SUPPORTING & ENHANCING

BGA

BRITISH GEAR ASSOCIATION

UK POWER & TRANSMISSIONS

GEAR TRAINING COURSES

The British Gear Association (BGA) are the leading providers of gear related training in the UK and Europe. All BGA training is developed and delivered by Gear experts from Academia and Industry.

Our Training Programme encompasses introductory classes to more in-depth specialist training . We have all of your gear training needs covered.

Our courses are suitable for all sections of the gearing world. From students and apprentices starting out in their careers to experts wanting to hone their skills or get up to date with the latest developments. Our training is CPD Accredited, considered Industry Standard and delivered flexibly to suit a variety of business needs.

Online training is completely free to BGA Members.

If you would like to register for any of our essential gear training please contact the BGA office admin@bga.org.uk or register online at www.bga.org.uk.

CPD CERTIFIED
The CPD Certification Service

PHASE 1

GEAR FOUNDATION 1

This introductory course is suitable for anyone joining the Gear Industry. This introduction to gearing is beneficial to staff directly working with gears and also wider departments, HR/ Sales etc to ensure every member of your organisation has a broad understanding of gears.

The BGA's Gear Foundation Day features three engaging, interactive sessions led by our Gear Experts. Each session allows participants to engage directly, ask questions, and receive immediate feedback.

Modules:

Gear Fundamentals

- Law of Gearing: Understand how gears work together to transfer motion efficiently
- The Involute Form: Learn why this design is crucial for smooth gear operation
- Power Transmission: Explore how gears convert rotational motion into useful work
- Motion Control: Discover methods for controlling speed and torque
- Gear Types – Features and Benefits: Get to know various gear types and their specific applications in real-world scenarios

Noise & Load

- Modes of Failure: Explore five common types, including bending and wear
- Gear Rating Methods: Understand how to evaluate gear performance with industry standard metrics
- Application Factors: Discover how different applications influence gear selection and effectiveness
- Gear Lubrication: Learn its role in maintaining efficiency
- Noise & Vibration Basics: How to measure and mitigate noise
- Transmission Error: Understand how error impacts overall performance and what can be done to minimize it

Gear Manufacture

- Gear Material Specification: Learn about the materials used in gear-making
- Gear Manufacturing Methods: Understand processes such as hobbing and grinding, providing insight into the manufacturing timeline
- Heat Treatment and Gear Measurement: Discover why these steps are crucial for producing high-quality gears that meet industry standards

GEAR GEOMETRY

Gear geometry is thought to be complex and often considered a 'black art'. This series of on-line session will dispel this myth and provide delegates with a basic knowledge of how gears work and cylindrical gear geometry. It is applicable to gear designers, manufacturing staff, machine operators, inspectors and those who are new to the gear industry.

Modules:

CYLINDRICAL GEAR GEOMETRY PART 1- How involute gears work

- Remind us why we use gears
- Introduce us to the requirements of gears and the involute curve
- Show how gears work and why gears need to be precise
- Explain why gears are noisy and how we make them quiet

CYLINDRICAL GEAR GEOMETRY PART 2- An Introduction to BS ISO 21771:2007

- Remind us how easy it is to specify gear geometry
- Explain why it's more complicated in practice
- Introduce us to ISO terms and more importantly to the symbols used in ISO gear standards. ISO symbols can be considered the international language of gears
- Introduce some basic geometry calculations and diagrams from ISO 21771 and how to interpret them
- Basic gear calculations which require a scientific calculator

CYLINDRICAL GEAR GEOMETRY PART 3- Gear pairs and their related gear geometry

- Introduce gear pair geometry and lines of contact
- Introduce the concepts of working pressure angle and show you how we work out where gears start to contact on the tooth flank
- Introduce profile shift coefficient, 'x', why we use it, and what effects it has on gear geometry
- Introduce basic tooth thickness calculations.
- Introduce the relevant geometry calculations and diagrams from ISO 21771

CYLINDRICAL GEAR GEOMETRY PART 4- Performance related gear geometry

- Contact on the tooth flank
- Profile shift coefficient, 'x', why we use it, and its effects on gear geometry
- Introduce you to basic tooth thickness calculations.
- Introduce the relevant geometry calculations and diagrams from ISO 21771

GEAR FOUNDATION 2

This introductory course is suitable and appropriate for anyone who has **completed Gear Foundation Part 1**. We have found this introduction to gears to be beneficial not just to staff directly working with gears but also those such as HR and Sales departments to ensure every member of your organisation a broad understanding of Gears and gearing.

