

## GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

### Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)

Semester - VIII

Course Title: Advance Welding Engineering

(Course Code : 4385508)

Diploma programmer in which this course is offered	Semester in which offered
Fabrication Technology	Eight

#### 1. RATIONALE

Welding is a fundamental process in manufacturing, construction, and various industries, serving as the backbone for joining metals and materials. As technology progresses and industries evolve, the demand for advanced welding techniques and expertise continues to grow. Due to the development in material science, energy and chemical engineering area, specialize advance welding processes are used. Advanced Welding Engineering programs can address these emerging technologies and equips student with the skills and knowledge needed to leverage them effectively. Industries such as automotive, aerospace, energy, chemical and construction rely heavily on welding for fabrication and assembly. Employers increasingly seek professionals with expertise in advanced welding techniques to remain competitive in the global marketplace. Offering a specialized program in Advanced Welding Engineering can help meet this demand for skilled professionals.

#### 2. COMPETENCY

The course content should be taught and with the aim to develop different types of skills so that students are able to acquire following competency:

- Describe the advance welding processes like hot wire TIG, Activated TIG, Narrow gap welding, SASC, ESSC, explosive welding, EBW, LBW and different weldability test.

#### 2. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

- i. Describe the advance welding process principle like pulse GTAW, hot wire tig, A-TIG , ESSC, SASC.
- ii. Describe the principle, working, advantage, disadvantage of solid state welding processes.
- iii. Describe the welding process like Thermit, atomic, under water, narrow gap welding process
- iv. Describe the radiant energy welding process.
- v. Describe the weldability test used for checking of weldability.

#### 4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	CA	ESE	CA	ESE	
4	0	2	5	30*	70	25	25	150

(\*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

**Legends:** L-Lecture; T- Tutorial/Teacher Guided Theory Practice; P -Practical; C – Credit, CA - Continuous Assessment; ESE -End Semester Examination.

## 5. SUGGESTED PRACTICAL EXERCISES

The following practical outcomes (PrOs) are the sub-components of the COs. *These PrOs need to be attained to achieve COs.*

Sr. No.	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. Required
1	Prepare a chart of classification of welding process and prepare a table on their basic requirements i.e., heat source, atmospheric protection, metallurgy, cleaning procedure etc.	1,2,3,4,5	2
2	Study the ESSC and SASC process.	2	2
3	Study ultrasonic welding process.	2	2
4	Study Explosive welding process.	2	2
5	Study friction welding process.	3	2
6	Study narrow gap welding process.	3	2
7	Study Thermit welding process.	3	2
8	Study Under water welding process.	4	2
9	Study electron beam welding process.	4	2
10	Study laser beam welding process.	4	2
11	Study hot cracking tests and cold cracking tests.	5	2
12	Perform any one weldability test of given metallic material.	5	2
13	Perform tensile test of given welded job.	5	2
14	Perform side bend test or root bend test or impact test for given job.	5	2
<b>TOTAL HOURS</b>			<b>28</b>

**Note :** More **Practical Exercises** can be designed and offered by the respective course teacher to develop the industry relevant skills/outcomes to match the COs. The above table is only a suggestive list.

Boiler suit, safety shoes & other safety items are compulsory while attending laboratory and has to be brought by students. (Annexure-1)

The following are some sample 'Process' and 'Product' related skills (more may be added/deleted depending on the course) that occur in the above listed Practical Exercises of this course required which are embedded in the COs and ultimately the competency.

Sr. No.	Sample Performance Indicators for the PrOs	Weightage in %
<b>For PrOs no. : 1 to 14</b>		
1	Knowledge of experiment	30
2	Quality of report	30
3	Participation	20

4	Punctuality	10
5	Originality	10
<b>Total</b>		<b>100</b>

## 6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

This major equipment with broad specifications for the PrOs are a guide to procure them by the administrators to use in uniformity of practical's in all institutions across the state.

Sr. No.	Equipment Name with Broad Specifications	PrO. No.
1.	Ultrasonic welding machine with all accessories.	2
2.	Friction welding machine with all accessories.	3
3.	Friction stir welding machine with all accessories.	3
4.	ESSC welding machine with all accessories.	1
5.	SASC welding machine with all accessories.	1
6.	Nozzle for narrow gap welding	3

## 7. AFFECTIVE DOMAIN OUTCOMES

The following *sample* Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs and PrOs. More could be added to fulfill the development of this course competency.

