237: Gearbox CSI: Forensic Analysis of Gear & Bearing Failures – Useful Tools for Optimizing Gear Design

INSTRUCTOR Information
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COURSE INFORMATION

Course Description
A good understanding of individual failure modes and the failure scenarios that led to the actual system failure is an essential skill to designing gear/bearing systems that will operate properly for their full design life. In this course, we will define and explain the nature of many gear and bearing failures and we will also discuss and describe various actual failure scenarios. In addition, a detailed primer on bearing technology prefaces the failure scenario discussions. You will gain a better understanding of various types of gears and bearings. Learn about the limitation and capabilities of rolling element bearings and the gears that they support. Grasp an understanding of how to properly apply the best gear-bearing combination to any gearbox from simple to complex.

It is recommended that you spend a minimum of 1 hour of reading each night.

Course Rationale/Students Course Designed to Serve
Gear and bearing design engineers, management involved with design, maintenance, customer service and sales.

Learning Objectives:
- Apply understanding of forensic analysis of gearbox failures in future gearbox designs
- Discuss bearing and gear types
- Explain how bearing selection is influenced by gear type and loading
- Select appropriate bearing types and configurations as influenced by gear type and loading
- Explain how to optimize bearing and gear combination
- Identify seven materials and manufacturing related defects

Required Textbooks (Provided by MPMA)
MPMA's *Gearbox CSI: Forensic Analysis of Gear & Bearing Failures – Useful Tools for Optimizing Gearbox Design* by Raymond J. Drago, PE, and Joseph W. Lenski, Jr.

COURSE OUTLINE

I. Introduction
- Recognize, analyze and correct failures; correlate problems and solutions
- Understand applications; realizing gears, bearings, housing and lubrication interact
- Study failures; "We learn more from failures than successes"
- Diagnosis; recognize the thing that broke may not be thing that caused the failure

- More than one thing can go wrong
- Beware of laboratory analysis

II. Gear design and failure analysis
- Appropriate application of technology
- Failure types; wear, scoring, interference, surface durability and fracture
- Lubrication failure
- Resonance
- Processes and related damage; handling, marking, electric arc, magnetic particle inspection, etc.
- Compound effects; misalignment with spacing errors, poor lubrication distribution

III. Material and manufacturing related effects
- Inclusions
- Hydrogen embrittlement
- Residual tensile stresses
- Voids and porosity
- Forging problems
- Heat treatment and processing controls
- Grinding burns and cracks

IV. Preventive measures
- Detailed gear design, manufacture and quality control specifications
- Advanced technology application

V. Bearing design and failure analysis
- Proper understanding and selection of bearing types and configurations – bearing selection as influenced by gear type and loading
- Design and fabrication controls; how to select a bearing supplier
- Basic bearing B-10 life calculations; standard catalog rating methods and modified load factors
- Methods to reduce manufacturing defects
- Understanding operating conditions as influenced by deflection and load
- Conducting a bearing forensic failure investigation
- Definition of true bearing fatigue failures
- Assembly induced failures
- Operational induced failures; loads, misalignment, lubrication, improper settings and clearance, contamination and dynamics

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
Plagiarism[1], 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 our Education inbox at education@motionpower.org. Or we can be reached by calling 703-684-0211.

Grievance Procedures
Students who have concerns about the class are encouraged to contact any Education Department staff at education@motionpower.org or by calling 703-684-0211.

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.testakingtips.com

Links for career resources:

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

Industry News:

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

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."