GUJARAT TECHNOLOGICAL UNIVERSITY

METALLURGY ENGINEERING (21)
METAL JOINING PROCESSES
SUBJECT CODE: 2162109
B.E. 6th SEMESTER

Type of course: Engineering Science

Prerequisite: Knowledge of Elements of Metallurgy and basic science skills

Rationale: Metal joining is an important manufacturing route to fabricate bulk storage and processing equipment & Power generation equipment. Out of Welding, Brazing & soldering processes, Welding is one of the major manufacturing processes used in the fabrication of process equipment, steel structures, piping and ship building, Plenty of Engineering equipment like Pressure vessels, Pharmaceutical & drug Processing, Food & dairy equipment, Chemical Processing vessels & storage tanks, agricultural equipment, turbines etc.

The subject focuses on knowledge and understanding of various joining process and equipment, the fundamental principles and their relative merits and demerits. Basic understanding of weldability of different metals and alloys is emphasised. Thus it is a key course, being important for students of metallurgy.

Metallurgy of welding plays an important role for obtaining good quality welded joints. This course also provides the knowledge about metallurgical effect of welding in various ferrous and nonferrous metals like carbon steel, stainless steel, aluminium and titanium. The student will be able to apply knowledge and skills of welding metallurgy in producing products of quality as per the quality standard of the industries.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
				Theory Marks			Practical Marks			
L	T	P	C	ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	0	2	6	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	**Introduction of Metal Joining Processes**, Joining process as a manufacturing route. Relevance of joining process to metallurgy. Classification of joining process. Safety aspects in Metal joining processes.	4	7 %
2	**Fusion welding**: welding procedure, Joint design and edge preparation, welding codes for weld position. Welding symbols. Selecting groove geometry, fillet weld, bead weld, dilution, stress concentration, plug weld, weld bead geometry, Welding parameters, welding process, welding consumable, cleanliness, flux, electrode diameter.	8	13 %
3	**Characteristics of Power Sources.** Review of Power Sources for Fusion Welding Processes. Nature of Heat sources, Electrical characteristic of arc, Machine Characteristics of Arc. Different modes of metal transfer.	6	10 %
4	**Physical Metallurgy of Welds.**	8	13 %

	Weld CCT diagrams, Role of Carbon equivalent. Heat flow - temperature distribution-cooling rates, Phase transformations during heating & Cooling Gas-metal and slag-metal reactions, evolution of gases, formation of porosity, inclusions in weld metal, weld pool solidification, residual stresses, , Role of preheating and post heating on metallurgy of weldments.		
5	**Fusion welding: SMAW** Function of coatings, based on slag metal, gas metal reactions- Coding Method (Specification) of consumable electrode & their functions. Selection Criteria for electrodes. AC, DCRP, DCSP configurations, Electrode shapes, polarity and its effects. Submerge arc welding, Electro -slag welding Processes.	6	10 %
6	**Fusion welding: GTAW, GMAW, FCAW Processes** GTAW Welding Equipment, Non Consumable electrode, Inert Gases Process Parameters. Plasma Welding, type of guns. GMAW-Welding Equipment, Shielding gases, Process Parameters & different metals welded. FCAW-Welding equipment, Flux cored electrode wire & its functions.	5	08 %
7	**Introduction to Modern Welding Processes** Electron beam welding. Laser beam welding. Submerged arc welding, Explosive Welding, Atomic Hydrogen Welding. Thermit Welding, Ultrasonic welding, Under water welding, Industrial applications of Modern Welding Processes, Friction stir techniques for material processing as; Friction Stir Welding, Friction stir processing, Friction stir Surfacing, Friction stir channeling etc. Use of Friction stir processing **t**o increase Fatigue Resistance of Fusion Welds.	6	10 %
8	**Resistance welding**: Contact resistance, spot, seam projection, resistance butt, flash butt etc. Basic operational steps of Soldering & Brazing, different Soldering and Brazing Alloys, Role of Flux, Types of Flux, Metallurgical aspects of soldering and brazing. Applications of soldering and brazing in Engineering. Adhesive joining.	4	08 %
9	**Weldability & Testing of Welded joints.** Weldability of Carbon steels, Stainless steels, Cast Iron, Aluminum & Titanium. Welding of dissimilar metals, repair welds, Welding defects, weld cracking Phenomena and its prevention. Review of Inspection and Mechanical testing of welded joints, Weld Solidification Cracking Susceptibility Test Methods.	8	13 %
10	**A.S.M.E. Sec IX For Welding** Interpret ASME Sec-IX codes applicable for welding. Understanding of WPS, PQR, WPQ Format. Cost calculations in welding. Welding procedure, qualification of operators, testing and inspection during and after welding. Welding defects	5	08 %

