125: Applied Design Basics for Spur and Helical Gears

INSTRUCTOR:
Terry Klaves
Email: terryklaves@gmail.com

COURSE INFORMATION

Course Description
Learn to turn a customer's gear drive application specification into an optimized spur or helical gear design. Working through two real-life examples, you'll select the key design parameters that determine tooth bending and contact safety factors, optimize those safety factors for a target design life, and use profile shift to fit new gear designs and ratios into an existing center distance.

Using commercially available software, you'll calculate gear geometry factors and optimize power density and performance. You'll also develop microgeometry with Loaded Tooth Contact Analysis software and learn how to compensate for "twist" error on ground gears. The course reviews common failure modes that occur when a design or its final accuracy falls short of application requirements.

Finally, you'll look at the time and cost involved in more than 20 other gear drive components and development steps, from prototype through shipment of compliant production drives. Bring your own questions: there will be time to discuss design challenges specific to your industry.

Gearing Application - Design - Optimize - Process - Manufacture - Test - ROI - Entry level class exceeds Machinery Handbook information, no prerequisites

Who Should Attend
This course would be of interest to entry level gear designers, process and manufacturing engineers can develop a basic understanding of gear geometry terms and variables. Gear manufacturing project managers can develop a better understanding of time required to design and optimize a gearset that is cost effective and meets or exceeds application expectations. Also, high level gear grind operators and machine setup technicians, inspectors and quality assurance people who need to better understand why and how gear designs are optimized and how to interpret non-standard gear geometry. They can also gain insight on how improper finishing techniques can contribute to pre-mature gear failures.

Learning Objectives
- Discuss aspects of gear tooth fatigue loading and typical failure modes as a basis for gear designs which exceed target design fatigue life
- Understand the various form of drive loads
    - Prime movers and suggested Safety Factors
    - Constant load applications
    - Variable load/duty cycle applications
- Ability to start with customer supplied gear drive application specification and develop an optimized gear design which meets or exceeds application and performance requirements
- Review gear geometry terminology and design optimization variables beyond information available in Machinery's Handbook, apply optimization tools currently used in industry
    - Basic Normal Plane Geometry factors – NDP, NPA, Helix Angle, Tooth Size

    - Transverse Rolling Plane Performance variables – Profile Shift, Material, Heat Treatment, Accuracy, High Contact Ratio gear geometry and efficiency
    - Rating factors – Tooth Bending S. F., Tooth Contact S. F., Micro Pitting S. F.
    - Additional performance enhancing processes – shot peen, isotropic finishing
- Calculate contact and bending Safety Factors as (Material and Design allowable loads) divided by (application loads) for a target design life.
- Learn how to fit a new gear ratio into existing housing and center distance using profile shift
- This course is focused on gear design, but reviews functionality of over 20 related drive components and design related processes
- Apply design tools and gear performance enhancements to optimize
    - Rating
    - Operating noise level
    - Efficiency
    - Gear mesh contact
    - Lubrication
- Discuss gear drive design process steps, time, and costs from receipt of customer application specifications through design, prototype development/testing to manufacturing and shipping production units which meet or exceed customer expectations
- Work through two real life examples, (pre-defined), developing optimized spur and helical gear sets which exceed customer application specifications. The trainer does not have and active license for KISSsoft and cannot work through examples "live"

Required Textbooks (Provided by MPMA)
Design Basics of Spur and Helical Gears manual by Terry Klaves.

COURSE OUTLINE

- Basic Gear Design – Overview
    - Factors affecting gear tooth bending and contact fatigue lives
    - Defining applied load, torque, speed, horsepower, target design life
    - Example of gear drive application data sheet/specification
    - Define gear geometry terms: Involute Profile, Helix-Lead, Profile Shift
    - Review gear accuracy for AGMA and ISO accuracy standards
    - Review how material and heat treat allowable stresses affect tooth bending and contact fatigue
- Basic Gear Design – Overview
    - Gear tooth bending stress - bending fatigue failure
    - Gear tooth contact stress - macro pitting
    - Micro pitting
    - Material and heat treatment relative allowable stresses
    - Other design considerations - shafts, bearings, housing
- Basic Gear Design – Design process tools
    - Loaded tooth contact analysis
    - Design process and interaction with customer
    - Gear rating calculation using commercially available software
    - Allowable bending and contact horsepower and target life factor
    - Design/rating optimization for max power density and least cost
    - Performance optimization for application critical parameters

- Review Hypothetical Optimized Gearing for Sample Application
  - Define sample application, review rating calculations from commercially available software
  - Iterate design variables to optimize tooth bending strength
  - Iterate design variables to optimize tooth contact strength
  - Iterate design variables to optimize operating noise levels
  - Iterate design variables to optimize operating efficiency
- Course quiz - work through second design example together with class participation
  - Define quiz application, review rating calculations from commercially available software
  - Discuss fitting new a ratio into existing non standard center distance using profile shift
  - Discuss shot peening
  - Discuss isotropic finishing
  - Probability of wear
  - Lubrication parameters
  - Contact analysis to improve loaded tooth contact
- Review, Examples, Discussion

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.

[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."

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/