalloys based on γ phase containing, nickel, cobalt, iron, chromium and molybdenum, Coherent and incoherent precipitates, γ' (Ni_3Al based $L1_2$ structure) precipitates, nickel – iron superalloys (IN718 and IN706) hardened by γ'' (Ni_3Nb based $D0_{22}$ structure), basal plane coherency, Grain growth and pinning of grain boundaries, Carbides and borides in superalloys; refractory elements and hard intermetallic TCP phases, Influence of microstructure on strength, ductility and creep life. Iron and cobalt based superalloys (**10L**)

Module 3

Conductors and semiconductor devices, solar photovoltaic materials, organic photovoltaic materials **(8L)**

Experiments:

1. Determination of crystal structure by X-ray diffraction in a diffractometer
2. Preparation of specimen and observation of microstructure in single phase alloy under optical microscope

3. Microstructure of cast and wrought alloys under optical microscope
4. Microstructure of iron based alloys in hydroturbines under optical and electron microscope
5. Microstructure of Ni-based superalloys in steam and gas turbines under optical and electron microscope along with SAD of precipitates.
6. Microstructure of alloys after service – erosion and cavitation in hydroturbines; creep cavitation in high temperature turbines
7. Microstructure of silicon wafers under optical and electron microscope

References

1. Robert E Reed-Hill and Reza Abbaschian, Physical Metallurgy Principles, Thomson, 2003 reprint.
2. Chester T Sims, William C Hagel, Superalloys II, Publisher: Wiley-Interscience, 1987
3. R. E. Hummel, Electronic Properties of Materials, Springer, 4th ed. 2011, Corr. 3rd printing 2013 edition