MS2016 – Phase Transformation and Kinetics

Course Code	MS2016					
Course Title	Phase Transformation and Kinetics					
Co-requisites	MS1016	Thermodyanmics of Materials				
Pre-requisites	NIL					
Pre-requisite for	NIL					
No of AUs	3					
Contact Hours	LECTURES	26 hrs	TUTORIALS	13 hrs		

Course Aims

The fundamental understanding of phase transformations in materials is the key for tuning their structure and properties. This course will provide you the necessary basic knowledge to relate bonding, atomic order, diffusion and temperature in solids. It also presents the connections between thermodynamic concepts and materials phenomena, starting from nucleation and growth to phase transformations.

Intended Learning Outcomes (LO)

By the end of this course, you (as a student) would be able to:

1. Predict the properties and interactions of different materials by understanding their composition, making connections to structure and bonding.
2. Explain the different types of imperfections in solids (metallic and ionic) and their influence on properties.
3. Identify carbon sites (interstitial positions – octahedral and tetrahedral) in both $\alpha-$ and $\gamma-$ iron lattices; illustrate the importance of strain energy in choosing the correct interstitial site; explain the symmetric and asymmetric distortion
4. Calculate the effect of temperature on vacancy formation and the rate at which they move in a lattice.
5. Explain and analyse Hume-Rothery rules that govern the formation of solid solutions.
6. Apply Fick's first and second laws for solid state diffusion in binary systems; to solve fundamental and industry-oriented problems and recognize the significance of diffusion coefficient D.
7. Explain the importance of interfacial energy and its influence on grain shape as well as grain boundary migration and pinning force concepts.
8. Explain the concepts of constitutional undercooling, solute pile-up at the solid-liquid interfaces, differences between columnar and equiaxed solidification, formation of dendrites, and eutectic solidification.
9. Analyse the implication of nucleation and nucleation rate in relation to Gibbs free energy requirements.
10. Describe the driving forces for growth of a pure solid or alloy after nucleation.
11. Demonstrate the use of Time-Temperature Transformation (TTT) diagrams.
12. Describe the effects of changing process parameters on the microstructure of steels.
13. Explain the mechanisms of phase transformations in steels (based on diffusion and diffusionless transformations).
14. Describe martensitic and pearlitic transformations.

15. Explain the importance and types of cast iron, effects of cooling rate on the microstructure of cast iron, and significance of carbon equivalent.

Course Content

Imperfections in solids, diffusion in solid systems, interface movement and solidification (includes nucleation, grain growth and further solidification), phase transformations and kinetics in solids (emphasis on steels).

Reading and References

Suggested reading:

1. Phase Transformations in Metals and Alloys, 3rd edition, David A Porter, Kenneth E Easterling, Mohamed Sherif, PUB Feb 2009, CRC Press.
2. Heat and mass transfer: fundamentals and applications, YA Cengel and AJ Ghajar, McGraw Hill, 2011 (only Chapters 1 and 2).
3. Fundamentals of solidification, W. Kurz and D.J. Fisher, Trans Tech Publications, 4th Edition, 1998.

Additional reading:

1. Materials science and engineering: an introduction, Willian D Callister, Wiley.
2. Introduction to the thermodynamics of materials, 5th edition by David Gaskell, Yaylor and Francis, 2008.
3. Thermodynamics: an engineering approach, YA Cengel and MA Boles, McGraw Hill, 2011.
4. Engineering heat transfer, 3rd Edition, William S Janna, CRC press, 2009

Course Policies and Student Responsibilities

(1) CA

Absentees must be supported by a medical certificate or other valid official documents.

Academic Integrity

Good academic work depends on honesty and ethical behaviour. The quality of your work as a student relies on adhering to the principles of academic integrity and to the NTU Honour Code, a set of values shared by the whole university community. Truth, Trust and Justice are at the core of NTU's shared values.

As a student, it is important that you recognize your responsibilities in understanding and applying the principles of academic integrity in all the work you do at NTU. Not knowing what is involved in maintaining academic integrity does not excuse academic dishonesty. You need to actively equip yourself with strategies to avoid all forms of academic dishonesty, including plagiarism, academic fraud, collusion and cheating. If you are uncertain of the definitions of any of these terms, you should go to the academic integrity website for more information. Consult your instructor(s) if you need any clarification about the requirements of academic integrity in the course.