- a) Follow safety practices in laboratory.
- b) Practice good housekeeping.
- c) Work as a leader/a team member.
- d) Maintain tools/equipment
- e) Follow ethical practices

The ADOs are best developed through the laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- i. 'Valuing Level' in 1<sup>st</sup> year
- ii. 'Organization Level' in 2<sup>nd</sup> year.
- iii. 'Characterization Level' in 3<sup>rd</sup> year & 4<sup>th</sup> year.

## 8. UNDERPINNING THEORY

The major underpinning theory is given below based on the higher level UOs of *Revised Bloom's taxonomy* that are formulated for *development* of the COs and competency. If required, more such UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
<b>Unit – I</b> <b>Advance welding processes</b>	1a. Describe the pulsed GTAW process 1b. Describe the Activated	1.1 Pulsed GTAW 1.2 High Frequency pulsed GTAW 1.3 Square wave AC GTAW 1.4 Active TIG welding 1.5 Hot wire TIG welding

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
	<p>TIG</p> <p>1c. Describe the ESSC and SASC</p> <p>1d. Describe the advance in GMAW – pulse GMAW process</p> <p>1e. Describe the safety in arc welding process</p>	<p>1.6 Electro Slag Strip Cladding (ESSC)</p> <p>1.7 Submerged Arc Strip Cladding (SASC)</p> <p>1.8 Advances in gas metal arc welding - Pulsed GMAW</p> <p>1.9 Advances in gas metal arc welding - Controlled dip short circuiting processes</p> <p>1.10 Safety in arc welding processes</p>
<p><b>Unit – II</b></p> <p><b>Solid state welding processes</b></p>	<p>2a. Describe the cold pressure welding process</p> <p>2b. Describe the diffusion welding process</p> <p>2c. Describe the ultrasonic welding process</p> <p>2d. Describe the explosive welding process</p> <p>2e. Describe the friction welding process</p> <p>2f. Describe safety in solid state welding processes</p>	<p>2.1 Cold pressure welding</p> <p>2.1.1 Definition</p> <p>2.1.2 Mechanism</p> <p>2.1.3 Material welded</p> <p>2.1.4 Base metal surface cleaning</p> <p>2.1.5 Joint design</p> <p>2.1.6 Equipment</p> <p>2.1.7 Application</p> <p>2.2 Diffusion (bonding) welding</p> <p>2.2.1 Definition and concept</p> <p>2.2.2 Methods</p> <p>2.2.3 Parameters</p> <p>2.2.4 Materials welded</p> <p>2.2.5 Advantages</p> <p>2.2.6 Limitation</p> <p>2.2.7 Application</p> <p>2.3 Ultrasonic welding</p> <p>2.3.1 Definition and concept</p> <p>2.3.2 Principle of operation</p> <p>2.3.3 Metallurgy of ultrasonic welds</p> <p>2.3.4 Equipment</p> <p>2.3.5 Variables</p> <p>2.3.6 Types</p> <p>2.3.7 Materials welded</p> <p>2.3.8 Advantages</p> <p>2.3.9 Limitation</p> <p>2.3.10 Application</p> <p>2.4 Explosive welding</p> <p>2.4.1 Definition</p> <p>2.4.2 Mechanism</p> <p>2.4.3 Arrangement of explosive welding</p> <p>2.4.4 Explosive used</p> <p>2.4.5 Metallurgy of explosive welds</p> <p>2.4.6 Testing of explosive welds</p> <p>2.5 Friction welding</p> <p>2.5.1 Definition</p>

