


# THERMO-MECHANICAL AND THERMO-CHEMICAL PROCESSES

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**INTENDED AUDIENCE:** Final year B.Tech., M.Tech. and PhD scholars in Metallurgical Engineering or Materials Engineering. Practicing engineers in steel and aluminum industries.

**PRE-REQUISITES :** Mechanical Metallurgy, Physical Metallurgy, Basic Thermodynamics

**INDUSTRIES APPLICABLE TO :** SAIL, TATA steel, Essar Steel, BHEL, JSW steel, Hindalco, TataMotors, Larsen & Toubro

## COURSE OUTLINE :

Microstructural features like grain size, phase fraction and size distribution can be tailored by understanding and optimizing thermo-mechanical and thermo-chemical processes i.e. coupling the heat treatment either by introduction of mechanical energy into solids or by altering the chemistry of solids. Accordingly, several Thermo-Mechanical and Thermo-Chemical processes/treatments have been developed by the researchers. This course is designed to provide the fundamental science behind these processes so that optimal utilization of these processes is possible. Course will cover the utilization of flow stress data from hot deformation experiments to develop constitutive equations and processing maps, the interrelationship between microstructure and deformation features with the thermo-mechanical deformation processes. Important thermo-chemical processes such as nitriding, carburizing, carbonitriding, nitrocarburizing and boriding will be covered.

## ABOUT INSTRUCTOR :

Prof. Vivek Pancholi obtained BE (Industrial and Production Engg.) in 1995 from G.S.I.T.S. Indore, M.Tech. (Industrial Tribology) from IIT Delhi in 1997 and PhD in Metallurgical Engineering from IIT Bombay, in 2005. He joined IIT Roorkee as a faculty member in the Department of Metallurgical and Materials Engineering in 2006. He has about 10 years teaching experience at IIT Roorkee. He taught UG core courses like Structural Metallurgy, Phase transformation and Heat treatment, Welding and Casting and, Mechanical Behavior of Materials. He also taught M.Tech. core course on Materials Characterization.. He has published more than 35 research papers in SCI/ SCIE indexed journals and completed 05 sponsored research projects. Under his guidance four PhD research scholars completed their thesis and five are working.

Prof. Sai Ramudu Meka is working as a faculty in the Department of Metallurgical and Materials Engineering, IIT Roorkee. He obtained his bachelor of engineering degree in Metallurgy from NIT, Surathkal in the year 2002. Then he served as a Junior Manager for Jindal Vijayanagara Steels Ltd. (JVSL), Toranagallu, Bellary, Karnataka. In 2004 he left JVSL to pursue his master's studies in Metallurgy and Materials science at IIT Kanpur. In 2007 he started with his doctoral studies at Max Planck Institute (MPI) for Metals Research, Stuttgart, Germany and obtained his Ph.D in the year 2011. Thereafter he worked as a research scientist at MPI, Stuttgart. He has extensively worked on fundamental understanding of gaseous nitriding of steels. He has published more than 35 peer reviewed research papers and currently actively working on thermodynamics and kinetics of thermos-chemical processes.

## COURSE PLAN :

**Week 1:** Introduction, Hot deformation processes I, Hot deformation processes II, Flow curves as a function of strain rate and temperature, Stress, strain, strain rate sensitivity.

**Week 2:** Microstructural evolution, Recovery, Recrystallization, Dynamic recrystallization, discontinuous dynamic recrystallization (DDRX), continuous dynamic recrystallization (CDRX), geometric dynamic recrystallization (GDRX).

**Week 3:** Texture, Deformation texture (BCC), Deformation texture (FCC), Recrystallization texture (BCC), Recrystallization texture (FCC).

**Week 4:** Constitutive analysis, Low strain rate , Medium strain rate, High strain rate, case study

**Week 5:** Deformation maps, Processing maps, Different models, Interpretation, Processing maps microstructure correlation, case study.

**Week 6:** SPD based thermo-mechanical processes, Friction stir Processing, Equal Channel Angular Processing, High pressure torsion, case study.

**Week 7:** Introduction to Thermo-chemical surface treatments, Thermodynamics of gas/solid interaction.

**Week 8:** Phase transformations and consequent surface property enhancement during nitriding of iron based alloys.