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AGMA Technical Paper

Comparison of the AGMA and FEA Calculations of Gears and Gearbox Components Applied in the Environment of Small Gear Company

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[The statements and opinions contained herein are those of the author and should not be construed as an official action or opinion of the American Gear Manufacturers Association.]

Abstract

The current AGMA standards provide a lot of information about the calculations of loose gears and gearbox components – shafts, splines, keys, etc. These recommendations are based mostly on the “traditional” methods of mechanical engineering, found in many classical textbooks and research papers. Their accuracy and reliability have been proven in many years of gearbox design and field tests. They are clear, concise, in most cases easy to program and apply even by a small gear company with limited resources.

However new methods for calculations of mechanical engineering components like FEA (finite element analysis) are becoming wide spread. Once these techniques were used only by big companies because of their complexity and price but with the development of the computer technology they become more and more accessible to small gear companies which are the majority of participants in the market.

In nowadays gear business even a small gear company is usually in possession of a modern CAD system which always includes a basic or advanced FEA package. Such CAD systems are most often run by one gear engineer who makes 3D models, engineering calculations and production drawings. The level of the FEA packages is such that it allows the gear engineer to be able to do components calculations without deep knowledge in the FEA itself.

So the question about the effectiveness of the traditional AGMA calculations and the new FEA methods becomes of vital importance particularly for small firms.

The presented paper compares AGMA with FEA strength and deflection calculations of spur gears and gearbox components and draws conclusion and recommendations about their effectiveness in the environment of a small gear company.

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American Gear Manufacturers Association
500 Montgomery Street, Suite 350
Alexandria, Virginia, 22314

October 2010

ISBN: 978-1-55589-980-6

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Introduction

AGMA calculations

The current AGMA standards [1] provide a lot of information about the calculations of loose gears and gearbox components – shafts, splines, keys, etc. These recommendations are based mostly on the “traditional” methods of mechanical engineering, found in many classical textbooks and research papers. Their accuracy and reliability have been proven during many years of gearbox design and field tests. They are clear, concise, in most cases easy to program and apply even by a small gear company with limited resources. Though the AGMA standards and information sheets are excellent source of gear information they are not recommended for beginners.

FEA calculations

A new method – Finite Element Analysis (FEA) – is used nowadays extensively for calculations of the strength and deflections of mechanical engineering components. Before it was used only by big companies because of its complexity and price, but with the development of the computer technology it becomes more and more accessible to small gear companies, which are majority of participants on the market. Almost all FEA manuals require simplification of the parts. This approach is very dangerous for gearbox components where the part features are very close to each other and every one of them usually influences the stress concentration of the other and the whole part. The proper modeling of the gearbox parts and assemblies requires mesh refinement which needs a lot of computing resources not always available to the small firm. It is common during the calculations to get a message that there is not enough calculation power, especially if convergence process is used. Apart from the mesh refinement the finite elements themselves require special attention, which usually is beyond the scope of the gear engineer knowledge. The FEA has its own inherent errors for each of its

stages – modeling, discretization and solution [4], that's why it is recommended to be only one of the methods for engineering design.

The small gear company

In nowadays gear business even a small gear company is usually in possession of a modern CAD system which always includes a basic or advanced FEA package. Such CAD systems are most often run by one gear engineer who makes 3D models, engineering calculations and production drawings. The level of the FEA packages is such that it allows the gear engineer to be able to do components calculations without deep knowledge in the FEA itself.

So the question about the effectiveness of the traditional AGMA calculations and the new FEA methods becomes of vital importance particularly for small firms.

This paper presents comparison of calculations of gears and gearbox components carried out according to AGMA standards and information sheets, and according to FEA package, which is part of commercially available CAD system [3].

Comparison of AGMA and FEA calculations

Table 1 shows the direct comparison of the capabilities of AGMA standards and information sheets and FEA to calculate gears and gearbox components. It also suggests that FEA is superior to AGMA and should be used extensively. However it is necessary to remember that FEA has its inherent errors as mentioned above and the AGMA calculations are empirical and proven by field experiments. It is sometimes very difficult to make direct comparison between the two methods. AGMA calculations in most cases are fatigue calculations based on proven fatigue data. Only high level FEA software is capable of doing fatigue calculations. This paper considers calculations which can be compared by both approaches – gear teeth, shafts and splines. Keys and bolts