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
		2.5.2 Steps in friction welding 2.5.3 Variables 2.5.4 Materials welded 2.5.5 Joint preparation 2.5.6 Advantages 2.5.7 Disadvantages 2.5.8 Application  2.6 safety in solid state welding processes
<b>Unit – III Miscellaneous Advance welding processes</b>	3a. Describe the Thermit welding process 3b. Describe the safety in thermit welding process 3c. Describe the atomic hydrogen welding process 3d. Describe the underwater welding process 3e. Describe the safety in under welding process 3f. Describe the narrow gap welding process	3.1 Thermit welding 3.1.1 Definition 3.1.2 Principle operation 3.1.3 Thermit welding mixtures 3.1.4 Procedure of Thermit welding 3.1.5 Advantages, limitation & application 3.1.6 Safety in Thermit welding process 3.2 Atomic Hydrogen Welding 3.2.1 Definition 3.2.2 Principle 3.2.3 Operation 3.2.4 Equipment 3.2.5 Advantages 3.2.6 Limitation 3.2.7 Application 3.3 Under water welding 3.3.1 Types 3.3.2 Characteristics of good under water welding 3.3.3 SMAW underwater welding 3.3.4 TIG under water welding 3.3.5 MIG Under water welding 3.3.6 Application of underwater welding 3.3.7 Safety in under water welding process 3.4 Narrow Gap Welding Techniques 3.4.1 Principles and features of narrow gap welding 3.4.2 Narrow gap welding processes 3.4.2.1 Narrow gap GTAW 3.4.2.2 Narrow gap GMAW 3.4.2.3 Narrow gap SAW

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
<p><b>Unit -IV</b></p> <p><b>Radiant Energy welding processes</b></p>	<p>4a. Describe the working of Electron Beam welding process</p> <p>4b. Describe the working of Laser Beam welding process</p> <p>4c. Describe the safety in radiant welding processes</p>	<p>4.1 Electron Beam Welding</p> <p>4.1.1 Introduction</p> <p>4.1.2 Definition</p> <p>4.1.3 Principle of operation</p> <p>4.1.4 Welding atmosphere</p> <p>4.1.5 Comparison of vacuum and atmospheric welding systems</p> <p>4.1.6 Equipment</p> <p>4.1.7 Variables</p> <p>4.1.8 Safety</p> <p>4.1.9 Advantages</p> <p>4.1.10 Limitation</p> <p>4.1.11 Application</p> <p>4.2 Laser Beam Welding</p> <p>4.2.1 Definition</p> <p>4.2.2 Principle of operation</p> <p>4.2.3 Forms of laser</p> <p>4.2.4 Joint design</p> <p>4.2.5 Advantages</p> <p>4.2.6 Limitation</p> <p>4.2.7 Application</p> <p>4.3 Safety in radiant welding processes</p>
<p><b>Unit -V</b></p> <p><b>Weldability testing</b></p>	<p>5a. Describe the different weldability test used to check weldability</p> <p>5b. Prepare the test procedure for weldability test</p> <p>5c. Describe the hot cracking test</p> <p>5d. Describe the cold cracking test</p> <p>5e. Describe the service weldability test</p>	<p>5.1 Weldability test</p> <p>5.1.1 Theoretical test</p> <p>5.1.2 Simulated test</p> <p>5.1.3 Visual examination</p> <p>5.1.4 Component sampling test</p> <p>5.1.5 Actual welding test</p> <p>5.2 Fabrication weldability test</p> <p>5.2.1 Hot cracking test</p> <p>5.2.1.5 Murex test</p> <p>5.2.1.6 Houldcroft test</p> <p>5.2.1.7 Vareststraint test</p> <p>5.2.1.8 Ring weldability test</p> <p>5.2.1.9 Hot ductility test</p> <p>5.2.2 Cold cracking test</p> <p>5.2.2.1 Controlled thermal severity test</p> <p>5.2.2.2 Tekken test</p> <p>5.2.2.3 Lehigh restraint test</p> <p>5.2.2.4 Longitudinal bead weld test</p> <p>5.2.2.5 Implant test</p> <p>5.3 Weldability test related to specific types of cracking</p> <p>5.3.1 Lamellar tearing</p> <p>5.3.2 Reheat cracking</p>

Unit	Unit Outcomes (UOs)	Topics and Sub-topics
		5.4 Service weldability test 5.4.1 Tensile test 5.4.2 Nick break test 5.4.3 Pillow test 5.4.4 Bend test 5.4.5 Impact test 5.4.6 Hardness test 5.4.7 Fracture toughness test 5.4.8 Fatigue test 5.4.9 Corrosion test 5.4.10 Creep test

