



### Joining Technologies for metals

#### ABOUT THE COURSE:

It is proposed to include following joining technologies of commercial importance under different groups of processes

- A) Fundamentals of Metal Joining Technologies: mechanisms for obtaining metallic continuity: fusion, deformation, diffusion, chemical interactions
- B) Fusion based processes: principle of fusion welding processes, oxy-fuel has welding, common arc welding processes, laser beam welding, spot welding processes, newer variants of fusion welding processes
- C) Solid-liquid joining processes: brazing and soldering, braze welding, cold metal transfer welding,
- D) Solid state joining processes: diffusion bonding, ultrasonic welding and explosive welding and
- E) Adhesive joining: design, procedure, and applications
- F) Metallurgical Aspects of Welding: weld thermal cycle, solidification of weld metal, weldability of carbon steel, alloys steel, stainless steels, and aluminium alloys, Fe-C, CCT and schaffler diagram for understanding the metallurgical transformation in weld and heat affected zone., basics of residual stresses
- G) Common issues related with joining technologies their causes and remedies: hardening and softening of heat affected zone, porosity, cracking.

#### COURSE LAYOUT

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