Modules

Gear System Arrangements - Design and selection

Introduces the different architectures that can be used in gear systems and their features and benefits. Gives access to the basic formula for the preliminary design and initial sizing of gear systems. On completion of this module the student will be able to create different preliminary gear architectures for a particular application and select the most suitable.

Gearbox Fundamentals

Design requirements and essential components required to fulfil these requirements to the tooth forces present and developed by Involute Gear Teeth.
From this base the student will be equipped to select and design the associated components of gears including: bearings ; shafts; couplings; seals; lubrication; gearcases and supporting structures.

Gear Lubrication Introduction

Introduce the fundamentals of Gear Lubrication and the surface conditions of gear teeth that occur during service. This will provide a foundation for the proper selection of lubricants, design of lubrication systems and avoidance of scuffing and wear **of gear teeth.**

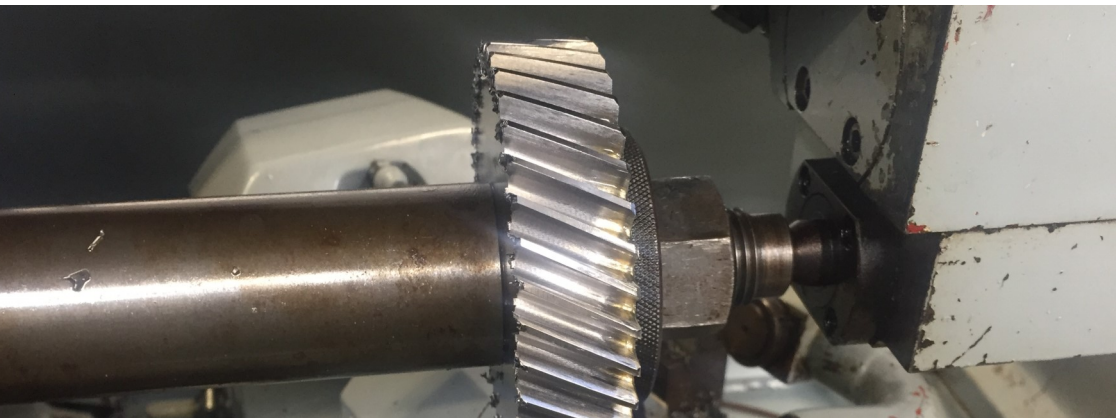
GEAR CUTTING AND MEASUREMENT

The BGA Introduction to Gear Cutting and Measurement course is essential for engineers who want to broaden their understanding first principals of gear design and cutting. Delegates will learn first principles of gearing and gain practical experience using our Maxicut 2A shaping machine and Sykes H150 hobbing machine. These manual machines will allow delegates to see the principles of gear design in reality giving a broader understanding of how the gear tools work.

- Understand basic spur and helical gear theory and terminology
- Carry out basic calculations for the manufacture and measurement of gears
- Understand how spur and helical gears are cut by hobbing and shaping
- Gain practical experience in setting up, producing and measuring gears made by hobbing & shaping
- Basic involute gear theory, terms and definitions for spur and helical gears including:
  - Gear terms and definitions
  - Introduction to the involute form and its construction/tables

Practical work on the measurement of gears including calculations on the following:

- Chordal tooth settings for gear tooth Vernier. Chord settings to gear tooth Vernier
- Base tangent micrometer settings
- Distance over rollers measurement
- Basic principles of gear hobbing and shaping
- Selection of index and feed change gears
- Setting up and producing spur & helical gears by hobbing and shaping using a *Maxicut 2A* shaping machine and *Sykes H150* hobbing machine



GEAR MEASUREMENT

This course is a series of on-line training sessions that will introduce delegates to the key skills and knowledge needed to measure and interpret gear measurement results. No prior gear knowledge is required but those who are new to gear technology would benefit from participating in the BGA Gear Foundation and Introduction to Gear Geometry courses.

