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Motion Tracking for Mechanical Load Tests of Gear Boxes

Precise Long-Term Displacement Measurement with the IDS3010

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Introduction

The components in drive engineering industries need to be tested for numerous mechanical characteristics, e.g. gear boxes need to be checked for long-term smoothness, synchronization, backlash, torsional stiffness, tribological behavior, and/or mechanical resilience [1, 2]. Testing laboratories are equipped with various test benches for analyzing the gears under close to real world conditions. While the production series components require continuous quality checks of the work pieces, newly developed prototypes need to be tested in order to identify and assure their technical characteristics.

WITTENSTEIN alpha – a Strategic Business Division of attocube´s parent company WITTENSTEIN SE – develops and produces mechanical and mechatronic servo drive systems for applications that require maximum precision. The testing facilities of WITTENSTEIN are fitted with gearbox test benches. WITTENSTEIN uses attocube´s fiber-based interferometer IDS3010; which provides picometer resolution and up to 10 MHz real-time data outputs, in their vertical, linear motion test bench. The test bench focuses on testing the long-term stability of the mechanical parameters of planetary gear boxes in rack & pinion drive systems.

Setup

The test bench setup includes a mass of 400 kg that is moved in the vertical axis. This load is coupled to a rack and pinion system that is driven by a WITTENSTEIN alpha gearbox and a servomotor.

The primary position feedback is based on a conventional glass scale. Since the glass scale is limited in accuracy, flexibility and in detecting high frequency vibrations, the initial setup was not capable of gathering all data needed by this test bench. To understand the behavior of the gearbox better, the test engineers were looking for a more precise measurement system that is easy to integrate into the existing setup.

To acquire more accurate displacement data, an IDS3010 was subsequently integrated into the setup. The compact and modular design of the sensor head as well as the flexible glass fiber cables enabled a fast installation and quick alignment. After less than two hours from starting the integration, the first measurement was performed and the IDS3010 continued

