



**PROE20**

**Green Material Joining and Forming**

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**COURSE OBJECTIVES:**

1. To emphasize the importance of green joining and forming methods.
2. To improve sustainability in friction and lubrication in metal forming practice.
3. To emphasize hybrid joining process in sustainable manufacturing.
4. To improve the joining and forming quality.
5. To discuss the development of materials and green lubricants for sustainable manufacturing.

**Introduction to Sustainable manufacturing processes:** Conventional Manufacturing Processes, Metal Forming Processes, Joining Processes, Sustainable Manufacturing, Sustainable Material Forming and Joining, Computer-Aided Engineering Analyses – Life cycle assessment.

**Green Joining:** Traditional Joining Methods and Sustainability, Sustainable and Green Joining Methods, Friction-Based Joining Methods, Surface-to-Surface Joining Methods, Laser Welding, Joining of Sheets and Tubes by Plastic Deformation, Computational Analyses and Relevance to Sustainable Joining, Hybrid Joining processes: Hybrid Fusion Welding Processes, Hybrid Solid-State Welding Processes, Hybrid Mechanical Joining Processes, hybrid Joining with Adhesive Bonding, Hybrid Brazing–Soldering–Welding Processes, and Mechanical Joining Processes.

**Green Forming:** Metal-Forming Process Design, Aspects of Green Forming, Energy Consumption in Hot, Warm, and Cold Forming vs. Green Forming, Number of Forming Stages vs. Green Forming, Amount of Plastic Deformation, Parasitic Energy Loss due to Friction, Minimizing Material Waste toward Green Forming, Indirect Energy Consumption in Material Forming, Continuous Improvement of Quality toward Green Forming, Green Rolling, Thermal Energy Consumption in Rolling Processes, Amount of Plastic Deformation and Roll Forces, Lubrication to Reduce Friction in Rolling, Arrangement of Rolling Mills vs. Green Rolling, Green Forging and Extrusion, Green Wire Drawing, Green Stamping, Some Recent Developments in Microforming, Tubular Hydroforming and Hydropiercing, Hot Stamping of Ultra-High-Strength Steel Parts and Smart Hot Stamping, Laser Metal Forming.

**Strategies to Improve the Forming Quality of Sheets:** Rolling Method and Conditions, Friction Stir Welding and Processing, Forming at Elevated Temperature, Incremental Sheet Forming, Hydroforming, Sandwich Sheet Formability, Tooling: Flexible Forming and Blank Holding.



**Development in Materials for Sustainable Manufacturing:** Environmental Impact Assessment, Material Selection, High-Performance Steels, Aluminum Alloys, Magnesium Alloys, Biocomposites, Eco-Materials, Fly Ash, Waste Utilization from Paper and Pulp Industry, Steel - A Sustainable Material of the Future, Green Lubricants and Lubrication.

**Sustainability, Health, and Environment** – A Case Study of Waste Management Sector.

#### REFERENCES:

1. R.Ganesh Narayanan, Jay S. Gunasekara, Sustainable material forming and joining, CRC Press, Taylor & Francis Group, ISBN 13: 978-1-138-06020-3, 2019, New York.
2. Davim J, Paulo, Green Manufacturing Processes and Systems (Materials Forming, Machining and Tribology), Springer, ISBN-13: 978-3642431951, 2014.
3. David A. Dornfeld , Green Manufacturing: Fundamentals and Applications (Green Energy and Technology), Springer, ISBN-13: 978-1441960153, 2012.

#### COURSE OUTCOMES:

1. Identify green joining and forming methods.
2. Improve sustainability in friction and lubrication in metal forming practice.
3. Explore hybrid joining process for sustainable manufacturing.
4. Explore the strategies to improve the joining and forming quality.
5. Apply materials and green lubricants for sustainable manufacturing.

#### MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

CO \ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓		✓	✓			✓	✓				✓
CO2	✓	✓	✓	✓			✓	✓	✓			✓
CO3	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
CO4	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓
CO5	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