THE OHIO STATE UNIVERSITY
COLLEGE OF ENGINEERING

# Advanced Metallurgy for Brazing and Soldering

## WELDENG 7123

**Credit Hours:**
3.00 - 3.00

**Course Levels:**
Graduate (5000-8000 level)

**Course Components:**
Lecture

**Course Description:**
Graduate level physical-chemical concepts of brazeability and solderability of metals, ceramics, and glasses and focuses on wetting by liquid filler metals, interfacial reactions, phase compositions of joint metal, hetero-diffusion, liquid embrittlement, as well as strength and reliability of brazed and soldered joints manufactured in aerospace, electronic, optical, mining, and other industries.

**Prerequisites and Co-requisites:**
Prereq: 4023 or 7023, and Grad standing; or permission of instructor.

**Course Goals / Objectives:**

- Provide a basic understanding of the theory of wetting of solid metals and ceramics, including of physical-chemistry of liquid-solid interface and interfacial reactions in brazing and soldering.
- Provide a basic understanding of phase formation in brazed joints and at the interface: solid solutions, eutectics, and intermetallcs. Hume-Rothery rules and designing of brazing alloys.
- Review of diffusion in brazing and soldering: theory, kinetics, effect on microstructure and mechanical properties of brazed joints. Diffusion exchange between solid and liquid metals. Matano diagram. TLP process.
- Basic understanding of erosion and dissolution of base metals in the liquid filler metals. Liquid embrittlement of base metals during brazing.
- Evaluation of strength and reliability of brazed joints by margins of safety approach and mechanical testing. Hot strength, creep resistance, and fatigue of brazed joints.
- Review of advanced soldering: methods and materials. Reliability of soldered joints.
- Review of brazing of refractory metals, ceramics in aerospace applications, as well as glasses and glass-ceramics in optical and electronic applications.
- Provide a basic overview of new advanced materials for brazing: flux-cored aluminum filler metals, composite filler metals, high-entropy alloys, amorphous foils, and others.
- Give students experience in mechanical testing of brazed or soldered joints and analyze mode of failure.
- Allow students to conduct detailed review of technical papers and provide a review to the class.

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**Course Topics:**

- Theory of wetting of solid metals. Physical-chemistry of liquid-solid interface. Interfacial reactions in brazing and soldering.
- Reactive wetting of ceramics by liquid metals and interfacial reactions.
- Formation of solid solutions, eutectics, and intermetallcs in the joint metals. Hume-Rothery rules and designing of brazing alloys.
- Practical case studies of reactive and non-reactive wetting in brazing and soldering.
- Brazing of superhard materials: silicon carbide, aluminum nitride, diamonds, and boron nitrides.
- Diffusion in brazing and soldering: theory, kinetics, effect on microstructure and mechanical properties of brazed joints. Matano diagram.
- TLP process (diffusion brazing). Solidification of joint metal above solidus of the filler metal.
- Diffusion brazing of titanium and nickel superalloys. Practical case studies.
- Erosion and dissolution of base metals in the liquid filler metals. Liquid embrittlement of base metals during brazing.
- Strength of brazed and soldered joints: a model of multilayer composite material, 3D-stresses, failure criteria to analyze brazed or soldered joints.
- Field tests against FEM modeling. Express test and standard mechanical test of shear strength.
- Evaluation of joint's reliability by margins of safety approach. Classification of defects in brazed or soldered joints. Ductile or brittle modes of mechanical behavior of brazed joints.
- Hot strength, creep resistance, and fatigue of brazed and soldered joints. Fracture surface types.
- Brazing and soldering of dissimilar materials. Practical case studies.
- Advanced soldering: methods and materials. Reliability of soldered joints. Practical case studies.
- Brazing of refractory materials: Mo, Ta, Nb metals, carbon composites, and ceramics. Practical case studies.
- Brazing of glasses and glass-ceramics in optical and electronic applications. Practical case studies.
- New advanced materials for brazing: flux-cored aluminum filler metals, composite filler metals, high-entropy alloys, amorphous foils, and others.

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**Designation:**
Elective