## 9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Advance welding processes	10	3	11	0	14
II	Solid state welding processes	14	3	15	0	18
III	Miscellaneous Advance welding processes	10	3	11	0	14
IV	Radiant Energy welding processes	8	3	7	0	10
V	Weldability testing	14	4	10	0	14
	<b>TOTAL</b>	<b>56</b>	<b>16</b>	<b>54</b>	<b>0</b>	<b>70</b>

**Legends:** R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)

**Note:** This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks and marks at different taxonomy levels (of R, U and A) in the question paper may vary slightly from above table.

## 10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory learning, following are the suggested student-related **co-curricular** activities which can be undertaken to accelerate the attainment of the various outcomes in this course: Students should perform following activities in group and prepare reports/charts for each activity. They should also collect/record physical evidences for their (student's) portfolio which may be useful for their placement interviews:

- Prepare sketchbook of drawing of various topics of syllabus
- Prepare a question bank.
- 10 min PPT presentation on the given topic from the syllabus or beyond the syllabus
- Report writing on various topics from syllabus and beyond syllabus

## 11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

- a) Massive open online courses (**MOOCs**) may be used to teach various topics/sub topics.
- b) Guide student(s) in undertaking micro-projects.
- c) **'L' in section No. 4** means different types of teaching methods that are to be employed by teachers to develop the outcomes.
- d) About **20% of the topics/sub-topics** which are relatively simpler or descriptive in nature is to be given to the students for **self-learning**, but to be assessed using different assessment methods.
- e) With respect to **section No.10**, teachers need to ensure to create opportunities and provisions for **co-curricular activities**.

## 12. SUGGESTED MICRO-PROJECTS

**Only one micro-project** is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-projects are group-based (group of 3 to 5). However, **in the fifth and eighth semesters**, the number of students in the group should **not exceed three**.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The duration of the micro project should be about **14-16 (fourteen to sixteen) student engagement hours** during the course. The students ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

- a. **Prepare a quiz on advance welding topics**
- b. **Chart making:** Prepare the charts on different topic given by faculty.
- c. **Video Preparation:** Student has to prepare his/her video on explaining different topics of subjects given by faculty.
- d. **E-learning projects:** Students have to use internet and other online resources for preparation of report and/or download video on the topic given by the subject teacher within the syllabus or beyond the syllabus.
- e. **Report preparation:** Student has to use different books, technical magazine, journals etc. for preparation of a report on the topic given by the subject teacher within the syllabus or beyond the syllabus.
- f. **Power point presentation:** Students has to prepare a power point presentation of 10 to 15 slides on the topic given by the subject teacher within the syllabus or beyond the syllabus. In the end of presentation student has to ask at least 3 to 5 MCQ based question to identify the gain of listeners at the end presentation.

### 13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Books	Author	Publication with place, year and ISBN
1	Welding process	Dr. R. S. Parmar	Khanna Publishers
2	Welding engineering and Technology	Dr. R. S. Parmar	Khanna Publishers
3	Welding technology	O. P. Khanna	Dhanpat rai publications
4	Advance Welding Processes	John Norrish	Institute of physics publishing Ltd.
5	Friction Stir Welding and processing	Rajiv S. Mishra Murray W. Mahoney	ASM International
6	Modern Arc Welding	S. V. Nadkarni	Oxford Publication
7	Welding Technology and design	V. M. Radhakrishnan	New Age International publication
8	Welding Technology for engineers	Baldev Raj V Shekhar A K Bhaduri	

### 14. SOFTWARE/LEARNING WEBSITES

- <https://nptel.ac.in/>
- <https://www.twi-global.com/technical-knowledge/faqs/faq-how-can-i-assess-the-weldability-of-a-material>
- <https://www.imtmaelearn.in/>
- <https://www.wileymetal.com/6-advanced-welding-processes-and-their-applications-explained/>
- <https://www.millerwelds.com/technologies/advanced-welding-processes>
- <https://www.thefabricator.com/thefabricator/article/arcwelding/weld-process-advancements>

