

Colorado School of Mines
Dept. of Metallurgical and Materials Engineering
MTGN 580 Advanced Welding Metallurgy
Spring 2009

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Time: M & W 4:00 - 5:15 PM

Room: HH 211

Textbook: No Textbook required.
Recent publications or classical papers in the welding literature will be used.

Course Topics:

1. Weld Thermal Experience & Weld Pool Mechanics - *Temperature Field Modeling, Weld Morphology Modeling, Different Driving Forces and Contributions*
2. **Residual Stress Management – *Modeling of Residual Stress Development, Methods to Counteract Residual Stress, Coefficient of Thermal Expansion, Phase Transformation Induced Stress, M_s and M_d*
3. Weld Metal Solidification - *Solidification Modeling, Microsegregation Effects, Back Diffusion, Grain Refinement - Second Phase Particles Effects, Fluid Flow Effects*
4. Consumables Development - *Flux/Slag Formulation, Weld Pool Pyrometallurgy, Weld Metal Recovery & Delta Quantity, Fume Formation, Slag Detachability, Weld Metal Microstructure Development*
5. **High Strength Steel Pipeline Welding & Heat Affected Zone - *Strength/Toughness Matching, Large Scale Testing Fracture Mechanics, Adequacy of Carbon Equivalent Concepts, Reheated Zone Formation, Microstructural Stability, HAZ-less Steels*
6. **Nickel Alloy Welding – *Alloys for Power Generation, Nil Ductility Dip Phenomenon, Liquation Cracking*
7. Hydrogen in Weldments - *Martensite Start Temperature as Weldability Index, Porosity Formation, Hydrogen Embrittlement, Microfissuring, Hydrogen Flux between Weld Metal and HAZ*
8. Stainless Steel Welding - *Duplex and Super Duplex Stainless Steel Welding, Supermartensitic Stainless Steel Welding*
9. **Welding of Aerospace Materials - *Structural Aluminum Alloys (e.g., 2XXX, 6XXX, 7XXX, etc.) Welding - Property Fluctuations, Liquation Cracking*

- **Structural Titanium Alloys (α Alloys, β Alloys, α/β Alloys) Welding - Property Fluctuations, Base Metal Interstitial Contamination*
10. ***Metallurgy of Friction Stir Welds – Different Weld Zones, Effects of Thermal and Mechanical Cycles, Weld Metal Homogeneity*
 11. ***Resistance Welding – Process Details, High Strength Steels, Dual Phase Steels, Interstitial Free Steels, Effect of Coatings, Failure Mechanisms*

**** Topics for student development**

Course Format

Seminar Format

Student Presentation - Based on a minimum of 15 or more recent (since 1998), relevant publications and standard/classical texts; Quality Handouts

Q&A

Discussion

Group Participation

Grading System:

8 to 10 Quizzes (one on each topic discussed)

2 Lecture Presentations (QCGM - Quality Content, Graphics, and Micrographs)

1 Presentation Quality Poster

1 Final Report (3500 Words plus Graphics) on selected topics on *Welding and Joining*

Submit Bibliography (at least 15 complete references with quality pdf files) - 3rd Week of Class

Submit Outline - 5th Week of Class

Submit Final Report - Monday Dead Week

References:

1. Alcoa. "Welding Alcoa Aluminum," Alcoa Tech Center, 1972.
2. Kaiser. "Welding Kaiser Aluminum," Kaiser Aluminum & Chemical Sales, Inc., 1978.
3. Committee on Methods of Inspection. "Welding Inspection," American Welding Society, 1980.
4. IIW/IIS. "Handbook on the Ultrasonic Examination of Welds," DOC IIS/IIW-527-76, 1982.
5. S. Schiller, U. Heisig & S. Panzer. "Electron Beam Technology," J. Wiley & Sons, 1982.
6. M. Dadian & H. Granjon. "The Metallography of Welds," in "De Ferri Metallographia IV," Verlag Stahl Eisen, 1983.
7. Y. Arata. "Plasma, Electron & Laser Beam Technology - Development & Use in Materials Processing," American Society for Metals, 1986.
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9. AWS. "Welding Handbook," Vol. I-III, 8th Edition, American Welding Society, 1987.
10. R. Stout. "Weldability of Steels," 4th Edition, Welding Research Council, 1987.
11. J. Cornu. "Advanced Welding Systems - V. I. Fundamentals of Fusion Welding Technology," Springer Verlag, 1988.
12. J. Cornu. "Advanced Welding Systems - V. II. Consumable Electrode Processes," Springer Verlag, 1988.
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14. E. Folkhard. "Welding Metallurgy of Stainless Steels," Springer-Verlag, 1988.
15. T.H. North. "Advanced Joining Technologies," Chapman and Hall, 1990.
16. I. K. Pokhodnya et al. "Metallurgy of Arc Welding - Vol. I. Arc Processes and Electrode Melting," Rieckensky Science Publishing Co., 1991.
17. H. Granjon. "Bases Metallurgiques du Soudage," IS.
18. H. Granjon. "Fundamentals of Welding Metallurgy," Abington Publishing, 1991.
19. B. L. Bourgeois. "Soudage a L'Arc - Tome 1 - Generalite," IS.
20. B. L. Bourgeois. "Soudage a L'Arc - Tome 2 - Procedes Avec Electrodes Enrobees," IS.
21. B. L. Bourgeois. "Soudage a L'Arc - Tome 3 - Procedes Avec Fil Electrode Fusible - Procedes Avec Electrode Refractaire," IS.
22. D. L. Olson and T. H. North. "Ferrous Welding Metallurgy," Trans Tech Publications, 1992.
23. J. Norrish. "Advanced Welding Processes," Institute of Physics Publishing, 1992.
24. K. Easterling. "Introduction to the Physical Metallurgy of Welding," 2nd Edition, Butterworths, 1992.
25. I. Hrivnak. "Theory of Weldability of Metals and Alloys," Elsevier, 1992.
26. T. Boniszewski, "Self-Shielded Arc Welding," Abington Publishing, 1992.
27. D. Radaj. "Heat Effects of Welding - Temperature Field, Residual Stress, Distortion," Springer-Verlag, 1992.
28. ASM. "Welding, Brazing, and Soldering," Materials Handbook Vol. VI, 10th Edition, ASM International, pp. 1299, 1993.
29. H. Cerjak and K. E. Easterling. "Mathematical Modeling of Weld Phenomena," The Institute of Materials, 1993.

30. H. Cerjak and K. E. Easterling. "Mathematical Modelling of Weld Phenomena," The Institute of Materials, 1993.
31. N. Bailey et al. "Welding Steels Without Hydrogen Cracking," Abington Publications, 2nd Edition, 1993.
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41. R. Messler, Jr., "Principles of Welding," Wiley-Interscience, 1999.
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43. K. Jata, M. Mahoney, R. Mishra, S. Semiatin, and D. Field. "Friction Stir Welding and Processing," TMS, 2001.
44. G. Mathers. "The Welding of Aluminum & Its Alloys," Woodhead Publishing Ltd., 2002.
45. S. Kou. "Welding Metallurgy," 2nd Edition, Wiley Interscience, 2003.
46. J. Pan. "Arc Welding Control," Woodhead Publishing Ltd., 2003.
47. AWS. "Welding Handbook," Vol. II - Welding Processes Part I, 9th Edition, American Welding Society, 2004.
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56. A. Scotti and V. Ponomarev. "Soldagen MIG/MAG," ArtLiber Editoria, 2008.
57. Recent Archival Journal Publications and Conference Proceedings.