CIF: Industrial Welding, ME-4122 (Programme Elective, PE)

Department of Mechanical - Mechatronics Engineering

Course Coordinator: Prof Sunil Pandey

Summary

<table>
<tr><td colspan="2">Programme
B. Tech. (ME)</td><td colspan="2">Course Title:
Industrial Welding</td><td colspan="2">Course Code
ME-4122</td></tr>
<tr><td colspan="1">Course type

Program Elective (PE)</td><td colspan="4">Prerequisites
ME-103, Engineering Physical Metallurgy
ME-211, Welding and Casting Technology</td><td>Total Hours:
42(L) + 28(P)
= 70</td></tr>
<tr><td>Eligibility: 3rd / 4th Year
V, VI, VII, VIII Semester</td><td>Lecture (L)
Hrs./Week = 3</td><td colspan="2">Tutorial
Hrs./Week = 0</td><td>Practical (P)
Hrs./Week = 2</td><td>Credits:
3(L)+1(P)=4</td></tr>
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Total credits: 3 (L) + 0 (T) + 1 (P) = 4

Learning Objective

Welding is the most economical and efficient way for permanently joining most of the industrial materials. It is the most efficient way of joining similar or dissimilar materials to make them act as a single piece. Nearly everything used in our daily life is welded or made by equipment that is welded. Welding is vital to our economy. It is often said that over 50% of the gross national product of the industrially advanced nations is related to welding in one-way or another. Welding ranks high among industrial processes and involves more sciences and variables than those involved in any other industrial process.

Welding Engineers employ their extensive knowledge of physics, engineering, metallurgy, materials, welding, and standards to design, examine, and evaluate welds as well as to plan, supervise, and document welding operations in accordance with relevant codes, contracts or drawings. The role of the Welding Engineer is critical to the integrity of the vast number of buildings, vehicles, machinery and products that require welds.

The objective of this course is to introduce the Industrial Applications of welding in such a manner that they find themselves competent to handle all kinds of challenges and bottlenecks be it in underwater welding / welding in space, welding in nuclear power plants, welding of rails for high-speed trains, being faced by our fabrication industry in welding a safe welded structure.

A welding engineer, play a crucial role in the design, development, and implementation of welding processes and systems. The expertise ensures the safety, reliability, and efficiency of various industrial applications. The demand for welding engineers remains high across various sectors: Construction, Nuclear power plants, Oil and Gas, Manufacturing (including automotive and aerospace), Shipbuilding, Renewable Energy, Welding of rails for high-speed trains, Infrastructure Projects, Cross Country Pipelines, Automation in our country and globally.

Importance of Laboratory Content

Welding practicals play a crucial role in an undergraduate mechanical engineering program. Brief description is given below:

- *Application of Theory:* Welding practicals allow students to apply theoretical knowledge gained in lectures. They learn about different welding processes, materials, and safety precautions.
- *Hands-On Experience:* Students get hands-on experience with welding equipment, tools, and techniques. This practical exposure enhances their understanding of the subject.
- *Career Relevance:* Welding is widely used in various industries such as aerospace, automobile, shipbuilding, and railways. Understanding welding processes prepares students for real-world engineering challenges.

- *Structural Integrity:* Proper welding ensures the structural integrity of components. Students learn about joint design, material compatibility, and quality control.

In summary, welding practicals provide students with practical skills, industry relevance, and a deeper understanding of materials and processes. They contribute significantly to a well-rounded mechanical engineering education.

Philosophy of Course / Topic Coverage in the Classroom

1. Introduce topic / title of the lecture.
2. Reason for teaching the particular topic.
3. Relevance to the Industry / Research.
4. Safety and Hazards.
5. The technology.
6. Equipment / consumables / parametric window.
7. Practical understanding of technology through physical observations / mechanical testing / metallurgical investigations / productivity etc. in the Laboratory.
8. Industrial visits.
9. Development of theoretical / empirical relationships with motivation to write a research paper.
10. Application of Digital Manufacturing / Computer Applications (includes CAPP, Expert Systems)
11. Advantages and limitations.
12. Possibility of Innovations.
13. Possibility of Start-ups.
14. Commercial aspects.

