



# JOINING TECHNOLOGIES FOR METALS

## PROF. D . K . DWIVEDI

Department of Mechanical & Industrial Engineering  
IIT Roorkee

**INTENDED AUDIENCE :** It is a core course for UG/PG students, practicing engineers.

### COURSE OUTLINE :

It is proposed to include following joining technologies of commercial importance under different groups of processes. Fundamentals of Metal Joining Technologies: mechanisms for obtaining metallic continuity: fusion, deformation, diffusion, chemical interactions. Fusion based processes: principle of fusion welding processes, oxy-fuel gas welding, common arc welding processes, laser beam welding, spot welding processes, newer variants of fusion welding processes. Solid-liquid joining processes: brazing and soldering, braze welding, cold metal transfer welding, Solid state joining processes: diffusion bonding, ultrasonic welding and explosive welding.

### ABOUT INSTRUCTOR :

Prof. D. K. Dwivedi Department of Mechanical & Industrial Engineering , Indian Institute of Technology Roorkee obtained BE (mechanical engineering) , in 1993 from GEC Rewa, ME (welding engineering) Univ. of Roorkee in 1997 and PhD in Met. Engineering from MNIT, Jaipur in 2003. He has about 9 years teaching experience at NIT Hamirpur and 12 years at IIT Roorkee of subjects related with manufacturing at UG level and welding engineering related subjects at PG level. He has published more than 95 research papers in SCI/SCIE indexed journals and undertaken 16 sponsored research and 48 industrial consultancy projects. Instructor has authored one book entitled "Production and Properties of Cast Al-Si Alloys with New Age International, New Delhi (2013).

### COURSE PLAN :

**Week 1:** Introduction: Manufacturing and Joining Fundamental Mechanisms of joining, heat and pressure in joining Classification of joining processes, Heat generation and power density concept in welding Protection of the weld metal approaches, effect of gases on weld properties

**Week 2:** Principle of fusion welding processes, oxy-fuel gas welding Fundamentals of welding: type of weld, types of joint, welding position, arc heat generation Physics of welding arc: arc initiation, maintenance, shielded metal arc welding Electrode melting rate, effect of electrode polarity and welding parameters Gas tungsten arc welding: electrode, shielding gases, Introduction of gas metal arc welding

**Week 3:** Variants of Gas tungsten arc welding: GTAW, Hot wire GTAW, Flux assisted GTAW Variants of Gas metal arc welding: Pulse GMAW, CMT welding Submerged arc welding Electro-slag and Electro-gas welding processes Laser beam welding

**Week 4:** Brazing Soldering and Braze welding, Fundamentals of resistance welding Resistance welding processes: spot, seam welding Flash butt welding

**Week 5:** Adhesive joining, Welding bonding, Solid state joining technologies: Fundamentals Ultrasonic joining, Diffusion bonding

**Week 6:** Explosive welding, Magnetic pulse welding, Weld thermal cycle, Heat affected zone and weld thermal cycle: I, Heat affected zone and weld thermal cycle: II

**Week 7:** Solidification of weld metal, Fundamentals of weldability of metals, Weldability of carbon & alloy steels: Fe-C, CCT, Weldability of stainless steels: schaeffler diagram, Metallurgical transformation in weld and heat affected zone of steels

**Week 8:** Weldability of aluminium alloys: porosity, HAZ softening, PMZ issues, Solidification cracking and their control, Residual stresses in weld joints: effect on joint performance, and control of residual stress, Cracking of welded joints: solidification and liquation cracks, Cracking of welded joint: cold cracking