



Gear Materials – Selection Metallurgy, Heat Treatment, and Quality Control

INSTRUCTORS:

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COURSE INFORMATION

Course Description

Learn what is required for the design of an optimum gear set and the importance of the coordinated effort of the gear design engineer, the gear metallurgist, and the bearing system engineer. Investigate gear-related problems, failures and improved processing procedures.

It is recommended that you spend a minimum of 1 hour reading and reviewing the material each day.

Course Rationale/Students Course Designed to Serve

Gear Engineers, gear designers, application engineers, people who are responsible for interpreting gear designs, technicians and managers that want to better understand all aspects of gear design.

Expected Student Learning (Course Level) Outcomes

- Improve their gear designs
- Apply their understanding of gear rating theory and analysis methods

- Investigate differences in stress states among various surface durability failure modes
- Discuss time dependent and time independent failure modes related to tooth design
- Use computer generated graphics to examine mesh action and tooth interaction
- Discuss the concepts presented

Required Textbooks (Provided by AGMA)

Gear Materials- Selection Metallurgy, Heat Treatment, and Quality Control manual by. Raymond J. Drago, PE

Materials and Tools for Learning

Computer generated animated graphics will be used for examining mesh action and tooth interaction. Each section discussion will be followed by an interactive question and answer period.

COURSE OUTLINE

1. Initial gear material selection – What are the advantages and disadvantages of the various gear material choices, including steel, cast iron, ductile iron, plastics, bronze and more exotic choices.
2. Heat treatment processes and their relation to gear performance, cost, reliability and load characteristics –Through hardening before and after tooth cutting, nitriding, various types of induction hardening (including coil, tooth-by-tooth, dual and multiple frequency) carbo-nitriding and various types of carburizing will be addressed in order to relate the properties obtained to the needs of the gear system.

3. Engineering drawing development - The best material selection process is only as good as the engineering drawing's ability to define and control the process in an ambiguous, clear and complete manner. The need for certification of material properties, heat treatment results and the quality control of the overall process will be addressed using examples of proper drawing practice.
4. Review of the engineering drawing - what should the metallurgist look for - five important areas - material, part configuration, heat treat requirements, surface finish technique and quality control requirements.
5. Understanding melt processing - types and quality level - effects of various elements, such as sulfur and phosphorus - hydrogen content, inclusion content, work ratio, normalizing, residual stress considerations. Inspection techniques and advantages - ultrasonic and magnetic particle.
6. Gear materials - their nomenclature, what makes steel steel, effects of the elements, is stainless really stainless? Typical heat treatment processing technique for gear materials.
7. What is carburizing? How does it occur? Comparison of various processes, how to optimize the cycle. What is stress relieving hardening, quenching, tempering and deep freezing? Enhancements, such as methods to control distortion, intergranular oxidation (IGO) and decarburization.
8. Why the metallurgist should review of the manufacturing process sequence - what he should look for. What about the welding process used for big parts? Review of the heat treat configuration of the part - what is important at this point in the cycle? When and when not to inspect. What about corrosion - can it occur in the shop? How can it be prevented?
9. The metallurgical review of the heat treat facility and the laboratory. The type of furnace, the carburizing atmosphere and its control should be understood. How to inspect and ensure that uniformity of both temperature and carburizing gases are maintained during the heat treat cycle. Circulation pattern of gases in the furnace – is it optimal? What equipment is every metallurgical laboratory from a test sample standpoint?
10. Control of the heat treat process during the actual cycle. How does the metallurgist ensure effective carburizing will occur? The use of test slugs, their size and placement. Where and how

does distortion occur? What about decarburization, intergranular oxidation, temper embrittlement. The heat treat procedure should be understood to minimize there.

11. Metallurgical heat treat test sample preparation and evaluation techniques to ensure the data is relevant to the actual parts. Sample and preparation techniques. What to do and not to do. What to look for – intergranular oxidation (IGO) causes and effects, decarburization, retained austenite, how much is OK, etc. Micro hardness evaluations and their comparison microstructure observed can be used to denote the effectiveness of the overall carburizing process. What about carbides? Are they bad or good?
12. Final inspection and finishing of the gear – This section will include a discussion on the types of grinding burns and how to prevent them from occurring. Other inspection techniques, such as magnetic particle, ultrasonic and eddy current, will be detailed. Finally, shot peening, the process and its benefits will be discussed.

STUDENT FEEDBACK AND GRADING PROCEDURES

Assignments

Assignments and learning activities are given and directed at the discretion of the instructor.

COURSE MANAGEMENT

Weather Delays and Cancelations

We will communicate any cancellations, delays or other concerns for safety prior to class via email, voicemail, and/or text message. Please be sure that we have all pertinent contact information as you travel to your class location.

Attendance for Domestic and International Students

Please be mindful that these are short, accelerated courses. Attendance is extremely important. If you are going to be absent from any class day, please contact the course coordinator.

Plagiarism, Cheating and other types of Misconduct

Plagiarism¹, cheating and other types of misconduct are unacceptable.

Students with Disabilities

Students requiring assistance and accommodation should complete the [Special Accommodation Request form](#) and submit it to Stephanie Smialek, Education Manager at smialek@motionpower.org. She can be reached at 773-302-8026.

Grievance Procedures

Students who have concerns about the class are encouraged to contact Stephanie Smialek, Education Manager, at smialek@motionpower.org or 773-302-8026.

Outline Changes

The instructor reserves the right to modify the outline during the course of the class.

LEARNING AND OTHER RESOURCES

Links for writing resources:

- grammar.ccc.commnet.edu/grammar
- www.merriam-webster.com

Links for Math resources:

- www.sosmath.com
- Khan Academy on www.youtube.com

Links for time management, study skills and note taking resources:

- www.mindtools.com
- www.testtakingtips.com

¹ Plagiarism is defined as “the use or close imitation of the language and thoughts of another author and the representation of them as one’s own original work.”

Links for career resources:

- <https://www.agma.org/newsroom/jobs/>

Industry News:

- <https://www.agma.org/newsroom/industry-news/>