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
15	**20**	**30**	**10**	**20**	**05**

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. The Metallurgy of Welding, Brazing and Soldering – J.F. Lancaster, George Alien and Unwin Ltd., London.

2. S V Nadkarni, Modern Arc Welding Technology, Ador Welding Limited, 2010, New Delhi.
3. Welding handbook, American Welding Society, 1987, 8th edition, volume 1 & 2, USA
4. Manufacturing Technology (Foundry, Forming and Welding)-P.N.Rao, Tata Mc-Graw Hill.
5. The Physics of Welding- L.F.Lancaster, Pergamon Press.
6. Principles of Welding- R.S. Parmar.
7. Welding Technology- O.P. Khanna, Khanna Pub.,
8. Friction Stir Welding and Processing, Editors Rajiv S. Mishra & Murray W. Mahoney, ASM International, 2007

Course Outcome:

After learning the course the students should be able to:

1. Acquire knowledge of various welding processes.
2. Select the appropriate metal joining process.
3. Decide the process parameters suitable for the material & processes.
4. Interpret weld plan as per WPS / PQR.
5. Apply knowledge of Friction stir techniques for material joining and processing
6. Evaluate the welding defects & suggest their remedies.
7. Decide the thermal treatments necessary for the weldments.
8. Apply knowledge of various Mechanical testing of welded joints.
9. Apply knowledge of various NDT testing of welded joints.

List of Experiments:

1. Identify and understand various parts of welding machines and various safety aspect of it.
2. Understand Various Parts of arc Welding Machine
3. To understand various parts of gas welding and performing gas welding process and its application
4. Understand and perform Spot welding Machine and process with its application.
5. To study modern welding process-EBW, LBW & SAW.
6. To study and perform Friction stir techniques for material joining and processing
7. Perform soldering operation with applications.
8. Identify and understand various welding defects.
9. Perform various DT and NDT for weld joints like Tensile testing, Ultrasonic testing, and visual inspection.

Design based Problems (DP)/Open Ended Problem:

1. Chart of different welding codes, joint design & symbols of welds.
2. Chart based Electrode Configurations & mode of metal transfer.
3. Chart explaining the full specifications of welding power sources.
4. Chart of microstructures of different regions –FZ, HAZ & PMZ of welded joint.
5. Chart of CCT Diagram of weld.
6. Chart of Welding defects & suggested remedies.
7. Chart of Friction stir techniques for material joining and processing
8. Chart of selection samples from different weld designs for Mechanical testing purpose.
9. Preparation of different welded joints using varying Heat Input, shielding gas composition filler metal composition & evaluate relative changes in Microstructure & Property.
10. Group discussion and Presentations on advancement in welding technology.
11. Any other problem decided by faculty based on syllabus.

Major Equipment:

1. Electric Arc welding machine MMAW, SMAW and safety gadgets.
2. TIG welding machine.
3. MIG/MAG welding machine.
4. SAW welding machine
5. Vertical milling machine for Friction stir material joining and processing techniques

List of Open Source Software/learning website:

1. www.gowelding.com
2. http://www.iws.org.in/
3. ii. http://www.asme.org
4. iii. http://www.aws.org
5. iv. http://www.ewf.be
6. v. http://www.astm.org

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.