ME669 Modelling Thermal Transport in Manufacturing Processes

Credits: 3L-0T-0P-0A (9 Credits)

Course description:
The objective of this course is to educate students with modelling of thermal transport involved in manufacturing processes. The focus will be on developing a feel about the physical processes, its mathematical description and numerical modelling. During introductory part on heat transfer in manufacturing, the basic of multimode heat transfer (conduction, convection and radiation), diffusive and convective heat and mass transport, natural convection and phase change will be reviewed. Thereafter, FDM/FVM based numerical modelling will be introduced which will involve model building, governing differential equations, numerical implementation, simulations, analysis of results etc. Remaining of the course will deal with modelling thermal transport in selected manufacturing processes. The case studies will be in the area of heat assisted manufacturing processes, casting, welding, thermal deposition and machining. For this the essential features of a particular manufacturing process will be discussed, in order to identify appropriate physical models of the process that are useful for describing the thermal transport. It will be followed by discussion to show how the physical model leads to a mathematical model of the process, and to interpret these models to study the transport phenomena in the process.

Course content:

	Topic
1. Review of fundamentals of thermal transport in manufacturing	1. Introduction to the course - Importance of heat transfer in manufacturing and applications 2. Steady and transient heat conduction, Convection and Radiation, Natural convection 3. Fluid flow and Mass transfer
2. Finite Difference and Finite Volume based modelling of heat transfer in manufacturing and numerical implementation	1. Basic introduction to FDM and FVM techniques, Mathematical formulation of thermal transport, Governing equations and general scalar transport equation 2. Steady and unsteady problems, Initial and Boundary conditions, Convection-diffusion problems 3. Mesh terminology, Accuracy, Consistency, Stability and Convergence 4. Phase change - Enthalpy based algorithm for Melting/solidification, Two-phase mushy zone flows, Liquid- vapour phase change involved in manufacturing 5. Illustration using code
3. Case studies on modelling of thermal transport in manufacturing processes	1. Solidification processing – Modelling of moving melting/solidification phase change interface, Alloy solidification, Segregation, Two-phase mushy zone flow, Modelling of casting, Marangoni convection driven flow, Modelling of welding 2. Heat assisted manufacturing process – Thermal modelling using enthalpy method for solid-liquid and/ or liquid-vapour phase change interface, Melt pool formation and flow behaviour, Beam heat flux models, Example problems of thermal modelling in Laser Melting (LM), Electron Beam Melting (EBM), Machining: Electric Discharge Machining (EDM) and Heat assisted micro manufacturing process 3. Thermal deposition process – Modelling of free surface evolution, Modelling of droplet impact and deposition on substrates