EMA 6107: High Temperature Alloys

Spring 2015
MWF 3rd Period
CSE E107

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Abstract

Physical and mechanical metallurgy of high temperature materials will be discussed. Topics include principles of strengthening alloys for high temperature service, alloy and process selection, alloy development and design principles for elevated temperature applications. Material classes covered include Ni-base, Co-base and Fe-Ni-base superalloys, refractory metals, titanium alloys, intermetallic compounds, ceramics and composites. Applications discussed include propulsion and power generation gas turbines, rocket engines, chemical processing and nuclear power generation.

Syllabus

1.) Introduction
- Applications
- Requirements
- Current Materials

2.) Design of Alloys for High Temperature Service
- Strengthening Mechanisms
- Creep and Stress Rupture
- Fatigue and Thermal Fatigue
- Environmental Effects

3.) Design of Superalloys
- Physical Metallurgy of Ni-Base Alloys
- Physical Metallurgy of Fe-Ni-Base Alloys
- Physical Metallurgy of Co-Base Alloys

4.) Processing
- Ingot Metallurgy
- Powder Metallurgy
- Wrought Processing

- Developmental Techniques

5.) Environmental Degradation
- Oxidation
- Hot Corrosion
- Coatings

6.) Alternative Materials
- Intermetallics
- Refractory Metals
- Composites
- Ceramics

7.) Materials and Process Selection

8.) Use of computational materials science

9.) Field Trip to Chromalloy(?)

References:

Text Book:
The Superalloys: Fundamentals and Applications
Roger C. Reed
Cambridge University Press, New York, NY, 2006
ISBN: 0-521-85904-2

General References:
"Heat Resistant Materials", Ed., J.R. Davis, ASM International, Materials Park, OH, 1997.

"The Superalloys", Eds. C.T. Sims and W.C. Hagel, J.W. Wiley, NY, NY, 1972.

"Superalloys II", Eds., C.T. Sims, N.S. Stoloff and W.C. Hagel, J.W. Wiley, NY, NY, 1987.

"The Development of Gas Turbine Materials", G.W. Meetham, Ed., Applied Science Publishers, London, 1981.

"Directionally Solidified Materials for High Temperature Service", M. McLean, The Metals Society, London, 1983

"High Temperature Alloys for Gas Turbines", D. Coutsouradis, et al, Eds., Applied Science Publishers, London, 1978.

"Refractory Alloying Elements in Superalloys", J.K. Tien and S. Reichman, Eds., ASM, Metals Park, OH 1984.

"Advances in High Temperature Materials and Protective Coatings". A.K. Koul, et al, Eds., Nat. Res. Council of Canada, Ottowa, 1994.

"Advanced Materials and Coatings for Combustion Turbines, V.P. Swaminathan and N.S. Cheruvu, ASM, Metals Park, OH, 1994.

"ASM Metals Handbook", Tenth Edition, Volumes 1 and 2.

"Alloying", J.L. Walters, et al, Eds., ASM, Metals Park, OH, 1988.

"Superalloys – Source Book", M.J. Donachie, Jr., Ed., ASM, Metals Park, OH, 1984.

"Source Book on Materials for Elevated Temperature Applications", E.F. Bradley, Ed., ASM, Metals Park, OH, 1979.

"Superalloys, Supercomposites and Superceramics", J.K. Tien and T. Caufield, Eds., Academic Press, Boston, MA, 1989.

"The Microstructure of Superalloys", M.Durand-Charre, Gordon and Breach Science Publishers, Amsterdam, 1997.

"Precipitation Hardening", J.W. Martin, Butterworth Heinemann, Boston, MA, 1998.

Processing:

"Superalloys – Metallurgy and Manufacture", Proc. Seven Springs Int'l Conf. On Superalloys, 1976, 1980, 1984, 1988, 1992, 1996, 2000, 2004, 2008 and 2012.

"Powder Metallurgy of Superalloys", G.H. Gessinger, Butterworth & Co. Publishers, London, 1984.

Intermetallic Compounds:

"High Temperature Ordered Intermetallic Alloys", Proc. MRS Symposia, 1985 (V. 39), 1987 (V. 81), 1989 (V. 133), 1991 (V. 213), 1993 (V. 288), 1995 (V. 364), 1997 (V. 460).

"Structural Intermetallics", Proc. TMS ISSI Symposia, 1993 and 1997.

Composites:

"Composite Materials", K.K. Chawla, Springer-Verlag, NY, 1987.

Grading:

Without Optional Final:
Approximately weekly homework: 25%
3 Mid-term exams (25% each): 75%

With Optional Final:
Approximately weekly homework: 20%
3 Mid-term exams (20% each): 60%
Optional Final exam: 20%

Homework given approximately bi-weekly, due within 1 week of assignment. Late homework accepted until solutions handed-out, but penalized 10% per day after due date. All work must be shown for full/partial credit.

Exams: 3 mid-terms (1 page of notes) tentatively schedule:

1.) February 13th
2.) March 23rd
3.) April 22nd.

Optional final exam.
All work must be shown for full/partial credit.
Questions require thought/common-sense.

No extra credit work accepted.
Optional Final Exam: During Finals Week.

Grading Scale: 93-100 A, 90-92 A-, 87-89 B+, 83-87 B, 80-82 B-, 77-79 C+, 73-77 C, 70-72 C-, 67-69 D+, 63-67 D, 60-62 D-, < 60 E

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University Counseling Center, 301 Peabody Hall, 392-1575, Personal and Career Counseling.
SHCC mental Health, Student Health Care Center, 392-1171, Personal and Counseling.

Center for Sexual Assault/Abuse Recovery and Education (CARE), Student Health Care Center, 392-1161, sexual assault counseling.
Career Resource Center, Reitz Union, 392-1601, career development assistance and counseling.

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