Fall Technical Meeting to highlight 26 compelling presentations

W ith more than three decades of technical conferences, AGMA is no longer a name just synonymous with gear standards. It has become the association to provide members with the latest information in gearing research from industry experts around the world. The AGMA Fall Technical Meeting (FTM) is the premier technical forum in the United States to hear and discuss the latest emerging technology as it relates to gear design, manufacture, operation, and processes.

This year we are on track to have 26 presentations in five sessions: Application, Design, and Rating; Optimization and Performance; Gear Wear and Failure; Manufacturing, Inspection, and Quality Control; and Materials and Heat Treatment. We solicited more than 50 peer reviewers from across the globe to assist us in evaluating all papers in a double-blind review process. All technical papers are published by AGMA and are later indexed in Scopus, the largest abstract and citation database of peer-reviewed literature: scientific journals, books, and conference proceedings. FTM attendees will receive PDF copies of all technical papers from the sessions for which they registered.

Some highlights for this year’s compelling research include a presentation by Sandeep Thube from Sumitomo Drive Technologies on “The Deliberate Application of Theoretical Quantitative Analysis Techniques to Improve Gearbox Development for the Food and Beverage Industry.” His paper explores the ability to design and construct a gearbox that stays in compliance with applicable general standards while optimized to fit the specific requirements of the application. In addition, we have a presentation from Georg Mies of Klingelnberg, who will be discussing the “Full Automated Roughness Measurement on Gears, Even on the Shop Floor.” Through his paper, we will learn about the capabilities of machining technologies that can create extremely smooth surfaces at a more cost-effective rate. The research shared at this year’s FTM will help bring the latest emerging technologies such as 3D printing and automation to the manufacturing floor. Attendees will be able to hear new processes and methods that they could employ to fine tune their manufacturing operations and lower their overall operating costs.

In addition to an information-packed three days, we are inviting FTM attendees to unwind and network in an evening of conversation and games at Pinstripes in Oak Brook. It is important to take a break from the presentations and meet new people or reconnect with peers from across the gear industry. What better way to do that than with great food, bowling, and bocce? This new event combined with luncheons and the welcome reception will make this FTM the event of the year.

As always, the integrity and quality of our conference would not be possible without the help of our reviewers. Therefore, I would like to take this opportunity to thank each and every one of our volunteer experts who helped as peer reviewers as well as the members of the AGMA Technical Executive Committee, chaired by Todd Praneis from Cotta Transmission Company, for their time and valuable assistance over the last several months to help bring you the high-caliber presentations that you have come to expect of the AGMA FTM. I encourage all gear industry engineers and technical experts to attend this year to engage with the researchers and presenters.

This year’s FTM is September 24-26 in Oakbrook, Illinois. Early bird registration ends August 24, so make sure to get your spot as soon as possible. A full list of presentations is available in this AGMA section of Gear Solutions, and presenter bios can be found on the AGMA website at www.agma.org. I look forward to seeing you this September.

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International spline standards and other widely used published documents have detailed definitions of two-dimensional spline geometry, and while they cover basic axial effects and stresses, more can be provided for design engineers. Results from an analytical study of misalignment factors and an experimental study of centering forces will be presented to provide information to help refine calculation methods. These include: how to calculate the effective pressure angle of straight-sided splines that must be used to accurately determine normal and radial loads; how to calculate the effective centering force of a spline pair; how to calculate the centering moment of a spline with “topping”; an update to current publications; and an update to the calculation of the maximum axial force that a spline can transmit via friction.

Methods to Determine Form Diameter on Hobbed External Involute Gears

Hobbed External Involute Gears | Shuo Zhang, Oerlikon Fairfield

Two mathematical methods have been developed to be used for the calculation of true involute form diameter when specialized software or original gear designer information is not easily accessible. These methods are designed for external involute gears produced by the hobbing process, possibly followed by a finishing operation. Method A is a more precise match, but it requires special inputs that may be time consuming. Method B, although not as accurate, still has a relative error of TIF diameter below 0.1 percent over wide ranges of gear design parameters. Method B is also easy to apply and can be integrated into most existing gear design programs.

Optimization of a Rack and Pinion Design for Offshore Jack-Up Applications

Optimization of a Rack and Pinion Design for Offshore Jack-Up Applications | Adrian Nowosky, Oerlikon Fairfield

The presenter will walk you through his concept for best practice of designing a rack and pinion for offshore jacking applications. They will demonstrate the impact of major gear parameters for a pinion design and their impact on the life expectation. They will also show the benefit of a custom pinion design and how much improvement can be achieved with emphasizing the design process properly.

The Deliberate Application of Theoretical Quantitative Analysis Techniques to Improve Gearbox Development for the Food and Beverage Processing Industry

The Deliberate Application of Theoretical Quantitative Analysis Techniques to Improve Gearbox Development for the Food and Beverage Processing Industry | Sandeep Thube, Sumitomo Drive Technologies

The food-and-beverage industry has a variety of gearbox applications that are regulated by governmental industry standards, such as the NSF and the FDA. What if we were to design and construct a gearbox that stays within compliance standards, but may be substantially different from typical industrial requirements? Details of this new gearbox design, developed for food-and-beverage applications, will be discussed. Designers used specific tools to minimize the number of needed prototypes. These tools included: Quality Function Deployment (QFD), Failure Mode Evaluation Analysis (FMEA), and computational ‘Finite Element Analysis’ (FEA). 3D printing was used to find design defects at early stages and validate the gearbox assembly procedure.

In this paper, the author will analyze the effects of thermal distortion on the profile geometry and tooth contact parameters in the transverse plane of a spur gear by calculating the steady-state temperature distribution relevant to immersion depth, temperature, and lubrication regime in the contact area. Then, thermally distorted geometry and tooth contact analysis is computed by means of a 2D finite element model where load distribution, transmission error, backlash, and other parameters will be analyzed. The results of the study will allow one to set the limits of design backlash to avoid gear jamming and to size the initial profile shift or tooth modifications to reach the desired contact behavior.

Oil-Off Characterization Method Using In-Situ Friction Measurement for Gears Operating Under Loss-of-Lubrication Conditions

Oil-Off Characterization Method Using In-Situ Friction Measurement for Gears Operating Under Loss-of-Lubrication Conditions | Aaron Isaacs, Gear Research Institute, Applied Research Laboratory – Penn State University

The oil-off performance evaluation of gears is of significant interest to the Department of Defense and various ro rocotor manufacturer s so the aircraft can safely land in an accidental loss-of-lubricant situation. However, unlike typical gear failure modes, gear failure in an oil-off situation is very rapid and likely catastrophic. This presentation describes the procedure and instrumentation used for an oil-off test to measure the frictional loss in the test gear mesh and the “air” temperature just out of mesh. Sound and vibration data was also recorded during testing. Data from typical failures showing the detection of scuffing onset and its progression to catastrophic failure for gears made from several aerospace alloy steels is presented.

Application of Finite Element Analysis for the Strain Wave Gear Tooth Surfaces Design and Modifications

Application of Finite Element Analysis for the Strain Wave Gear Tooth Surfaces Design and Modifications | Zhiyuan Yu, Penn State University

This presentation is on a rigorous definition and parametric study of tooth surface modification of the strain wave gear. You will see that optimal modification for a sample strain wave gear is found from FEA and tested by contact pattern, transmission error, and life cycling experiments. The resulting innovative design with modified fully conjugate tooth surface improves accuracy, backlash, and the life of the existing design.

Experimental Study on the Pitting Detection Capabilities for Spur Gears Using Acoustic Emission and Vibration Analysis

Experimental Study on the Pitting Detection Capabilities for Spur Gears Using Acoustic Emission and Vibration Analysis | Mateusz Grzeszowski, Technical University Berlin, Chair of Electronic Measurement and Diagnostic Technology

During this presentation, you will learn about an experimental investigation on spur gears to characterize the pitting degradation process using monitoring features. Previous investigations have revealed that pitting has an impact on the gear
vibration behavior. But is it possible to detect pitting at an early stage using acceleration sensors and acoustic emissions (AE) sensors to avoid consequential damages and subsequent correction activities? Come learn of this experimental investigation on spur gears to characterize the pitting degradation process using monitoring features. You will hear about the results of the investigation, including how the results show a detection of pitting is possible several hours before complete gear failure and more.

Optimization of Power Density by Local Gear Failure Modeling | Marco Kampka, Fraunhofer USA

Power density is a key factor in gear design. Increasing the power density enables engineers to use smaller gears for their applications, which leads to smaller and lighter gear boxes. The most common way to design gears is using industry standards in which material strength can be obtained either from fatigue limit tables or by means of empirical formulae. Due to limited empirical data, a lot of averaging and approximations are used to make the available standards applicable to a wide range of applications. To design the gear closer to the power density limit, a high level of information is necessary. The presenter will present how local FEA-based calculation approaches can be used to design gears closer to their power density limits for pitting, tooth root breakage, and flank fracture. The calculation results will be validated in running tests on different test rigs.

Load Intensity Distribution Factor Evaluation from Strain Gauges at the Gear Root | José Calvo Irisarri and Unai Gutierrez, Gamesa Energy Transmission (Spain)

Strain gauges are commonly used to obtain the load intensity distribution on the flank of a gear mesh. To get the load distribution on the flank, the strain data must be processed and changed into load intensity distribution on the tooth flank. Research has been conducted on the best methodology to place strain gauges when calculating load intensity distribution on the flanks of a gear. The presenter will discuss these research methods that use FEA modeling and his analysis of how to deal with the effect of strain gauge positioning errors, in order to find the optimal placement.

Impact of Root Geometry Manufacturing Deviations from a Theoretical Hob Rack on Gear Bending Stress | Rahul Nigade, Eaton Technologies Pvt. Ltd. (India)

Gear reliability is a key requirement of any automotive transmission. Two common failure modes of gears are pitting and bending fatigue. So, the total gear reliability depends upon the bending and pitting reliability. Come and listen to a comparison of a theoretical root fillet geometry generated by the hob racks of gear drawings to an actual measured tooth fillet geometry of manufactured gears, which determines the impact of the different root fillet geometries on tooth bending stresses. An emphasis will be placed on the importance of using a root fillet geometry truly representative of the actual gears in production for the bending stress calculation to get the required bending reliability which can be achieved in the field.

Fatigue Life Predictions of Spherical Gear Couplings | Ibai Ulaci, Mondragon University (Spain)

Spherical gear couplings are mechanical components that allow transmitting torque by means of equally spaced teeth. Modern roll-leveling machines are characterized to level high-strength steels by using small rolls under high torque requirements. The small size of the rolls decreases the space between the spline couplings, causing misalignments up to 7 degrees. The presenter will discuss a geometry-generating procedure that has been developed for both the hub with internal teeth and the crowned teeth shaft in spherical gear couplings. A finite element model has been developed to study the effect of backlash and misalignment on the number of teeth in contact and root stresses. Finally, fatigue tests are performed, and numerical predictions are correlated with experimental results.

Potentials of Free Root Fillets in Planetary Gearbox Applications | Jonas Pollaschek, Laboratory of Machine Tools and Production Engineering (WZL) of RWTH Aachen University

Planetary gear stages are commonly used in many different fields of application, including wind turbine and automotive gearboxes. In this presentation, you will hear about a potential for increased root load carrying capacity at the planet gear of a planetary gear application. The approach considers local material characteristics such as hardness, fatigue strength, and mean stress sensitivity, as well as residual stresses and different stress ratios that result from the mesh with the sun and ring gear. It offers a detailed tooth contact analysis based on the Finite Element Method. The result of this work allows for the possibility of changes in the gear design.

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In the last few years, improvements in clean steel technology have been coupled with development of new ultra-high-strength, high-toughness steels. These technologies provide affordable solutions for critical, power-dense components. The presentation will review and compare steel cleanliness metrics between re-melted steels and steels that meet AGMA grade 3 cleanliness. The new steels provide yield strengths ranging from 175-210 KSI, ultimate tensile strengths ranging from 230-250 KSI, and Charpy impact energies ranging from 35 to 50 foot-pounds, allowing these grades to provide longer life, more power, and/or lighter weight. The higher fatigue strength of these steels is compared to more commonly used gear steels, and an analysis is presented that illustrates a potential for either a 30-percent reduction in gear set mass or a 45-percent increase in gear set torque capacity.

Reliability of Gears — Determination of Statistically Validated Material Strength Numbers I Michael Hein, Gear Research Center (FZG) – Technical University of Munich

This presentation is intended to provide a review on the statistical reliability behavior of cylindrical gears with regard to pitting and tooth root breakage failures. A mathematical reliability approach was developed and drafted to expand standardized load capacity calculation methods. The deduced models and procedures allow the consideration and conversion of different reliability levels in the design process of cylindrical gears. Practical examples of the research will be provided.

Combining Ultra-High-Strength and Toughness for Affordable Power Densification in Steel Gears I Buddy Damm, TimkenSteel

In the last few years, improvements in clean steel technology have been coupled with development of new ultra-high-strength, high-toughness steels. These technologies provide affordable solutions for critical, power-dense components. The presentation will review and compare steel cleanliness metrics between re-melted steels and steels that meet AGMA grade 3 cleanliness. The new steels provide yield strengths ranging from 175-210 KSI, ultimate tensile strengths ranging from 230-250 KSI, and Charpy impact energies ranging from 35 to 50 foot-pounds, allowing these grades to provide longer life, more power, and/or lighter weight. The higher fatigue strength of these steels is compared to more commonly used gear steels, and an analysis is presented that illustrates a potential for either a 30-percent reduction in gear set mass or a 45-percent increase in gear set torque capacity.

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