MSE 8803-C
Processing and Applications of Engineering Alloys

SYLLABUS

Course Description: The course will emphasize the basic elements of processing, structure, and properties of ferrous and non-ferrous metals and alloys, with a focus on process-structure-property relationships and microstructural design at nano-, micro-and meso-length scales.

Prerequisite Knowledge: You must have knowledge of the following topics from your earlier courses.
Thermodynamics: Laws of thermodynamics, entropy, free energy, chemical potential, activity, activity coefficient, free energy-composition diagrams, equilibrium phase diagrams, Gibbs phase rule, lever rule, reaction kinetics, equilibrium constant
Transformation Kinetics: Principles of Solidification including nucleation and growth, coring, overall transformation kinetics including effects of cooling rates, diffusional and diffusionless transformations, recovery, recrystallization, grain growth, and particle coarsening and sintering
Mechanical Behavior: Elastic and plastic deformation, Young's modulus, fundamentals of plasticity including dislocations, slip and slip systems, high temperature deformation (creep) and monotonic and cyclic mechanical properties
Strengthening Mechanisms: Dislocation particle interactions, solid solution hardening, precipitation hardening, and dispersion hardening are topics essential to the understanding of the development of strength in all alloy systems. These topics will first appear in our discussions on steels, but they appear as a reoccurring theme throughout the course. Understanding of diffusionless martensitic transformation and its effects on material properties are essential for understanding heat processing and properties of numerous ferrous and non-ferrous alloys.
Structure: Atomic structure, primary and secondary chemical bonds, crystal structure, Miller indices of planes and directions in crystals, close packed planes and directions, point defects, gran boundaries and interfaces, microstructure (grain size, volume fraction, etc.)

Course Outcomes and Expectations: (1) The student will demonstrate understanding of how process conditions and alloy chemistry affect microstructure. (2) The student will demonstrate understanding of deformation processing of engineering alloys and how the deformation processing parameters affect microstructure and mechanical properties. (3) The student will develop understanding of isothermal and continuous cooling transformations, major heat treatments, and thermo-mechanical processing of steels. (4) The student will develop understanding of applications of different classes of steels based on their chemistry, microstructure, and processing. (5) The student will develop understanding of processing-structure-properties relationships and applications of Al-, Mg-, Ti- , and Cu- and Ni-alloys, and refractory metals and their alloys. (6) The student will develop understanding of processing-structure-properties relationships and applications of Ni- , Co-, and Fe-base superalloys

Instructor:
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Office Hours: Office hours of Professor Gokhale are on Thursdays from 11 am to noon

Reference Books:
1 William F. Smith *Structure and Properties of Engineering Materials*, McGraw-Hill, 1993.
2 George Krauss, *Heat Treatment and processing Principles*, ASM, Materials Park, 1990.

3 David A. Porter and Kenneth E. Easterling, *Phase Transformations in Metals and Alloys*, Chapman and Hall, London, 1991.

4 G. E. Dieter, *Mechanical Metallurgy*, McGraw-Hill, 2nd Edition.

Course Website: https://canvas.gatech.edu

Class Attendance: MSE 8803-C is **not** an on-line course. Students are expected to attend the in-class lectures and participate in class discussions

Tests and Grades: Grading will be based on the performance in two tests, final examination, and term paper and its presentation. Each test will be 25% of the final grade and the final exam will be will be also 25% of the final grade. The term paper and its presentation will be 25% of the course grade. Students are expected to attend at least 75% of the lectures. The tests and final exam will be in-class, closed-books, and closed-notes. There will be 8 to 10 Home Assignments. Students are NOT required to submit completed home assignments and they will not be graded.

Midterm grades: When required, the midterm grades will be reported as satisfactory (S) or unsatisfactory (U). The midterm grade will be based on the marks in the first test.

Extenuating Circumstances: Please contact the Dean of Students if you have extenuating circumstances that interfere with your ability to attend class, and/or prepare for tests, and/or take the tests. The Dean's office is your best resource when you prefer not to discuss your personal situation with the instructor.

Special Needs and Accommodations: Georgia Tech encourages qualified persons with disabilities to participate in its programs and activities. If you anticipate needing any type of accommodation in this course or have questions about physical access, please tell the instructor as soon as possible.

Grading/Recording Errors: Errors in grading and/or recording of test/homework marks must be brought to the attention of the instructor within one week of posting on CANVAS by contacting the instructor in writing via e-mail or in person.

Academic Integrity: The students must follow the Georgia Tech honor code and behave in a professional manner when it comes to academic integrity. Any students violating the honor code or suspected of academic misconduct will be turned over to the office of Academic Integrity, Dean of Students to investigate the incident(s).

Course topics to be covered:

A. Metals Processing Fundamentals

- Rolling, forging, and extrusion based deformation processing

B. Metallurgy of Iron and Steel

- Iron and steel making
- Primary processing of iron and steel
- AISI codes for steels
- Fe-C diagram
- Microstructures of carbon and low alloy steels
- Eutectoid, pro-eutectoid, and hyper-eutectoid transformations
- IT diagrams and continuous cooling TTT diagrams
- Martensite transformation, hardenability, and properties of martensite
- Tempering of steels

- Bainite transformation
- Chemistry, microstructure, processing, and properties of Stainless steels
- Chemistry, microstructure, processing, and properties of ausforming steels and maraging steels
- Chemistry, microstructure, processing, and properties of tool steels
- Chemistry, microstructure, processing, and properties of cast irons

C. Metallurgy of Nonferrous Metals and Alloys

- Processing, microstructure, properties, and applications of Al-alloys
- Processing, microstructure, properties, and applications of Mg-alloys
- Processing, microstructure, properties, and applications of Ti-alloys
- Processing, microstructure, properties, and applications of Ni-alloys
- Processing, microstructure, properties, and applications of superalloys
- Processing, microstructure, properties, and applications of refractory metals
- Processing, microstructure, properties, and applications of low melting point metals and alloys