Modules

Cylindrical gear geometry measurement Part 1- Introduction to measurement methods and radial composite (double flank) measurement.

- Why we measure gears, failure modes that are influenced by gear geometry
- The requirements of gears and the involute curve.
- Introduce single element measurement (helix, profile, pitch and radial runout) and composite measurement (double flank and single flank) methods
- Look at double flank measurement in more detail including the measurement principles, equipment and ISO 1328-2:2020 tolerance parameters.

Cylindrical gear geometry measurement Part 2- Introduction to tangential composite (single flank) measurement and tooth thickness measurement.

- Introduce single flank measurement in more detail including the measurement principles, equipment, and ISO 1328-1 tolerance parameters.
- Discuss the relationship between single flank measurement, Transmission Error (TE) and links to noise and vibration.
- Introduce fast Fourier Transforms (FFT) without any sums.
- Discuss the benefits and limitations of tooth thickness measurement methods.

Cylindrical gear geometry measurement Part 3- Introduction to single element (helix, profile, pitch and runout) measurement.

- Introduce single element measurement principles and equipment (CMMs and GMMs)
- Discuss the importance of gear datum axis definition for measurement.
- Ensure you are confident with results sheet formats.
- Look at good measurement practice- how to minimise the risk from common errors.
- Discuss the benefits and limitations of single element measurement methods.

GEAR MEASUREMENT CONTINUED

Cylindrical gear geometry measurement Part 4- Introduction to single element (helix, profile, pitch and runout) tolerance standards and how to interpret results to a standard.

- Introduce ISO 1328-1:2013 cylindrical gear tolerance standard.
- Review some of the key features that were introduced with the latest revision.
- Discuss common errors when applying the standard.
- Work through an example to evaluate the ISO 1328-1 quality grade of a gear.

Cylindrical gear geometry measurement Part 5- Introduction to gear measuring machine calibration.

- Introduce common errors in measurement processes
- Demonstrate how we calibrate a simple hand-held micrometer
- Review the common sources of error in CNC gear measuring machines and CMMs with gear software
- Introduce the comparator method and ISO 18653:2003 Gears — Evaluation of instruments for the measurement of individual gears and related information in ISO TR 10064-1:2019
- Show you how easy it is to apply this standard and how you use the results

HEAT TREATMENT OF GEAR STEELS

This course will present the heat treatment of gear steels assuming minimal prior knowledge. After an introduction to the basic metallurgical concepts and key principles, the enhancement of surface properties by carburising and induction hardening will be explained. The properties imparted by, and the consequences and problems of the chosen process with reference to material selection, distortion and growth will be covered with the aid of case histories.

- Introduction to steel heat treatment – metallurgical principles; hardening & tempering
- Carburising
- Introduction to nitriding, nitro-carburising & other surface treatments
- Laser & Electron Beam Hardening
- Induction & flame hardening
- Problem solving – low/high hardness; case-depth
- Controlling distortion

PHASE 2

GEAR WEAR AND FAILURE RECOGNITION

The seminar gives delegates an insight into the appearance and underlying causes of gear failure modes. It provides gear manufacturers and users with the necessary skills to examine, assess and recognise common gear failure modes.

- How gears work and how they fail and wear
- Failure recognition strategy
- An introduction to the common investigation methods and equipment used to establish the root cause of a failure
- An introduction to the ISO 10825 failure modes standard and supporting ISO standards
- Case studies
- Failure recognition- a chance to test your failure recognition skills with 20 failed gear samples

GEAR NOISE AND TRANSMISSION ERROR

This seminar is aimed at both gear users and gear manufacturers. The course will examine the basic causes of gear noise and the path from initial gear design and manufacturing errors to the final noise generation.