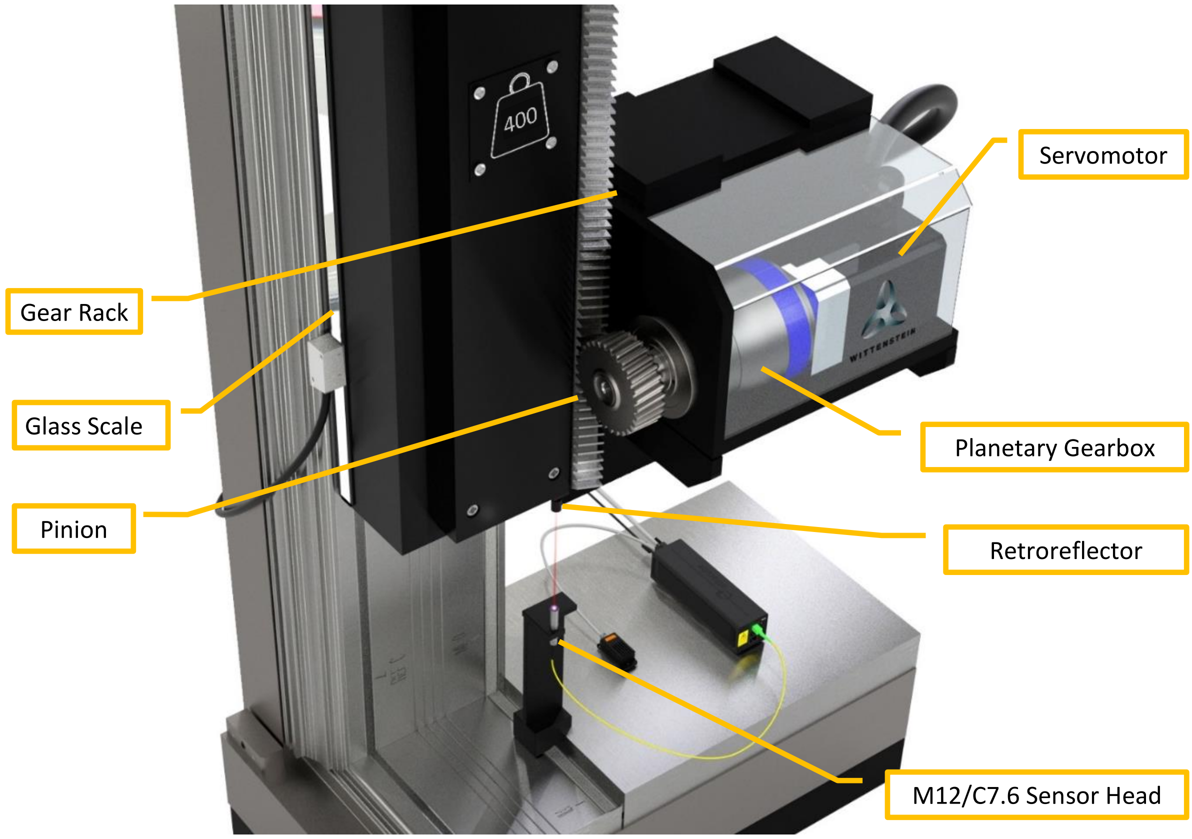

Figure 1: Test bench for mechanical load tests of a gearbox

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measuring over the entire 0.747 meter working range. Figure 1 shows the test bench including a retroreflector that was mounted on the 400 kg weight and a M12/C7.6 collimating sensor head, while reading out the analog Sin/Cos data from the IDS3010 with a 1 MHz bandwidth.

Measurement Results

Figure 2 shows the displacement data of a few cycles over the entire working range. The cycles turn out to be close to a sinusoidal-shaped curve as seen in subplot (a). Subplot (b) zooms in on an interesting region of the curve: the turning points of the movement. Here, the high-resolution displacement data provides new insights into the gearbox behavior concerning the synchronization and the transmission error.

The ability to explore the details down to the nanometer scale opens new opportunities for frequency and movement analysis. With the IDS3010 and further optimization, it should be possible to visualize the impact of single teeth of the planetary gearbox. Furthermore, as seen in subplot (e), the differences in the two methodologies illustrate that the glass scale readings provide less accurate measurement data. Due to the periodicity of the difference between the two signals, it is clear that it is not based on noise or changing measurement inaccuracies, but that the glass scale encoder is located far away from the