The course takes care of aspirations of the students in terms of EMPLOYABILITY, SKILL DEVELOPMENT, ENTREPRENEURSHIP, TEACHING and R&D.

Teaching Methodology

Lectures have been designed to ensure brainstorming through ‘how & why’, Bloom’s taxonomy levels (1-6), Programme outcomes (1-12) and PSOs (1-3).

Brainstorming through **‘how & why’**	Bloom’s Taxonomy (1-6)	Cos (1-6)	POs (1-12)	PSOs (1-3)

CO and Bloom’s level Correlation

COs	CO1	CO2	CO3	CO4	CO5	CO6
Bloom’s levels (BL)	BL-1	BL-2	BL-3	BL-4	BL-5	BL-6
	Remembering	Understanding	Applying,	Analysing	Evaluating	Creating

Welding: Course structure, Course outcomes (CO), Bloom's levels (BL) and Number of lectures (L).

#	Topics	CO	BL	L
1.	Introduction to importance of welding in fabrication, Problems & difficulties in welded structures, how to obtain a sound welded structures and analysis: • *Understanding:* Students should be able to explain the meaning of material properties, classify materials based on descriptive terms, and discuss the impact of alloying elements.	2	2	3
2.	Properties for selection of materials, Characteristic properties and behaviour of commonly used materials, Effect of alloying elements. • *Applying:* Students should be able to explain the meaning of material properties, classify materials based on descriptive terms, and discuss the impact of alloying elements.	3	3	3
3.	Heat flow in welds, Heating and cooling cycles in welding, Effect on HAZ, Hot cracking, Development of phases, microstructure etc. • *Analyze:* Students should apply their understanding of heat flow and welding processes to analyze the effects on heat-affected zones (HAZ), cracking, and microstructure development.	4	4	3
4.	Causes and cures for various discontinuities & defects in weldments. • *Evaluating:* Students should evaluate different types of weld defects, identify their causes, and propose solutions for prevention or repair.	5	5	4
5.	Weldability, Weldability of commonly used materials, Mechanical testing of weldments, Service and fabrication weldability tests and their importance. • *Evaluating:* Students should evaluate weldability factors, compare materials, and assess the significance of mechanical testing and weldability tests.	4	4	3
6.	Thermal stresses and distortion. • *Evaluating:* Students should understand, analyze and evaluate the concepts of thermal stresses and distortion in welded structures.	5	5	2
7.	Brittle fracture and fatigue in welded joints. • *Evaluating:* Students should comprehend the mechanisms of brittle fracture and evaluate fatigue in welded joints.	5	5	2
8.	NDE of welds. • *Applying:* Students should apply non-destructive evaluation (NDE) techniques to assess weld quality.	3	3	3
9.	Joint preparation and weld symbols. • *Applying:* Students should apply knowledge of joint preparation techniques and interpret weld symbols.	3	3	3
10.	Joining metallurgy and microstructures. • *Analyzing:* Students should understand the relationship between joining processes, metallurgy, and microstructures.	4	4	4
11.	Welding Procedures and Computer Added Process Planning. • *Analyzing:* Students should apply welding procedures and understand the role of expert systems in welding.	4	4	3
12.	Qualification of Welders and Operators. • *Understanding:* Students should apply qualification criteria for welders and operators.	2	2	2

13.	Cost analysis of welded joints. • *Evaluating:* Students should evaluate the cost implications of different welding approaches.	5	5	2
14.	Welding Codes & Standards • *Understanding:* Students should understand the purpose and significance of welding codes and standards.	2	2	1
15.	Innovative automation and computer applications in welding operations: • Creating (Synthesis): Students design automated welding systems, integrating robotics, sensors, and computer control.	6	6	4
	TOTAL			**42**

Note: Bloom's level indicates that all preceding levels are included.