Gear Design for Low Noise

- TE and spur gears ,TE and helical gears
- The relation of TE to contact ratios and the concept of integer contact ratio
- Effect of misalignment on tooth contact
- Practical approaches to designing gears for low TE
- TE in planetary gears (theory of factorising and non-factorising)

Noise Signals

- Tooth passing frequencies
- Gear pairs
- Planetary gears
- Run out ; generation of side bands
- Ghost frequencies and their origin

Noise measurement

The practical aspects of noise measurement will be considered in order to correctly diagnose the cause/source of the noise.

GEAR STRESS ANALYSIS

This is a series of on-line training sessions that will introduce delegates to the key skills and knowledge needed to perform gear contact and bending fatigue stress analysis. The course covers the application of ISO 6336 bending and contact stress analysis methods. No prior gear knowledge is required but those who are new to gear technology would benefit from participating in the BGA Gear Foundation and Introduction to Gear Geometry online courses.

It is applicable to gear designers, users of ISO 6336 and those who are involved with gear manufacture and want to understand why designers use tight tolerances and high grade materials.

Modules:

Introduction to gear loads, failure modes and geometry

- Remind us how gears work, gear loads and load direction, what increases the instantaneous load as gear teeth mesh
- Define common gear failure modes
- An introduction to ISO 6336, the scope of the document and its key features
- The principle of how we calculate gear stress safety factors
- Selected terms and symbols- how the ISO symbol strategy works

Introduction to gear load modifying factors and permissible stresses for contact and bending fatigue

- Generic factors that influence the applied predicted load based mainly on ISO 6336-1
- Load application factors and Miner's Sum cumulative damage
- Load dynamic factor
- Accounting for shaft, bearing and housing deflections
- Random manufacturing errors
- Load distribution factors- key influences
- The effect of micro geometry corrections on load
- Review permissible stresses- options in ISO 6336-5

Introduction to gear contact stress and bending stress key influence factors

- Introduce bending stress key influence factors
- Show the effect from reverse torque loading and the effect on bending stress
- Introduce contact stress key influence factors
- Review example analysis results

Introduction to using ISO 6336 and optimising bending and contact safety factors

- Minimum safety factors
- Material quality
- Case depth assumptions and requirements
- Shot peening and residual stress
- Contact marking- interpretation
- Review some application examples and how to optimise ISO 6336 safety factors

GEAR NOISE DATA INTERPRETATION AND DIAGNOSTICS

Noise and vibrations are omnipresent, and while they may seem straightforward to interpret in some scenarios, industrial applications often introduce complexities that require a deeper understanding. This seminar explores the theoretical foundations of noise and vibrations, their sources, modes of transmission, and their implications for both systems and their surroundings. This seminar is designed to share the knowledge and tools necessary to interpret and diagnose noise and vibrations effectively in various industrial applications.

Modules

- Principles of noise and vibrations
- Measurement techniques
- Understanding Gearbox Noise and vibrations
- Gear geometry, microgeometry and Transmission Error
- Gear design optimisation
- Rattle and Whine in gears
- Modal analysis and Modal shapes
- Data analysis and signal processing- time domain plots, FRF, FFT, Hilbert Transforms
- Case studies from a versatile selection of industrial applications

GEARBOX SYSTEMS PROBLEMS & SOLUTIONS

Many reliability and wear problems in transmission systems are not directly associated with the design of the components themselves but are the result of system dynamics: starting and transient torques, self-excited vibration and the dynamics of the motor or engine and of the driven machine. Particular characteristics of bearings, couplings and gearbox mounting can also significantly affect system performance. Typical problems and solutions are discussed and instrumentation for troubleshooting noise, bearing failures, vibrations and in-service load measurement demonstrated.

Modules

- Tackling Unexplained Bearing and Gear Element Failures
- The Dynamics of Gearbox Systems
- Gearbox Noise and Vibration
- Problem Solving using State of the Art Data Acquisition & Analysis Techniques
- Wind Turbine Gearboxes: Type Testing, Instrumentation & Early Stage Troubleshooting
- Gear Alignment Instrumentation (KHβ, KΥ)
- In-Service Unattended Load (Torque) Data Collection Techniques
- Case Studies in Rail, Marine Propulsion, Renewables, Automotive and Heavy Industries
- State of Art Condition Monitoring Techniques

PHASE 3

DESIGN OF EXPERIMENTS

Properly designed experiments will improve understanding of the Cause and Effect relationship in any process. Predictive knowledge of the process, in order to improve it. Control process costs, while meeting or exceeding customer requirements.

