

## **EMA 6107: High Temperature Alloys**

Fall 2022

MWF 6<sup>th</sup> Period (12:50pm-1:40pm)

CSE E122

Instructor: G.E. Fuchs  
Office: 116 Rhines Hall  
Phone: 846-3317  
E-mail: gfuch@mse.ufl.edu  
Office Hours: TBD

### **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.

### **Subjects to be covered:**

- 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.) Repair and refurbishment
- 10.) Pirates, the PMA process and gas turbine economics

## **General References**

### **Superalloys:**

“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 Superalloys – Fundamentals and Applications”, R.C. Reed, Cambridge University Press, 2006.

“Superalloys XXXX”, Proc. Seven Springs Int’l Conf. On Superalloys, 1976, 1980, 1984, 1988, 1992, 1996, 2000, 2004, 2008, 2012, 2016 and 2020.

“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, Ottawa, 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 (2<sup>nd</sup> edition published in 2002).

“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.

“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. Once solutions are handed-out, late homework will not be given any credit. All work must be shown for full/partial credit.

Attendance is not taken, but if attendance becomes a concern, unannounced “pop quizzes” will be instituted and will count as extra-credit for those students in attendance.

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

- 1.) Monday, September 26<sup>th</sup>.
- 2.) Monday, October 31<sup>st</sup>.
- 3.) Wednesday, December 7<sup>th</sup>.

Will provide at least 1 week “warning” before each exam.

Optional final exam: (Tuesday, December 13<sup>th</sup>, 3:00-5:00pm).

All work must be shown for full/partial credit.

Questions require thought/common-sense.

No extra credit work accepted.

Optional Final Exam: Tuesday, December 13<sup>th</sup>, 3:00-5:00pm

**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**

Honesty Policy: All students admitted to the University of Florida have signed a statement of academic honesty committing themselves to be honest in all academic work and understanding that failure to comply with this commitment will result in disciplinary action. This statement is a reminder to uphold your obligation as a UF student and to be honest in all work submitted and exams taken in this course and all others. Any cheating/plagiarism/copying will be prosecuted to the fullest extent and a zero (0) given on the assignment.

Accommodation for Students with Disabilities: Students Requesting classroom accommodation must first register with the Dean of Students Office. That office will provide the student with documentation that he/she must provide to the course instructor when requesting accommodation.

UF Counseling Services: Resources are available on-campus for students having personal problems or lacking clear career and academic goals. The resources include:

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.

Software Use: All faculty, staff and student of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

**For EDGE Students Only:** Due dates for all assignments and tests will be provided. However, in general, all EDGE students should attempt to turn in all assignments within 1 week of in-class due dates. The EDGE students who can not meet these due dates, should contact the professor immediately and establish an appropriate due date.

**Covid-19:**

- If you are sick, stay home and self-quarantine. Please visit the UF Health Screen, Test & Protect website about next steps, retake the questionnaire and schedule your test for no sooner than 24 hours after your symptoms began. Please call your primary care provider if you are ill and need immediate care or the UF Student Health Care Center at 352-392-1161 (or email [covid@shcc.ufl.edu](mailto:covid@shcc.ufl.edu)) to be evaluated for testing and to receive further instructions about returning to campus.
- If you are withheld from campus by the Department of Health through Screen, Test & Protect, you are not permitted to use any on campus facilities. Students attempting to attend campus activities when withheld from campus will be referred to the Dean of Students Office.
- UF Health Screen, Test & Protect offers guidance when you are sick, have been exposed to someone who has tested positive or have tested positive yourself. Visit the [UF Health Screen, Test & Protect website](#) for more information.