Title: **High Torque Gear (HTG) - The New Premium Class in Azimuth Thruster Gear Technology**

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Abstract

Under the project title “high-torque-gear (HTG)” SCHOTTEL´s mechanical development team together with Dresden university´s institute for machine elements (IMM, TU Dresden) has developed fundamentally new kind of bevel gears specially optimized for the azimuth thruster application. The whole project, consisting of several sub-projects covers a development period of almost exactly 10 years.

The idea of the HTG came up around 2005 in a period of significant growth of the offshore market and a resulting lack of large bevel gear sets for offshore thrusters.
This bottleneck even limited the business for SCHOTTEL and there seemed to be no way out of the dilemma due to the very limited number of large specialized bevel gear production machines worldwide. In this situation SCHOTTEL teamed up with Dutch gear manufacturer BIERENS who had already started to copy standard spiral bevel gear shapes of Klingelnberg type using more or less standard 5-axis milling centers. In the following years SCHOTTEL made production tests and manufacturing accuracy surveys and even tested such new gears under load to bring this production method into safe application for azimuth thrusters. The final results in accuracy of the new production method were so promising that several innovative ideas for macro geometry and flank topography of the bevel gear sets came up.

This was possible using the almost unlimited kinematic freedom of the 5-axis machines. Ideas were further worked out around 2008-2011 within a governmentally founded research project, which leads to several international patent applications. The project was completed by a software development, which allows modeling, and calculating the HTG gears under consideration of displacements and elastic deformations of the underwater gear system of the azimuth thruster, which transmits all thrust and steering forces and is further exposed to dynamic sea loads and thermal expansions.

As a result a full design package with locally calculated stress and safety values at each individual point of the gear flank contact under any load situation is generated ready to be transmitted to the CNC 5-axis machine; even the reverse calculation of measurement values of machined gear sets is possible. It can be proven that a significant safety increase of all relevant design criteria such as pitting and micropitting safety, sub-surface fatigue safety, scuffing safety and tooth breakage safety can be reached at once. This was proven both in simulation with the new software and by extensive series tests on independent test benches at SCHOTTEL R&D and Dresden university and meanwhile also in multiple applications of different thruster sizes. Safety increases of approximately 20% have been demonstrated by tests.

As a conclusion SCHOTTEL can offer a complete closed-loop system of design and production of significantly improved thruster gear technology which is also used as standard in the recently released Ecopeller thruster series (SRE) which actually was awarded the Fuel Efficiency Award of the European Marine Engineering Conference.