Stereo-PIV Study of Oil flow Inside a Model Gearbox

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For dip lubrication system, the correct amount of oil is important, an excessive amount of oil will lead to high load-independent losses (viscous losses), but on the other hand, too little oil will not provide sufficient cooling for the gears (Höhn, et al. 2008). Current work reveals the flow structure around the test gear and three-dimensional flow streamlines in the recirculation regions in the vicinity of the test gear as well as the shape of the three dimensional boundary layer. Measurements in the meshing region clearly showed the details of the squeezing flow and the effect of the squeezing flow on the overall flow inside the gearbox.

Experimental Setup

Stereo-PIV setup was used to measure the oil flow inside the model gearbox. Two cameras (Imager X Pro 4M) with 105-mm f/2.8 Sigma lenses and low-pass filters (570 nm) were placed on the either side of the liquid prism with 45° angle. Nd-YAG laser equipped with the laser guiding arm and laser sheet optics was used for particle illumination. The test oil was a hydrotreated process oil and seeded with spherical fluorescent Rhodamine B-based polymer particles with mean diameter of 10 μm. Figure 1 shows the experimental setup and the measurement plane.

Fig. 1 Experimental setup and measurement location

Results and Discussion

PIV results were a phase-average from 100 images. The vector calculation was performed in multipass procedure with decreasing window size. Initial interrogation window size was 64×64 pixel with 50 % overlap and square 1:1 weighing factor for the first 2 passes. Final 3 passes were performed with 32×32 pixel window size, 50 % overlap and round 1:1 Gaussian weighing factor.

Figure 2 clearly reveal the three-dimensional flow structure inside the gearbox. Figures 2 (b, d) show the flow in the crossflow plane. These recirculations are one of the sources of the load independent losses in the gearbox. Previous study by Changenet and Velex (2008), suggested that power losses can substantially be reduced by mounting flanges close to the lateral faces of the wheels. Presumably, this happens because of the reduced volume of the recirculation regions.

Conclusion

Stereo-PIV measurement of oil flow inside the model gearbox has been done for two different pitch line velocities (0.55 m/s and 1.1 m/s) below the gear and in the meshing region. The measurements were successful due to specially developed setup with maximized optical access and the refraction index matching of the test oil and of the gears. This study complements the previous study (Hartono et al., 2013). Current information provides solid background for future numerical studies of the flow inside the gearbox, which aim at optimizing the oil flow in order to decrease the viscous losses and optimize cooling.

Fig. 2 Velocity fields of oil flow below the gear, with oil level at the centerline; (a, c) Vt = 0.55 m/s; (b, d) Vt = 1.1 m/s

Fig. 3 Crossflow velocity field at the meshing region with fully filled box; (a) Vt = 0.55 m/s, (b) Vt = 1.1 m/s