Tips for designing grease-lubricated gearboxes: The SPN steering drive as an example

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Developing efficient and durable gearboxes is a key challenge in mechanical engineering. An optimized design is especially important for steering drives because they are subject to high loads and speeds. Lifetime lubrication is often necessary to ensure that the gearbox operates without requiring additional lubrication.

To minimize wear and prevent overheating, the lubricant must be distributed evenly. SPN Schwaben Präzision (SPN) sometimes uses grease in its travel drives for this purpose.

Grease has several advantages: it allows for the use of cost-effective seals; it is less volatile; it remains stable over a longer period of time; and it adheres well to the relevant points, even at low speeds.

Challenges in gearbox design

Using grease also presents unique challenges. The key is determining the optimal amount of grease. Too little grease results in insufficient lubrication, and too much grease reduces efficiency and can cause overheating.

At the same time, the housing must be designed so that the grease is effectively retained at critical points. This requires optimized geometries that guarantee the formation of grease reservoirs and keep the grease in place, even at high speeds.

Simulation-based optimization of lubricant distribution

Simulation-based tools are increasingly being used to overcome the challenges of lubricant distribution in gearboxes. SPN Schwaben Präzision uses the Particleworks software for this purpose. Particleworks is based on the MPS (moving particle semi-implicit) particle-based method. This method accurately simulates the movement, distribution, and heat generation of lubricating grease.
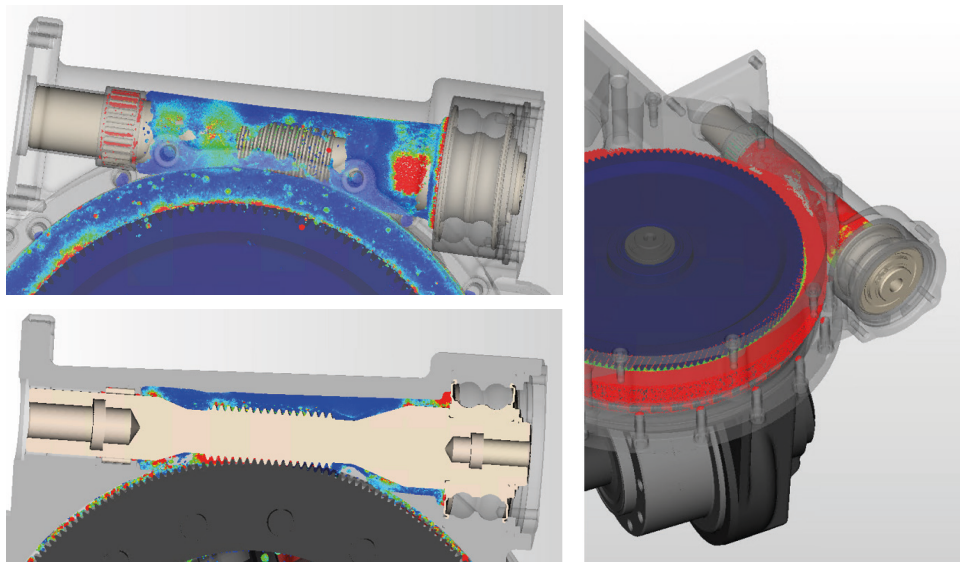
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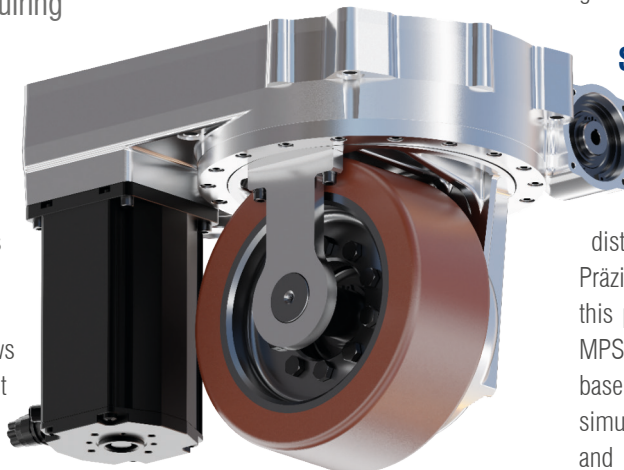
Fig. 1, Fig. 2, Fig. 3. Grease distribution in the simulated steering drive.

The software tracks the movement of individual particles, making it advantageous for simulating complex fluid movements such as lubricant distribution in gearboxes.

In the simulation, the lubricating grease is modelled as a non-Newtonian fluid. Rheological data from the lubricant manufacturer is taken into account, particularly the kinematic viscosity as a function of shear rate. The complete calculation of the Navier-Stokes equations within the software enables precise modelling of the flow dynamics.

Creating grease reservoirs

The simulation results are valuable tools in the field. They enable the selective adjustment of the housing geometry to create grease reservoirs near critical lubrication points, such as tooth flanks and bearings. This optimization process enables pockets, grooves or recesses to be developed to redirect the grease in a targeted manner, ensuring its presence at critical points, even at high speeds.

The simulation results also help to determine the optimal amount of grease. It should be noted that both a lack and an excess of
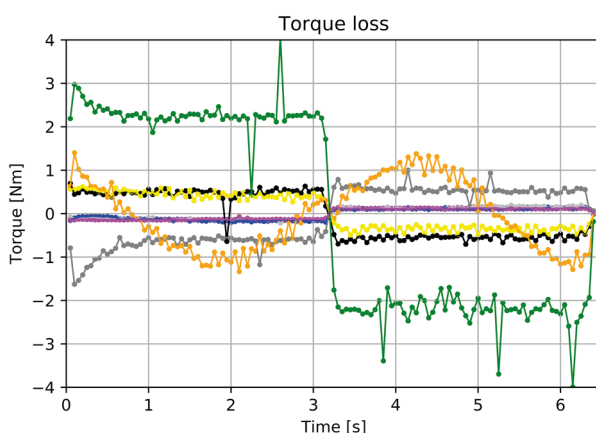

Fig. 4. Torque loss in Nm: with simulations developers can and developers not only the lubrication performance and the service life of a gearbox but also minimize efficiency losses minimize efficiency losses.

grease can negatively impact gearbox performance. The type of grease used is also crucial. Its kinematic viscosity must meet the demands of high speeds and loads, while ensuring high shear stability in the intended application.

Validating simulation results

SPN Schwaben Präzision's testing laboratory conducted physical tests in order to realistically reproduce the demanding simulations associated with lubricating greases. The developers compared grease distribution using transparent housings. The results showed that the simulation accurately replicated real lubricant distribution and grease reservoir formation. In addition, the simulation software parameters were optimized to achieve comparable loss torques for common types of gears.

Using simulations strategically improves lubrication performance and service life in gearboxes while minimizing efficiency losses. The result is better technical performance and reduced overall operating costs, including lower energy requirements.

Conclusion

The purposeful use of this type of simulation improves lubrication performance and the service life of gearboxes, while also minimizing efficiency losses. This results in increased technical performance and reduced operating costs, such as lower energy consumption. Intelligent housing design, an optimal grease quantity, and targeted grease distribution can make travel drives more efficient, durable, and economical.

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About SPN

SPN Schwaben Präzision is a technology-independent gearbox designer with a high-tech production facility in Nördlingen in Germany. Around 300 employees at the Nördlingen headquarters develop and manufacture gearboxes, gearing elements, drive systems, and components for drive technology and mechatronics in a 10,300m² production area. The focus is always on the customer's individual requirements. Drive solutions from SPN are precisely tailored to these requirements, even in small quantities.

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