Course Syllabus

Department/Faculty: School of Engineering
Graduate Program: Materials Engineering and Nanotechnology
Degree: ☒ Academic Master's ☒ Doctorate (PhD) ☐ Professional Master's
Course Name: Special Steels and Alloys
Professor:
Office hours: 48
Course Overview: The module initially addresses, in a general way, carbon steels, their microstructures, properties, and applications. The main focus is on special steels. Tool steels are discussed based on their primary applications: cold working, shock-resistant, hot working, mould steels, and high-speed steels. Stainless steels are also presented broadly, covering the various types, their microstructures, properties, and applications. In addition to steels, the module also covers special alloys. Within this class, nickel-based and cobalt-based superalloys are discussed, considering their properties at both high and very low temperatures. The heat treatments and microstructures of superalloys are addressed, focusing on their various application possibilities. Shape memory alloys are presented with an emphasis on shape reversal due to thermally induced martensitic transformation. Intermetallic alloys are discussed in terms of their main characteristic: excellent mechanical strength and corrosion resistance at elevated temperatures, but low ductility at room temperature.

Program content:

- **Carbon steels**: Effect of alloying elements. New technologies for optimising their mechanical properties through microstructure control.
- **Tool steels**: Classification: cold working, shock-resistant, hot working, mould steels, high-speed steels. Effect of alloying elements. Expansion of chemical composition ranges and optimisation of mechanical and tribological properties through powder metallurgy.
- **Stainless steels**: Classification: austenitic, ferritic, martensitic, duplex, and precipitation-hardenable. Effect of alloying elements on the formation of their different microstructures.
- **Superalloys**: Nickel-based and cobalt-based superalloys. Applications at elevated temperatures and in aggressive environments. Solutionising and ageing heat treatments. Characteristics of their microstructures, intermetallic compounds, carbides, and inclusions.
- **Shape memory alloys**: Applications of shape memory alloys. Near-equiatomic Ni-Ti alloys. Plastic deformation below transformation temperature/reversion to original shape. Thermoelastic martensitic transformation. Pseudoelasticity.
- **Intermetallic alloys**: Long-range ordered crystal structures. Titanium, iron, and nickel aluminides. Applications of intermetallic alloys. Properties of mechanical strength and creep resistance at elevated temperatures and low ductility at room temperature. Oxidation and corrosion resistance properties.

Letter Grade Assignment:
Grade A (Excellent) - Grade points between 9 and 10
Grade B (Good) - Grade points between 8 and 8.9
Grade C (Satisfactory) - Grade points between 7 and 7.9
Grade D (Unsatisfactory) - Grade points between 0 and 6.9

Texts, Materials, and supplies

Basic Bibliography:

- LEXCELLENT, C. *Shape-memory Alloys Handbook*. John Wiley & Sons, Inc., 2013.
- ARTINI, C. *Alloys and Intermetallic Compounds from Modelling to Engineering*. CRC Press, 2017.
- HASHMI, S. *Comprehensive Materials Processing, Vol 12 - Thermal Engineering of Steel Alloy Systems*. Elsevier, 2014.
- CEVIK, S. *Superalloys for Industry Applications*. InTech Open, 2018.
- DOSSETT, J. L.
- TOTTEN, G. E. *ASM Handbook - Steel Heat Treating Technologies*. ASM International, 2014.
- HONEYCOMBE, R. W. K., BHADESHIA, H. K. D. H. *Steels Microstructure and Properties*. 3rd Edition, Elsevier Inc., 2006.
- ROBERTS, G.; KRAUSS, G.; KENNEDY, R. *Tool Steels*. 5th Edition, ASM International, 1998.

Supplementary Bibliography:

- DAVIS, J. R. (Ed.) *ASM Specialty Handbook - Nickel, Cobalt and Their Alloys*. ASM International, 2000.
- REED, C. R. *The Superalloys: Fundamentals and Applications*, 2nd Edition, London, Cambridge University Press, UK, 2006.
- DAVIS, J. R. (Ed.) *ASM Specialty Handbook - Heat-Resistant Materials*. ASM International, 1997.