The course will cover:

- Background to DOE in understanding the cause and effect relationship
- Understanding data types, and the wide range of experimental tools
- Planning an experiment (including gear measurement considerations)
- Screening trials and observations
- Statistical control and stability
- Analysis of Results via ANOVA and define prediction equations
- Process optimisation to reduce costs
- Case studies

Modules

Introduction to DoE Theory.

- Understand the strategy behind Design of Experiments (DoE/DoX)
- Understand the types of experiments
- Understand the goals of an experimental strategy
- Understand the concept of “between group” variation and “within group”

Methods of Data Analysis:

- Understand the importance of control charts as analytical tools in DoE, and how to interpret them
- ANOM, ANOR, and ANOME
- Understanding multi-level factors and the concept of interaction
- ANOVA for graphical and numerical analysis
- Testing Results via “SPC for Excel®” and “Minitab®”
- General measurement issues
- Evaluating the Measurement Process (EMP) studies

INTRODUCTION TO ROLLING ELEMENT BEARINGS

Bearings are an integral part of all mechanical power transmissions and rolling element bearings are often the most accurate component on the transmission. A good understanding of how they work is essential to those involved in transmission design, manufacture and assembly activities. We will be examining both as run and damaged bearings which illustrate common failure modes.

Modules

- How rolling element bearings work and the history of their development
- Common radial and thrust bearing types and their application
- Benefits and limitations of each type of bearing
- Lubrication considerations
- Calculation of bearing loads caused by the gears and discuss good design practice
- Common bearing failure modes and an introduction to BS ISO 15243:2017 – Rolling bearings — Damage and failures — Terms, characteristics and causes
- Basic bearing life calculation to BS ISO 281:2007 – Rolling bearings — Dynamic load ratings and rating life, for L10 life calculation and the modified life calculation Lmn considering endurance limit, lubrication and lubricant contamination. How do you use them?
- Miner's sum cumulative damage analysis methods to account for varying load conditions
- Examination of failed bearings and typical witness marks on bearings in service

INTRODUCTION TO BEVEL GEARS

Bevel gears play a crucial role in mechanical systems by enabling power and motion transfer between shafts that are not parallel. Even though they are fundamental components, the details of bevel gear transmission can be challenging to grasp, even for experienced engineers. This training session offers a unique chance to explore the fascinating world of bevel gears.

This "Introduction to Bevel Gears" training session is an invaluable resource for anyone eager to deepen their understanding of bevel gear technology. Participants will have the opportunity to dive into the intricacies of bevel gears during this in-depth online course.

Modules

- Bevel Gears Types and General Applications
- Bevel Gear Classifications
- Fundamentals of Geometry
- Offset, Hand of Spiral & Direction of Rotation
- Face Milling – Face Hobbing Comparison
- Basics of the Continuous Indexing System
- Contact Pattern Development
- Tooth Contact Analysis
- Process of Design
- Calculation of Load Capacity
- Production Methods
- Measurement, Checking, and Assembly of Bevel Gears
- Failure Modes
- Optimisation

INTRODUCTION TO GEAR MANUFACTURE

This seminar is aimed at engineers and technicians who wish to gain a sound overview of the manufacturing methods and process available to the gear designer or manufacturer. The seminar will cover the processes available as well as place some specific focus on the link between gear design and the production methodology. All the methods commonly used to produce gears will be introduced. However, the principle focus will be placed on metal cylindrical gear production by either cutting or grinding while looking at the detailed mechanics and design considerations.

Modules:

- Summary introduction of the range of gear production methods
- Summary of heat treatment and surface treatment methods
- Overview of process capability, selection and tooling requirements
- Detailed overview of the gear cutting and finishing processes of cylindrical gears
- Influence of gear production aspects on gear design and performance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