Welding Laboratory Practical Content

#	Topic	Hrs.	CO
Experimental Content			
1.	1. The effect of direct and indirect welding parameters for SMAW, SAW, GMAW, GTAW and PESMAW processes on: 2. The effect of direct and indirect welding parameters on 'weld bead geometry and shape relationships [BG&SR]. 3. Effect of heat input on heat affected zone [HAZ]. 4. Loss and gain of elements due to pyro-chemical reactions and basicity index of the consumables. 5. Effect of flux composition on weld metal chemistry. 6. Effect of heat input and cooling rate on microstructure and hardness.	12	3

Analysis			
2.	1. Statistical design of experiments. 2. Cutting, metallurgical polishing and etching of specimens. 3. Recording of BG&SR, tabulation and measurement of various BG&SR parameters including the extent of heat affected zone. 4. Microstructural and microhardness investigations. 5. Developing correlations between the various responses and welding parameters. 6. Interpretation and analysis of results.	16	6
	Total Laboratory Hrs.	**28**	

Recommended books and reading material

1.	Analysis of Welded Structures	Koichi Masubuchi	Pergamon Press
2.	Materials Science and Engineering, an Introduction	William D. Callister, Jr.	John Wiley & Sons, Inc
3.	Metallography and Microstructures: Volume-9	ASM Handbook	ASM International, USA
4.	Metallurgy of Welding	J. F. Lancaster	Abington Publishing, Cambridge, England.
5.	Welding Metallurgy	Sindo Kou	Wiley Interscience A John Wiley & Sons, Inc., Publication, USA.

6.	Introduction to the Physical Metallurgy of Welding	Kenneth Easterling	Butterworths, London.
7.	The Metallurgy of Welding	D. Seferian	Chapman and Hall, London.
8.	Welding, Brazing and Soldering, Volume-6	ASM Handbook	ASM International, USA.
9.	Welding Handbook, Volume:1-5	American Welding Society (AWS)	American Welding Society (AWS).
10.	Engineering Physical Metallurgy	Y. S. Lakhtin	MIR Publishers, Moscow
11.	Introduction to Physical Metallurgy	S. H. Avner	McGraw Hill Book Company, Singapore

Additional Resources: NPTEL, MIT Video Lectures, Web resources etc.

Evaluation Method

Event	Weightage (%)	COs
Mid term	30	6
Laboratory Assessment	10	6
Laboratory Quiz	10	6
End term Examination	50	6
Total Assessment	**100**	

CO and PO Correlation Matrix (MME)

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO4	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
CO6	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3

Explanation and Justification for Correlation Matrix

The CO and PO correlation matrix indicates a perfect correlation (value of 3) between each Course Outcome (CO), each Program Outcome (PO) and Program Specific Outcomes (PSO). The justification for this corelation matrix is as under:

1. **Perfect Alignment**: A correlation value of 3 across all Course Outcome (CO), each Program Outcome (PO) and Program Specific Outcome (PSO) suggests that each course outcome is designed explicitly to fully align with and achieve every program outcome. This indicates a meticulous design where every aspect of the curriculum and course objectives directly contributes to meeting the overarching program goals.

2. **Comprehensive Coverage**: Each CO is intended to comprehensively cover the knowledge, skills, and competencies outlined in the corresponding Pos and PSOs. This ensures that students, upon completing the courses associated with these COs, will have acquired all the intended learning outcomes of the program.

3. **Assessment and Accreditation**: Such a matrix is highly favourable in educational assessment and accreditation contexts. It demonstrates that the curriculum is carefully structured to ensure that students receive a well-rounded education that meets or exceeds the standards set by accrediting bodies or educational institutions.

4. **Curriculum Integrity**: The matrix suggests a high level of integrity in curriculum design, with clear mapping between what is taught in courses (COs) and what is expected in terms of program outcomes (POs) and program specific outcome (PSOs). This helps in maintaining consistency and quality across different offerings of the program.

5. **Continuous Improvement**: While a perfect correlation may indicate strong alignment, it also invites scrutiny for continuous improvement. Even with perfect alignment on paper, there is often a need for review and update curriculum to ensure relevance and responsiveness to changes in industry, technology, and educational best practices.

In a nutshell, a correlation matrix where all values are 3 indicates an ideal scenario where the course in the program is meticulously crafted to ensure students achieve all intended program outcomes. It reflects a rigorous approach to curriculum design aimed at providing students with a comprehensive educational experience aligned with institutional and external standards.

Prepared by: Sunil Pandey
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Approved by: