

American Gear Manufacturers Association Fall Technical Meeting 2015

Detroit, Michigan, USA
18-20 October 2015

ISBN: 978-1-5108-1555-1

Printed from e-media with permission by:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571



Some format issues inherent in the e-media version may also appear in this print version.

Copyright© (2015) by American Gear Manufacturers Association
All rights reserved.

Printed by Curran Associates, Inc. (2016)

For permission requests, please contact American Gear Manufacturers Association
at the address below.

American Gear Manufacturers Association
1001 N. Fairfax Street
Suite 500
Alexandria, VA 22314-1587
USA

Phone: (703) 684-0211
Fax: (703) 684-0242

webmaster@agma.org

Additional copies of this publication are available from:

Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571 USA
Phone: 845-758-0400
Fax: 845-758-2633
Email: curran@proceedings.com
Web: www.proceedings.com

Session I – Materials & Heat Treatment

Influence of Surface Finishing on the Load Capacity of Coated and Uncoated Spur Gears....1

Philip Konowalczyk M.Sc., Laboratory for Machine Tools and Production Engineering (WZL) of RWTH Aachen University

PVD/PECVD coatings have been proven to increase the pitting and scuffing resistance of materials. However, due to concerns that the application process of PVD/PECVD coatings leads to a reduction in tooth root strength, as well as high production costs, the use of these coatings have not been adopted by the gear industry. The aim of this work is to investigate and determine the influence of surface finishing processes specifically the impact of PVD/PECVD coatings applied using an optimized coating process, on the pitting load capacity of gears.

Improved Materials and Enhanced Fatigue Resistance for Gear Components....12

Dr. Volker Heuer, ALD Vacuum Technologies

To answer the demand for fuel-efficient vehicles, modern gearboxes are built much lighter. Improving fatigue resistance is a key factor to allow for the design of thin components used in advanced transmissions. The choice of material and the applied heat treat process are of key importance to enhance the fatigue resistance of gear components. This presentation shows the latest progress in steel grades and case hardening technology for gear components.

Practical Approach to Determining Effective Case Depth of Gas Carburizing....28

March Li, Lufkin Industries, LLC

This presentation shows calculations of the effective case depth governed by carburizing temperature, time, carbon content of steel, and carbon potential of atmosphere. This method provides simple and practical guidance of optimized gas carburizing and has been applied to plant production.

Case Hardening for Mass Production of Gears with Minimal Distortion and Maximum Repeatability....40

Maciej Korecki, Seco/Warwick

This presentation looks at the major causes of deformation during traditional heat treatment and methods of their control, correction, and elimination. A case hardening system will be presented, which allows individual adjustment to the size and shape of the particular gear, in order to minimize hardening distortion and ensures ideal repeatability of results throughout the gear series. Additionally, this presentation will discuss the operational aspects, the costs, and productivity.

Innovative Steel Design and Gear Machining of Advanced Engineering Steel....55

Lily Kamjou, Ovako

This presentation will describe how shot peening may be eliminated in high cleanliness, as-carburized steel components using an alternative composition. The fatigue performance of such a solution is compared to conventional grades used today, both with and without shot peening. It will also deal with the production process, including quantitative machining trials and the importance of tooling selection.

Powder Metal Gear Technology: A Review of the State of the Art....67

Anders Flodin, Höganäs AB

Several hurdles had to be overcome to put powder metal gears into automotive transmissions, such as fatigue data generation on gears, verification of calculation methods, production technology, materials development, heat treatment recipes, design development, and cost studies. The advancements needed—and achieved—to overcome these hurdles will be discussed, and examples of current vehicles using powder metal gears in transmissions will be shown.

Session II – Manufacturing

Industry 4.0 and its Implication to Gear Manufacturing....78

Dr. Hermann J. Stadtfeld, The Gleason Works

This presentation will provide an overview of the Industry 4.0 initiative and discuss the four industrial periods from the viewpoint of gear manufacturing. It will discuss in depth the techniques and elements of the “cyber physical production systems” and how they will change the way of industrial manufacturing.

Proposed Pre-Finished Cylindrical Gear Quality Standard....102

Peter Chapin, The Gleason Works

Final gear quality can be vastly different from pre-finish quality. Using finished gear quality class such as ANSI/AGMA ISO 1328 is not recommended or even appropriate for pre-finish gear quality evaluation. This presentation will outline a proposed standard for pre-finished cylindrical gear quality for typical finishing operations. It proposes to only include the inspection elements that are important to properly evaluate pre-finished gear quality as it applies to the finishing operation.

Influence of Hobbing Tool Generating Scallops on Root Fillet Stress Concentrations....121

Benjamin Sheen and Matthew Glass, Eaton Corporation

This paper will discuss the specific example of parallel-sided splines manufactured with a finish hobbing process and the effects of generating root fillet stress concentrations. To estimate the value of the stress concentrations, finite element analysis was performed on the components for two unique hobbing tool designs. The FEA results were then correlated to actual components with known field service lives.

Selecting the Proper Disc Cutter Design for Milling of High Quality Parallel Axis, Cylindrical Gears and Splines....131

Brent Marsh, Sandvik Coromant

This presentation will provide a comprehensive view of topics such as tool selection, material selection, and surface finish requirements to assist the manufacturing engineer or process planner in successfully choosing the design of disc mill cutters, in order to make cost effective cylindrical gears to the appropriate quality.

Simulation of Hobbing and Generation Grinding to Solve Quality & Noise Problems....150

Prof. Dr.-Ing. Günther Gravel, Institute for Production Engineering, Hamburg University of Applied Sciences (HAW)

When deviations occur during generation manufacturing of gear teeth, it is not easy to pinpoint the causes due to the tool design and complex kinematics. A simulation tool has

been developed to allow the simulation of typical faults that occur during hobbing and generation grinding to help solve quality and noise problems. This presentation will discuss practical examples to demonstrate applications for the simulation program.

Session III – Gear Application

Thermal Capacity of a Multi-stage Gearbox....161

Benny Wemekamp, SKF Engineering Research Centre

In many industrial gearbox applications, the thermal rating is a key factor in the practical utilization of the gearbox. A simulation tool that goes beyond traditional thermal estimation methods, such as those found in ISO/TR 14179, by calculating the interaction between heat losses, thermal expansions, and (bearing) pre-loading, has been used to understand the interaction between mechanical and thermal equilibrium.

Minimum Backlash of Helical Gear Pairs in Complex Shaft Gearbox Systems....173

Dr. Carlos Wink, Eaton Corporation - Vehicle Group

Increasingly, there has been pressure on gearbox designers to reduce the noise produced from a gearbox, especially in the truck market where engines are running at lower speeds to increase fuel efficiency. An analytical model was developed to determine the minimum backlash of each gear pair when not transmitting load, and thus susceptible to generating a noise, at lower transmission power paths.

New Refinements to the Use of AGMA Load Reversal and Reliability Factors....181

Ernie Reiter, P.Eng., Web Gear Services Ltd.

Information will be presented on two ways to calculate a load reversal factor, which will be material specific, based either on Modified Goodman or Gerber failure theories. This presentation will further provide a method of calculating the reliability factors which very closely match the tables found in ANSI/AGMA 2101-D04.

*Homogeneous Geometry Calculation of Arbitrary Tooth Shapes –
Mathematical Approach and Practical Applications....196*

Dipl.-Ing. Maximilian Zimmer, Gear Research Centre (FZG), Technical University of Munich

This presentation will outline a mathematical framework, and its implementation, for calculating the tooth geometry of arbitrary gear types, based on the basic law of gear kinematics. The mathematical algorithms are summarized in implemented software modules for the particular gear types.

Rating for Asymmetric Tooth Gears....213

Dr. Alexander L. Kapelevich, AKGears, LLC

This presentation will describe a rating approach for asymmetric tooth gears by their bending and contact stress levels in comparison with equivalent symmetric tooth gears, whose rating is defined by standards. This approach applies FEA for bending stress definition and the Hertz equation for contact stress definition. It defines equivalency factors for practical asymmetric tooth gear design and rating.

Session IV – Lubrication, Efficiency, Noise & Vibration

Worm Gear Efficiency Estimation and Optimization....228

Massimiliano Turci, Studio Tecnico Turci

This presentation will outline the comparison of efficiencies and of transmissible torques of worm gear drives with center distance sized from 28 mm to 150 mm and single reduction from 5 to 100, calculated by several standards (AGMA, ISO, DIN, BS). It will also outline the experimental works required for the calibration of an analytical model, now used for bevel and cylindrical gears only, but ready to become suitable to predict worm gear drive efficiency too.