### 15. PO-COMPETENCY-CO MAPPING

Semester VIII	Advance Welding Engineering (Course Code:4385509)						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 3 Design/development of solutions	PO 4 Engineering Tools, Experimentation & Testing	PO 5 Engineering practices for society, sustainability & environment	PO 6 Project Management	PO 7 Life-long learning
<b>Competency</b>	<ul style="list-style-type: none"> <li>• Describe the advance welding processes like hot wire TIG, Activated TIG, Narrow gap welding, SASC, ESSC, explosive welding, EBW, LBW and different weldability test.</li> </ul>						
<b>CO1) Describe the advance welding process principle like pulse GTAW, hot wire tig, a tig, ESSC, SASC.</b>	3	-	-	-	1	-	1

<b>CO2)</b> Describe the principle, working, advantage, disadvantage of solid state welding processes.	3	-	-	-	1	-	1
<b>CO3)</b> Describe the welding process like Thermit, atomic, under water, narrow gap welding process	3	-	-	-	1	-	1
<b>CO4)</b> Describe the radiant energy welding process.	3	-	-	-	1	-	1
<b>CO5)</b> Describe the weldability test used for checking of weldability.	3	-	-	2	-	-	2

Legend: '3' for high, '2' for medium, '1' for low and '-' for no correlation of each CO with PO.

## 16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

### GTU Resource Persons

S. No.	Name and Designation	Institute	Contact No.	Email
1.	Mr. Ashoksinh M. Gohil <i>Lecturer in Fabrication Technology Department</i>	Sir Bhavsinhji Polytechnic Institute Bhavnagar	9924682010	<a href="mailto:amgohilges@gmail.com">amgohilges@gmail.com</a>
2.	Mr. Nilesh M. Bhangale <i>Lecturer in Fabrication Technology Department</i>	Sir Bhavsinhji Polytechnic Institute Bhavnagar	9016926792	<a href="mailto:nileshbhangalefabtechbpi@gmail.com">nileshbhangalefabtechbpi@gmail.com</a>
3.	Mr. Kapilkumar B. Pipavat <i>Lecturer in Fabrication Technology Department</i>	Sir Bhavsinhji Polytechnic Institute Bhavnagar	9427343525	<a href="mailto:kbpipavat.bpti@gmail.com">kbpipavat.bpti@gmail.com</a>

**ANNEXURE-1**

❖ **SAMPLE SAFETY CONTRACT:**

(To be filled by the students and submitted to concerned faculty/staff)

-- Use for reference purposes only --

1. You have to read and sign the safety contract.
2. The safety contract says that you understand that safety is your responsibility.
3. The safety contract to be signed before you carries out any work in the laboratory and if you don't observe and obey the safety rules, you will not be allowed in the laboratory.

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**Safety Contract**

Date: \_\_\_\_\_

Name of Institute: \_\_\_\_\_

Name of Course with Code: Advance Welding Engineering (4385509)

Name of Faculty/Staff with Designation: 1. \_\_\_\_\_

2. \_\_\_\_\_

3. \_\_\_\_\_

**I RECOGNIZE THAT:**

1. Safety is my responsibility while using any tool or equipment.
2. Safety regulations have been provided to me.
3. The possibility of accident and injury increases if I do not follow all the safety guidelines.
4. I must act responsibly to ensure my own safety & the safety of others in the work area.

**I AGREE TO:**

1. Never work in the shop without my faculty's/instructor's supervision.
2. Read and practice all the safety regulations that have been distributed to me in this course or have been posted in the work areas.
3. Act in a responsible manner at all times in the laboratory.
4. Follow all instructions given by the faculty.
5. Immediately report any unsafe condition or activity to my faculty.
6. Wear eye protection at all times when working with tools or working anywhere near someone who is using tools.
7. Cut or Tie back long hair, remove jewellery, secure loosed clothing, and wear boiler suit & safety shoes in the laboratory.
8. Clean all work areas and put equipment away before leaving the laboratory.

I, \_\_\_\_\_, have read and agree with all the safety instructions.

**Particulars:**

Programme: \_\_\_\_\_

Student Signature

Batch No.: \_\_\_\_\_

\_\_\_\_\_

Enrollment No.: \_\_\_\_\_