

## Part 1: Course Information

### Description

The purpose of this course, “Joining Aluminum and Dissimilar Materials”, is to provide the fundamental knowledge and hands on experience on joining techniques related to aluminum products needed for community college students, practicing technicians, or for the students in a 2-year Associate Degree Program. The course topics cover the main technologies of joining aluminum and other materials, as well as applications in automotive and other industries. This course is designed to meet over a period of 6 weeks, 2 meetings per week, and 2 hours per meeting.

**Prerequisites**      Entry level knowledge of mechanical properties of materials, stress and strength concepts, CAD.

### Reference Books

- The Aluminum Automotive Manual by European Aluminum Association, 2015 <http://www.european-aluminum.eu/aam/>
- Aluminum Auto-Body Joining by G. N. Bullen, SAE International, ISBN 978-0-7680-8252-4, 2015
- Various SAE and other conference paper will be provided for reference
- Siemens NX User Manuals

**Tools to be used**    Calculator and/or Excel math tool for simple calculations, Siemens NX9 or similar CAD Software

## Part 2: Course Learning Outcomes (CLOs)

The course learning outcomes are to have students:

1. Develop motivational and self-teaching techniques (in a blended learning environment) by reading lecture handouts ahead of time in preparation for class room discussions (sometimes called “*Flipped class room*”);
2. Understand the various joining techniques related to aluminum materials;
3. Develop a basic knowledge of aluminum joining, applications, and the best practices;
4. Develop an understanding of aluminum joints against such defects;
5. Develop a basic knowledge and confidence of aluminum joining applications and design guidelines in automobile industry;
6. Develop an understanding and ability to redesign a product using aluminum materials with the best choice of joining techniques;

7. Perform simple research on selection of joining techniques of real parts or real life applications using aluminum, and communicate them effectively to the class in the form of presentation;
8. Communicate effectively with aluminum designers, CAE analysts, manufacturing engineers and suppliers at work;
9. Demonstrate effective communication and teamwork skills through technical presentations and reports in course projects.

## Part 3: Course Topics and Roadmap

### Topics covered

#### 1. Introduction to Joining

#### 2. Overview of Aluminum welding

2.1. Characteristics of aluminum in fusion welding

2.2. Arc welding

2.3. Beam welding

2.4. Electric resistance welding

2.5. Brazing

2.6. Solid state welding

#### 3. Mechanical joining

3.1. *Introduction*

3.2. *Mechanical joining without additional fastener*

3.2.1. Hemming

3.2.2. Clinching

3.2.3. Mechanical interlocking

3.3. *Mechanical joining with an additional fastener*

3.3.1. Screws and bolts

3.3.2. Riveting

#### 4. Adhesive bonding

4.1. *Introduction*

4.1.1. Adhesive joints

4.1.2. Benefits of adhesive bonding

4.1.3. Adhesive bonding in the automotive industry

4.2. *Design aspects*

4.2.1. Design for adhesive bonding

4.2.2. Types of Adhesive Bonds

- 4.2.3. Design for adhesive bonding
- 4.2.4. Structural analysis and modelling
- 4.3. *Adhesive selection*
  - 4.3.1. Selection criteria
  - 4.3.2. Type of adhesives
- 4.4. *Adhesive application*
  - 4.4.1. Application techniques
  - 4.4.2. Adhesive curing
- 4.5. *Surface pre-treatment for adhesive bonding*
  - 4.5.1. Aims of a surface pre-treatment
  - 4.5.2. Surface pre-treatment of aluminum alloys
- 4.6. *Properties of adhesively bonded aluminum alloys*
  - 4.6.1. Mechanical and thermal properties of adhesives
  - 4.6.2. Performance of adhesively bonded joints
  - 4.6.3. Long-term durability
- 5. Hybrid joining techniques**
  - 5.1. *Introduction*
  - 5.2. *Combination of adhesive bonding with mechanical joining*
    - 5.2.1. Hem flange bonding
    - 5.2.2. Adhesive bonding in conjunction with mechanical point joints
    - 5.2.3. 10.1.3 Adhesive injection fasteners
  - 5.3. *Combination of adhesive bonding with fusion welding*
    - 5.3.1. Adhesive bonding combined with resistance spot welding
    - 5.3.2. Adhesive bonding combined with other fusion welding processes
  - 5.4. *Combinations of fusion welding techniques*
    - 5.4.1. Laser – arc welding processes
    - 5.4.2. MIG plasma welding
  - 5.5. *Friction self-piercing riveting – a combination of two mechanical joining techniques*
- 6. Joining dissimilar materials**
  - 6.1. *Introduction*
  - 6.2. *General issues and limitations*
    - 6.2.1. Metallurgical limitations
    - 6.2.2. Galvanic corrosion