Investigations on the Efficiency of Worm Gear Drives....243

Dipl. Ing. Eva Maria Mautner, Gear Research (FZG), Technical University of Munich

This presentation will examine the efficiency and the load carrying capacity of worm gears. The tests performed consisted of generally pairing a bronze worm wheel with a case hardened worm with center distances between a 65 and 315 mm. In the course of these investigations, overall gearbox efficiencies of up to $\eta = 96\%$ were achieved.

Polish Grinding Gears for Higher Transmission Efficiency....265

Walter Graf, Reishauer AG

This presentation introduces a new gear polish grinding process and describes its multiple benefits, especially to makers of automotive transmissions. The overall increase in efficiency realized through the new polish grinding process has been demonstrated through independent scientific studies and field trials. The production process and economic considerations of this new process will also be discussed.

Development of a New Class of Industrial Gear Oil....278

David B. Gray, Evonik Oil Additives

A new class of industrial gear lubricants, based on alternative synthetic materials, has been developed to satisfy the critical market performance expectations, ensure global supply chain security, and address both economic and performance challenges. This presentation will describe the technical aspects of the novel synthetic gear oil lubricant approach.

Noise Reduction in an EV Hub Drive Using a Full Test and Simulation Methodology....289

Dr. Owen Harris, Smart Manufacturing Technology, Ltd.

With the current trend towards electric vehicles more work is being conducted in the area of noise reduction specific to these vehicles. This presentation will outline a series of tests and simulations that have been performed to specifically look at noise reduction in an EV hub drive. A detailed methodology is presented, combining both a full series of tests and advanced simulation to troubleshoot and optimize an EV hub drive for noise reduction.

Tribological Coating Wear and Durability Performance Guideline for Gear Applications....311

Randy Kruse, The Timken Company

It is important to understand the performance enhancement limits of DLC tribological coatings so that gear and bearing engineers can accurately specify and predict system life. This presentation reports the results of testing a tungsten incorporated diamond-like carbon coating as applied to SAE4320 and AMS6308 gear materials using a ball on disk test machine under conditions that simulate the contact stresses and sliding velocities of gears.

Session V – Gear Wear & Failure

An Experimental Evaluation of the Procedures of the ISO TR 15144 Technical Report for the Prediction of Micropitting....325

Donald R. Houser, The Ohio State University

This presentation will provide practical information on some of the idiosyncrasies of using the ISO/TR 15144 micropitting prediction methodology. A review of the ISO methodologies is presented and its application in a spreadsheet analysis using contact stresses predicted from load distribution prediction is discussed.

Calculating the Risk of Micropitting Using ISO Technical Report 15144-1:2014 – Validation with Practical Applications....343

Dr. Burkhard Pinnekamp, RENK AG

This presentation describes the calculation method in ISO Technical Report 15144-1:2014 and its application to practical examples where micropitting has either occurred or not. The examples give evidence, that the Technical Report reliably predicts the risk of micropitting where it is later found on the gear flanks, and it does not do so when the gears run without micropitting.

Wear: A New Approach for an ‘Old’ Failure Phenomenon of Gears....359

Dr. Ing. Ulrich Kissling, KISSsoft AG

This presentation outlines research conducted on gear wear and how it affects the performance of the gear over time. The progress of wear is calculated step by step

because the tooth form changes as it becomes worn, and therefore the load distribution will change over the meshing. This new calculation method predicts the modification of the tooth contact area through wear and the consequences for the gear behavior.

Application of Advanced Mesh Analysis to Eliminate Pinion Field Failures....374

Terry Klaves, Power Transmission Solutions – Regal Beloit America, Inc.

This presentation will walk through a specific case study involving field macro pitting failures on production helical gearing. It will include evaluation of the pitting failures for root cause, review of gearing service factors, and application of advanced mesh analysis tools to define root cause of the failures.

Tooth Flank Fracture – Influence of Macro and Micro Geometry....384

Dr. Stefan Beermann, KISSsoft AG

This presentation discusses the first results obtained from a systematic variation of gear parameters – both for the macro geometry, (mainly the pressure angle) and the micro geometry (with tip reliefs of various kinds and profile crowning)–to show the influence of these parameters as modeled by the method being developed by ISO/TC 60 Working Group 6.