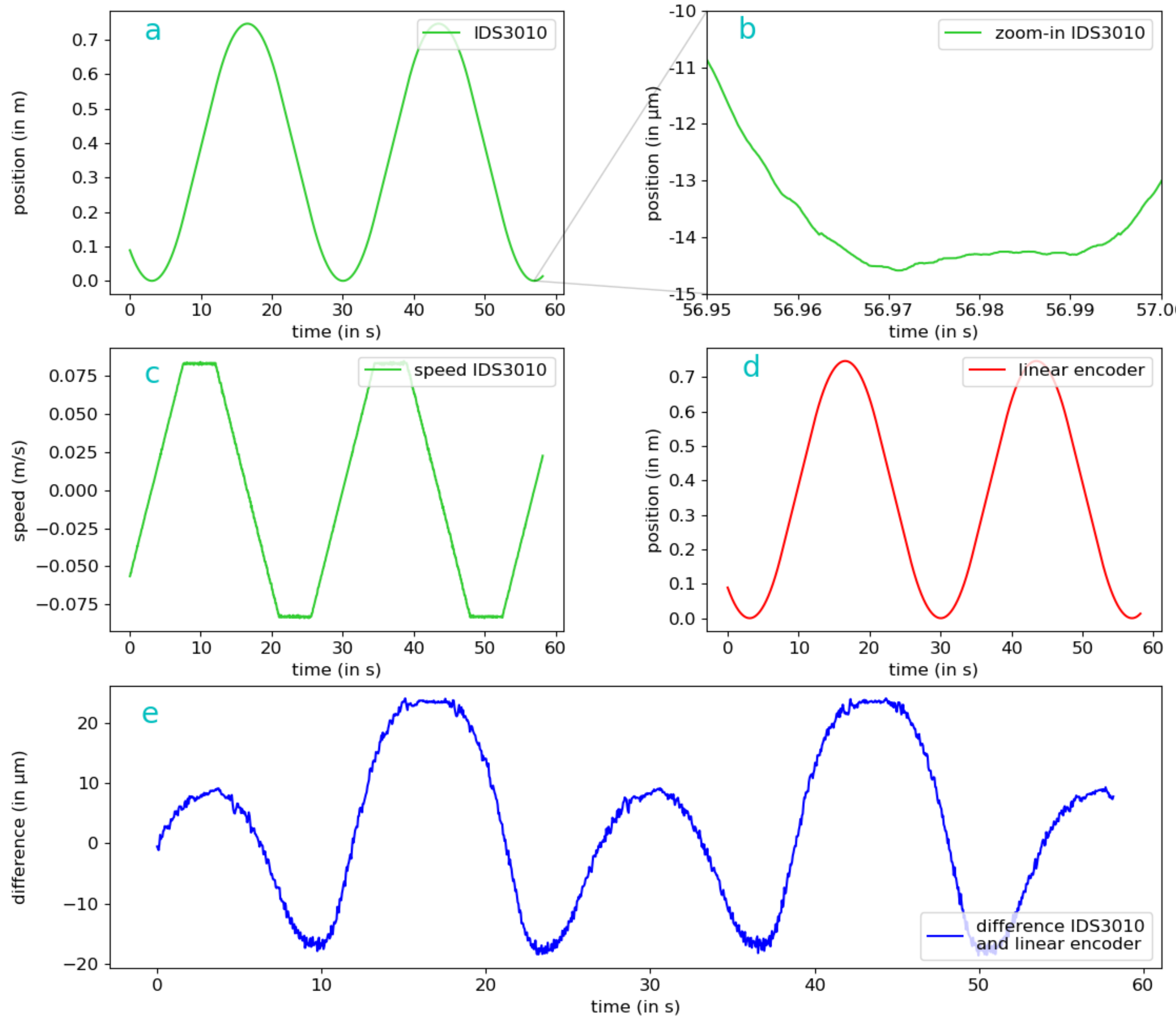

Figure 2: Displacement data of the weight moved by the gearbox. (a) shows the position of the mass that was measured with the IDS3010. (b) is a 160 000 times magnified segment of a) to show the precision of the interferometric measurement. (c) is the speed measurement of the weight movement obtained from the data of a). (d) is the same measurement as a) but with an optical linear encoder – which looks similar until one looks at the detail of the difference – as seen in plot (e).

measurements point of interest and the glass scale is not as accurate or precise. Furthermore, the IDS3010 with its optical components has further clear advantages such as the compact sensor head and retroreflector with their negligible masses.

Conclusion

As shown in this Application Note, the IDS3010 improves the achievable accuracy and resolution of the test bench. The laser based measurement and the miniaturized components allow to measure as close as possible to the point of interest, without influencing the setups behavior. This enables test and development engineers to determine more mechanical and tribological phenomena that could not be detected using a glass scale. Moreover, the IDS3010´s compact design, easy installation, and fast alignment allow the flexible application and set-up at multiple test benches within one lab. Since the IDS3010 measures up to 5 meter working distances while simultaneously measuring up to three optical axes, the interferometer can also be utilized for larger test benches.

References

[1] R. Russo, R. Brancati, E. Rocca: "Experimental investigations about the influence of oil lubricant between teeth on the gear rattle phenomenon", Journal of Sound and Vibration, Volume 321, Issues 3-5, 2009, Pages 647-661.

[2] Y. Chen, A. Ishibashi: "Investigation of the Noise and Vibration of Planetary Gear Drives", GEAR TECHNOLOGY, Jan/Feb 2006.