



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Metallurgy

Subject Code : BE05021081

Subject Name: Friction Based Metal Processing

w. e. f. Academic Year:	2024-25
Semester:	5
Category of the Course:	Professional Elective Course

Prerequisite:	Nil
Rationale:	In conventional metallurgy, we often fight the "physics of the melt"—porosity, oxidation, and brittle intermetallics. But if, we operate in the Solid State; we are not just joining metals; we are "stirring" them at a molecular level to create microstructures that were once thought impossible. The most transformative domains of modern manufacturing: Friction-based Metal Processing harnessing the power of frictional heat and severe plastic deformation to join and process materials in the solid state - retaining properties that melting would otherwise destroy. This specialized course is a gateway to the high-tech aerospace, automotive, and renewable energy sectors thriving right here in Gujarat and globally. Gujarat is a hub for manufacturing. This course is tailor-made for the GTU BE Metallurgy Engineering framework, focusing on the physics, the metallurgy, and the industrial application of Friction based "green" technologies to take this knowledge and innovate in our local industries.

Course Outcome:

After Completion of the Course, Student should be able to:

Sr. No.	CO statement	Marks % weightage
CO-1	Understand the friction based processing/welding for different engineering applications.	60
CO-2	Analyze the properties of friction stir processed materials.	20
CO-3	Select tool design and process parameters for friction based processing/welding.	20

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
L	T	P	PBL*	Total no of hours per semester		Theory		Tutorial / Practical			
						ESE (E)	PA / CA (M)	PA/ CA (I)	PBL* (I)	ESE (V)	
45	0	30	15	90	03	70	30	20	30	50	200



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Metallurgy

Subject Code : BE05021081

Subject Name: Friction Based Metal Processing

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = End Semester Examination, PA = Progressive Assessment

* Problem Based Learning (PBL) aims to accommodate learning beyond syllabus as per clause 9.4 of NBA manual.

Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1	The Physics of the Solid State Introduction to Solid-State Processing: Limitations of fusion-based processes (porosity, shrinkage, segregation). Powder Metallurgy Route, The history and advent of the Friction Stir family, advantages over fusion processes and the Green manufacturing aspect. Heat generation at the tool-workpiece interface. Plastic flow of materials. The Tool-Workpiece Interaction: sticking and sliding conditions. Material suitability: Aluminum/ Magnesium vs. Steel/Titanium. Thermal Cycle.	7	16
2	Friction Stir Tooling and Machine Tool Material Characteristics. Tool Material. Tool Shoulders Design. Pin Designs. Complex Motion Tools. Tool Dimensions. Pinless tool. Thermal Management. Tool wear and life. Machine and Fixtures.	8	18
3	Friction Stir Welding The FSW Process: process parameters. Macro- and Micro-structural Evolution: The four distinct zones - Base Metal, Heat Affected Zone, Thermo-Mechanically Affected Zone, and the Nugget zone. Dynamic Recrystallization (DRX) and grain refinement. Joint Design: Butt, lap, T-joints. Challenges in dissimilar material joining. Defects. Friction Stir Welding Variants. Application of FSW and case Studies.	12	27
4	Friction Stir Processing Fundamentals of FSP: Use of stir tool to modify surface microstructures and properties without joining. Friction Stirring Imperfections. Defect Healing: FSP of castings and weld Joints. Microstructural Refinement. Fabrication of Surface Composites: different reinforcements and reinforcing methods, Hybrid surface composites. FSP for super plasticity. Review of current developments. Application of FSP and case Studies. Characterization of processed layers: hardness mapping and wear resistance testing.	12	27



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Metallurgy

Subject Code : BE05021081

Subject Name: Friction Based Metal Processing

5	Friction Surfacing Technologies Friction Surfacing: Coating mechanisms and bond strength for corrosion and wear resistance, Consumable rod. Friction Stir Channeling. Friction Stir Additive Manufacturing: The future of solid-state 3D printing of metals.	6	12
Total		45	100

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
20	40	35	05	0	0

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

The syllabus of Friction Based Metal Processing directly contributes to:

SDG 4	Quality Education
SDG 7	Affordable and Clean Energy
SDG 9	Industry, Innovation and Infrastructure

Reference Books:

1. Friction Stir Welding and Processing, edited by Rajiv S. Mishra, Murray W. Mahoney, 2007, ASM International.
2. Friction Stir Welding and Processing IV, Edited By Rajiv S. Mishra, Murray W. Mahoney, Thomas J. Lienert, Kumar V. Jata, Wiley, May 2007, ISBN: 978-0-87339-661-5.
3. Advances in Friction-Stir Welding and Processing, Mohammad-Kazem Besharati- Givi & Parviz Asadi, Woodhead Publishing, Oct 2014, Print Book ISBN :9780857094544, eBook ISBN :9780857094551.
4. Friction stir welding from basics to applications; Edited by Daniela Lohwasser and Zhan Chen; CRC Press Boca Raton Boston New York Washington, DC; Woodhead Publishing Limited.
5. Friction Stir Processing for Enhanced Low Temperature Formability, Christopher B. Smith, Rajiv S. Mishra, Butterworth-Heinemann, Elsevier, USA, First edition 2014, ISBN: 978-0-12-420113-2.

