MTGN 477 METALLURGY OF WELDING - LABORATORY
Fall Semester 2001

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Teaching Assistants:
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Time: Tuesdays 10:00 a.m. - 12:00 noon
Thursday 10:00 a.m. - 12:00 noon

Room: Welding Lab
Physical Metallurgy Lab

Laboratory Topics: Each lab work will include the design of an experimental matrix and the selection of welding parameters. The weld specimens prepared will be characterized using metallurgical and mechanical testing techniques. Individual written reports will be required. The organization of the laboratory work, as well as the results presented will be considered in the determination of the final lab grade.

Lab 4 – Weeks of October 1st to October 15th – Effect of Welding Parameters on Weld Solidification Structure

Lab 5 – Weeks of October 22nd to November 5th - Effect of Shielding Gas on Magnesium Welding

Lab 6 – Weeks of November 12th to November 29th - Effect of Porosity on Weld Metal Microstructure and Properties.
**Topic:** Effect of Composition on the Weld Bead Morphology and Solidification Structure of Chromium/ Nickel and Chromium/ Manganese Alloys Weldments

**Objectives:** This laboratory program is designed to observe the influence of chemical composition on:
(a) Weld bead morphology;
(b) Solidification “macro” structure;
(c) Solidification substructure;
(d) Reheated zone microstructure
(e) Weld composition.

**Equipment & Materials:**
(a) GMA welding equipment;
(b) Optical microscope;
(c) SEM/ EDS;
(d) Welding wire: Chromium/ nickel and chromium/ manganese (Stainless steel);
(e) Base metal: Low carbon structural steel (A-36)
(f) Shielding gas: 90%Ar 10%O₂ mixture

**Experimental Procedure:**
(a) Bead-on-plate (BOP) MCA welds with 10 different compositions (10Cr16Ni, 10Cr13Ni, 10Cr10Ni, 10Cr6Ni, 10Cr3Ni, 10Cr15.9Mn, 10Cr12.9Mn, 10Cr9.9Mn, 10Cr5.9Mn, 10Cr2.9Mn);
(b) Bead-on-bead (BOB) welding with 2 compositions (10Cr10Ni and 10Cr15.9Mn);
(c) Sample characterization - Metallography (Macro and micro);
(d) Bead morphology and defect characterization;
(e) Solidification structure characterization;
(f) Reheated microstructure characterization;
(g) Dilution characterization using chemical analysis;
(h) Schaeffler and DeLong Diagram application.

**Expected Results:**
(a) Description of surface ripple pattern, crater cracking, and porosity;
(b) Relationship between bead shape, toe angle, penetration, reinforcement, width, dilution, etc. with chemical composition;
(c) Description of solidification substructure such as dendrites, cells, etc.;
(d) Relationship between columnar grain size, equiaxed grain size, fraction of columnar grain and equiaxed grains, fraction of dendrites and cells, secondary dendrite arm spacing with chemical composition;
(e) Relationship between solidification rate with chemical composition;
(f) Relationship between weld chemical composition and original chemical composition;
(g) Prediction of weld microstructure using Schaeffler and DeLong Diagram.
**Topic:** Effect of Shielding Gas on Arc Voltage and Magnesium Fusion Zone Characteristics.

**Objectives:** This laboratory program is designed to observe the influence of shielding gas on magnesium welding regarding:
(a) Arc characteristics (shape, voltage);
(b) Weld bead morphology (depth, width, fusion zone area, bead surface depressions, underbeads);
(c) Weld defects (cracks, macro- and micro-porosity).

**Equipment & Materials:**
(a) GTA welding equipment;
(b) Current-voltage data acquisition;
(c) Optical microscope;
(d) Scanning electron microscope;
(e) Base metal: AZ91 or AM50;
(f) Shielding gas: Ar; Ar-1%H₂; Ar-10%H₂; He; He-1%H₂

**Experimental Procedure:**
(a) Bead-on-plate (BOP) GTA welds with different sets of welding parameters (all combinations between 3 currents, 2 arc gaps, 1 travel speed, and the 5 shielding gases); (Total of 30 GTA welds – 15 on Tuesday/15 on Thursday)
(b) Sample characterization - Metallography (Macro and micro);
(c) Bead morphology and defect characterization.

**Expected Results:**
(a) Description of the arc shape (from observations in lab).
(b) Voltage – current lines with welding conditions (gas, travel speed, arc gap)
(c) Relationship between weld fusion zone dimensions and welding parameters (e.g. heat input);
(d) Description of defects, particularly porosity (qualitative and quantitative; e.g pore fraction);
(e) Relationship between porosity and hydrogen levels in shielding gas;
(f) Characterization of weld metal microstructures.
**Topic:** Relationship between Weld Porosity and Weld Metal Microstructure and Properties.

**Objectives:** This laboratory program is designed to characterize weld porosity and observe the influence of weld defect such as porosity and precipitates on:
- (a) Weld metal microstructure;
- (b) Weld metal mechanical properties;

**Equipment & Materials:**
- (a) GTA welding equipment;
- (b) W electrode (1/4 in. diameter)
- (c) Optical microscope;
- (d) SEM/EDS;
- (e) Base metal: Nickel-Copper alloys (or Stainless steel);
- (f) Shielding gas: Ar- 5 and 10%N₂ .

**Experimental Procedure:**
- (a) Bead-on-plate (BOP) GTA welds with two different sets of welding parameters at both DCEP and DCEN polarity (a total of four welds);
- (b) Bead-on-bead (BOB) welding with two of the BOP welds (select one from DCEP and DCEN polarity);
- (c) Sample characterization - Metallography (Macro and micro);
- (d) Defect characterization;
- (e) Solidification structure and behavior characterization;
- (f) Tensile and hardness testing of welds (six sets)

**Expected Results:**
- (a) Description of weld macro-and micro-porosity;
- (b) Relationship between amounts of porosity with welding parameters (weld speed);
- (c) Description of solidification rate and substructure (dendrites, cells, secondary dendrite arm spacing, etc.);
- (d) Relationship between amounts of porosity with solidification and welding parameters;
- (e) Relationship between amounts of porosity with shielding gas (Supplement your data with literature data);
- (f) Relationship between amounts of porosity with subsequent weld layer;
- (g) Description of weld metal precipitates;
- (h) Relationship between amounts of porosity with tensile and hardness properties.
### ABSTRACT OR SUMMARY REPORT:

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<td>2</td>
<td>Abstract or summary, comprising a maximum one-half page of double-space type. Must discuss succinctly the results by specific reference to figures or tables.</td>
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<td>3 to 5</td>
<td>Figures or tables, limited to the three most important for clarifying the summary.</td>
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### TECHNICAL REPORT (Required sections are capitalized and underlined below):

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<td>ABSTRACT (do not reference figures)</td>
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| 3 and 4 | Text, limited to two double-spaced typed pages (minimum type size: 12 pt). Text must include these sections:  
  **INTRODUCTION** - Two to three sentences which scope the experiment  
  **DISCUSSION** - Analysis of results emphasizing fundamental principles  
  **CONCLUSIONS** - Maximum of three statements that incorporate the most important points |
| 5    | FIGURES/ TABLES |
| A1 to A? | Appendix A (if required) |