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Reliable Measurements of Large Gears

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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

Large gears have become an indispensable part of modern technical applications. The expanding industrial sectors of power generation and transmission, like shipbuilding industry, wind turbine generators and petroleum conveying systems, have led to an increasing demand for large-scale gear boxes. Thus, the qualified measurement of large gears has become more and more important as well. Their conformance with specifications according to ISO 14253-1 [1] has to be proved, which is not possible without a qualified statement of the task-specific measurement uncertainty. As a consequence, the manufacturing processes cannot be controlled quantitatively and at a reasonable process capability level, especially if tolerances are small compared to the achievable measurement uncertainty. This specifically applies to large gears.

In recent years, large gear metrology has gained in importance among the research activities at PTB. In this report, three current projects are presented. First of all the first national comparison for large involute gears is described. It has been organized by PTB and is just about to be finished. The measurement results are included in this paper. As a second step towards traceable measurements of large gears, a special calibration laboratory is intended to be established. This is part of a joint research project, in which a new measurement artifact of 2 m in diameter has been developed. Lastly, information about a Joint Research Project within the European Metrology Research Programme which will start in September 2014 is provided.

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Introduction

The Physikalisch-Technische Bundesanstalt (PTB) has developed new large involute gear measurement artifacts up to 2 m in diameter and corresponding calibration techniques. These can be used to quantify the quality of large gear manufacturing processes for the first time. This fulfills the essential demands from industry which can be traced back to the tremendous growth of wind energy systems during the last few years. The gear measurement artifacts represent different internal and external gears usually used in wind mill gear boxes. Their workpiece-like design allows convenient handling on conventional gear measurement instruments or coordinate measuring machines with or without rotary tables.

The first large involute gear artifact representing a cut-out of an external gear of 1 m in diameter was developed in 2010. A national comparison with nine partners from industry will be finished soon. The presented results will give an impression of the reliability of large gear measurements under consideration of different types of measurement machines and different measurement strategies.

Within another joint research project a complete traceability chain for large gear metrology is to be established. New measurement artifacts embodying internal as well as external large involute gears with different helix angles are manufactured. Moreover, a calibration laboratory for large gearings will be accredited.

Finally, the European Metrology Research Programme (EMRP) recently decided to support a major project focusing on traceable measurements of drivetrain components. Six other European metrology institutes and designated institutes as well as partners from industry and universities will participate. For the first time metrology traceable to the SI will be provided for the measurement of highly accurate components of renewable energy systems such as wind energy systems or tidal power generators.

In this paper the above-mentioned projects together with the current results are presented. On that basis the challenges of measuring large gears, the consequences for a qualified statement of the task specific measurement uncertainty and future activities in that field are discussed.

First intercomparison for large involute gears

In 2010 the world's first large measurement artifact for involute profile and helix measurements was developed at PTB, see Figure 1. It represents a cut-out gear segment with a diameter of 1 m and embodies three different helix angles and directions. Its parameters are listed in Table 1.

Table 1. Gear parameters of large measurement artifact

Parameter	Value
Gear type	external (1 segment, 3 different gear specifications)
Number of teeth	38/37/36
Normal module	20 mm
Pressure angle	20°
Face width	400 mm
Helix angle/hand	0°/spur; 10°/right; 20°/left
Outside diameter	1000 mm
Root diameter	905 mm
Material CTE	Steel/11.5 $\mu\text{m}/\text{K}/\text{m}$
Weight (including dismountable counter mass)	450 kg (700 kg)
Reference bands diameter (form deviation)	200 mm (1 μm)