List of Experiments:

1. Demonstration of FSW/P tools.
2. To understand the temperature profile during the Friction stir welding / processing.
3. To perform Friction stir welding of given Sample.
4. To observe microstructure modification by Friction stir processing of given sample.



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Metallurgy

Subject Code : BE05021081

Subject Name: Friction Based Metal Processing

5. To identify the different zones in FSW/P samples.
6. To fabricate Surface Metal Matrix Composites using hole method.
7. To fabricate Surface Metal Matrix Composites using groove method.
8. To develop a Micro-Hardness Profile across the Weld / Stir Zone.
9. To observe the effect of FSP on wear rate.
10. To observe internal volumetric defects on FSW samples.
11. Deposit a layer onto a Mild Steel substrate by Friction Stir Surfacing.
12. Report on lab visit/industrial visit/expert talk/online videos.

Major Equipment:

Vertical Milling Machine, Digital Thermometer with thermocouples, Optical Microscope, Micro-hardness tester, Wear Testing Machine, etc.

List of Open Source Software/learning website:

- <https://swayam.gov.in/>

List of suggested activities for Problem-based Learning (PBL):

Sr. No.	PBL Category	Name of the activity	No. of hours	Evaluation Criteria
1	Industry / Research Laboratory Visit	Industry / Research laboratory Visit	Visit = 5hrs, Report preparation = 5hrs Total = 10hrs	Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
2	Video Based Learning	Technical Video based learning related to the subject (MOOC/ NPTEL Video)	Duration of video = 5hrs Report preparation = 5hrs Total = 10hrs	Report /presentation based on the video learning outcomes.
		Self-learning on-line course	Minimum duration of the course should be 10hrs.	Examination based assessment at the end of course. Based on the certificate produced.
		Annotated Video Explanation of Concept/Problem	10hrs (Preparation + Recording + Submission)	Based on accuracy of explanation, clarity, and presentation style.
3	Assignment/ Technical Writing /	Assignment writing. Numerical based	5 assignments of 2hrs each. Total = 10hrs	Based on the assignment submitted.



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Metallurgy

Subject Code : BE05021081

Subject Name: Friction Based Metal Processing

	Research Writing	assignment is preferable.		
		Blog or Technical Article Writing	10hrs (Research – 6hrs, Writing – 4hrs)	Based on originality, technical content, references cited, and clarity of communication.
4	Complex Problem-Solving targeting relevant SDGs. / Mini Project	Complex problem solving	Maximum 2 problem. Study of the problem and solution finding, Total = 15 hrs	Based on the depth of the solution submitted.
5	Research Paper Review / Analysis	Discussion on research paper based on relevant subject (Indexed Journal)	5 research paper = 20 hrs	Summarize research paper and evaluate critical parameters
6	Poster/ Chart/ Power point presentation	Poster/chart/power point preparation on technical topics	Duration = 6 hrs	Based on poster/chart preparation and presentation skills
7	Micro Project	Working/non-working model on technical topics	Working = 10 hrs Non-working = 10 hrs	Based on inter department/external evaluation
8	Group Discussion / Quiz / Simulation	Group Discussion on emerging/trending technical topics based on subject	Duration = 1 hrs each	Based on performance in group discussion, technical depth, knowledge etc.
		Online Technical Quizzes/ MCQ test/ Simulations	Multiple quizzes summing up to 10hrs	Based on quiz score and reflection summary.
9	Case Study Analysis / Seminar	Real world case studies-based learning	Duration of data collection/study = 5hrs Report preparation = 5hrs Total = 10hrs	Based on in-depth study, technical depth, data collected, fact finding, etc.
10	Other	Patent Search and Innovation Gap Identification	10hrs (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.

Note:



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering

Level: UG

Branch: Metallurgy

Subject Code : BE05021081

Subject Name: Friction Based Metal Processing

1. In alignment with Outcome-Based Education (OBE) and NBA accreditation requirements, the subject Friction Based Metal Processing incorporates;

- Mini Project – 10 Marks
- Micro Project and – 5 Marks
- Seminar activities – 10 Marks

These activities are incorporated as integral Project-Based Learning (PBL) components. These activities are designed to foster experiential learning, encourage innovation, and strengthen problem-solving skills by engaging students in practical applications of power converter design, simulation, and analysis. The inclusion of PBL ensures that learners develop higher-order cognitive abilities mapped to Bloom's taxonomy, while simultaneously enhancing teamwork, communication, and research competencies essential for professional engineering practice.

2. The hours allocated to specific activities should be proportionate to the total no. of PBL hours and marks.

* * * * *