Test stand for internally cooled metal gears

Int´l Conference on Gears 2019

Dr. **Hans-Jörg Dennig**, **Simon Winterberg**: Both Zurich University of Applied Sciences, Winterthur Switzerland

Newly emerging manufacturing processes, in particular selective laser melting (SLM), open up new possibilities for the manufacturing of components. Examples include functional integration and the production of complex geometries. With this process, already known materials will be processed in a new way.
Drive systems must be made lighter and more efficient. Smaller mass moments of inertia and optimized design for cooling, lubrication and tooth meshing can noticeably increase the efficiency of gears. Gears manufactured using the SLM process with typical gear steels offer great potential. For example, an integrated cooling system (Figure 1) can reduce the amount of required lubrication and thus the ventilation and splashing losses.

Figure 1 SLM Gear with internal cooling channels

A typical failure mode which can be influenced by such a cooling principle is the scuffing of the gears. Since the scuffing resistance depends essentially on the prevailing temperature, internal cooling of the gear can reduce the risk of scuffing.
In the event of a shortage of lubricating oil or an interruption of the lubricating film, the metallic flanks rub directly against each other, which leads to short-term local welding. Sufficient lubrication improves the service life and increases the efficiency of the gearing. Due to the lubricating effect of the mostly liquid lubricant, the unavoidable friction between the tooth flanks is reduced to a minimum and thus the power loss is reduced. The power loss is

usually noticeable as undesirable heat generation. In order to achieve the highest possible efficiency of the gear body, heat generation must be avoided as much as possible. The heat generated must nevertheless be removed with the aid of lubrication in order to avoid overheating and damaging the gear body. In some cases, more than 80% of the lubricant used is required for cooling the gear bodies. The increased lubricant requirement leads to increased gear no-load losses and therefore reduces the efficiency of the gear unit.
The use of splash lubrication is generally understood, especially at low gear speeds. However, splash lubrication leads to high gear no-load losses. With high-speed gearings, a significant part of the power loss is generated by friction losses of the circulating, partly turbulent, flows, which are so-called ventilation losses. If a gear wheel can be sufficiently cooled via integral cooling channels, this loss will be reduced, and the gear will become more efficient. The question arises as to how much lubricant can be reduced in order to keep the service life of a gear wheel constant. If the lubrication lines are too large, too much lubricant is thrown away. The cooling part of the lubricating oil thus gets into the gear housing, which leads to ventilation losses. If the lubrication lines are too small, too little heat can be applied.
In order to verify the problems mentioned above, an electrically braced gear test rig at the Zurich University of Applied Sciences was modified in a partial work package of a project 25648.1 PFIW-IW funded by Innosuisse (Figure 2), so that, for example, FZG-A gears with a centre distance of 91.5 mm can be supplied with internal cooling channels. For this purpose, the shafts were equipped with rotary feedthrough and deep-hole bores. Based on the scuffing load capacity according to DIN 3990-4, certain load stages can be run, and conventionally manufactured gear pairs can be compared with additive manufactured gears. The scuffing safety (integral temperature and flash temperature) can thus be verified.

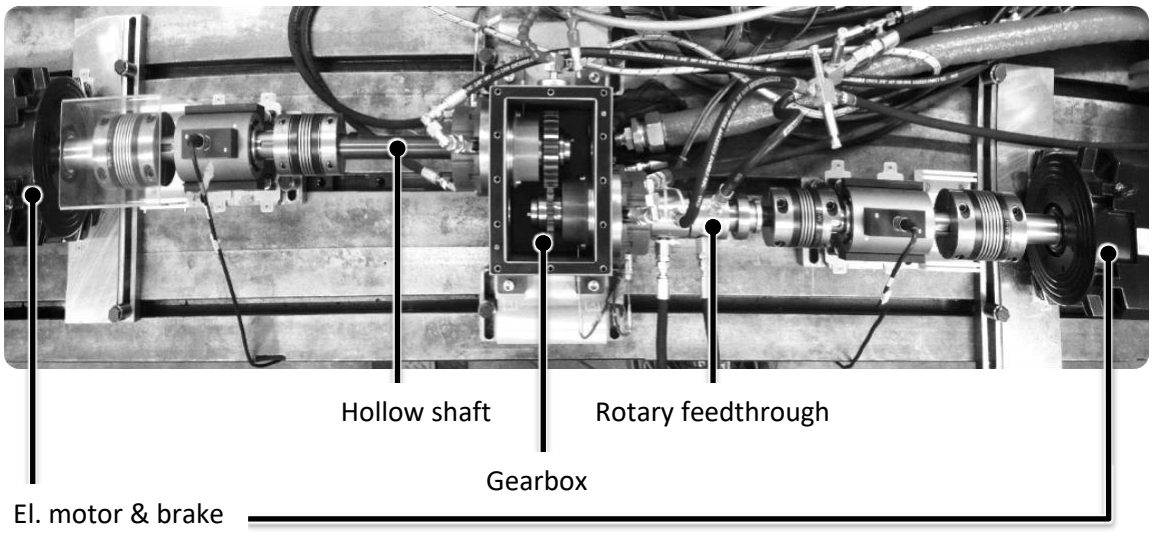

Figure 2 SLM Gear with internal cooling channels