- 6.2.3. Thermal expansion
- 6.3. *Joining aluminum to other metals*
  - 6.3.1. Fusion arc welding processes
  - 6.3.2. Other fusion welding processes (beam welding, resistance welding)
  - 6.3.3. Solid-state joining processes
  - 6.3.4. Brazing and soldering
  - 6.3.5. Mechanical joining processes
  - 6.3.6. Adhesive bonding
  - 6.3.7. Joining aluminum to magnesium
- 6.4. *Joining aluminum to plastics and composites*
  - 6.4.1. Joining aluminum to plastics
  - 6.4.2. Joining aluminum to composites

## Roadmap

The following roadmap is recommended for instructors:

Week	<ul style="list-style-type: none"> <li>• Lecture Topics</li> <li>• CLOs</li> </ul>	Main Concepts, Terms, and Applications	<ul style="list-style-type: none"> <li>• Course Materials,</li> <li>• Quizzes &amp; Projects</li> </ul>
1	<ul style="list-style-type: none"> <li>• Introduction to Joining</li> <li>• 1, 2, 3</li> </ul>	<ul style="list-style-type: none"> <li>• Main joining techniques and their different characteristics</li> <li>• Mechanical fastening systems</li> <li>• Advantages and disadvantages of the discussed joining techniques</li> <li>• Design of a joining area especially for the particular joining technique</li> <li>• Hybrid joining methods</li> <li>• Suitability of different joining methods for different demands</li> </ul>	<ul style="list-style-type: none"> <li>• Handout #1</li> <li>• Quiz 1</li> <li>• Project</li> </ul>
2	<ul style="list-style-type: none"> <li>• Overview of aluminum welding</li> <li>• 4, 5</li> </ul>	<ul style="list-style-type: none"> <li>• Arc welding</li> <li>• Beam welding</li> <li>• Electric resistance welding</li> <li>• Brazing</li> <li>• Solid state welding</li> </ul>	<ul style="list-style-type: none"> <li>• Handout #2</li> <li>• Quiz 2</li> <li>• Project</li> </ul>

3	<ul style="list-style-type: none"> <li>• <b>Mechanical Joining</b></li> <li>• 4, 5, 6</li> </ul>	<ul style="list-style-type: none"> <li>• Mechanical joining without additional fastener</li> <li>• Mechanical joining with an additional fastener</li> <li>• Special Mechanical Joints</li> </ul>	<ul style="list-style-type: none"> <li>• Handout #3</li> <li>• Quiz 3</li> <li>• Project</li> </ul>
4	<ul style="list-style-type: none"> <li>• Adhesive Bonding</li> <li>• 5, 6</li> </ul>	<ul style="list-style-type: none"> <li>• Design aspects for adhesive bonding</li> <li>• Adhesive selection</li> <li>• Surface pre-treatment for adhesive bonding</li> <li>• Factors influencing the strength of adhesive joints</li> </ul>	<ul style="list-style-type: none"> <li>• Handout #4</li> <li>• Quiz 4</li> <li>• Project</li> </ul>
5	<ul style="list-style-type: none"> <li>• Hybrid Joining Techniques</li> <li>• 4, 5, 6, 7</li> </ul>	<ul style="list-style-type: none"> <li>• Main hybrid joining techniques</li> <li>• Application criteria</li> <li>• Production considerations</li> </ul>	<ul style="list-style-type: none"> <li>• Handout #5</li> <li>• Quiz 5</li> <li>• Project</li> </ul>
6	<ul style="list-style-type: none"> <li>• Joining Dissimilar Materials</li> <li>• 7, 8, 9</li> </ul>	<ul style="list-style-type: none"> <li>• General issues and limitations</li> <li>• Joining aluminum to other metals</li> <li>• Joining aluminum to plastics and composites</li> </ul>	<ul style="list-style-type: none"> <li>• Handout #6</li> <li>• Quiz 6</li> <li>• Project</li> </ul>

## Part 4: Grading and Assessment

### Quizzes

Quizzes are assigned related to some of the topics described above.

### Course Project

The course project is about the application of joining techniques. The main focus is about the design of a product with different materials to be joined, after all the course topics are completed.

### Computer Usage

CAD software and MS Office would be used.

### Grading Scheme (Grading rubric will be given in the class)

- |                       |     |
|-----------------------|-----|
| ➤ Quizzes (6)         | 60% |
| ➤ Pre Exam (1)        | 10% |
| ➤ Final Exam (1)      | 10% |
| ➤ Course Projects (1) | 20% |

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