Damage detection in high performance gears using a magnetoelastic sensor to measure rate of change of torque

A. Clarke[a], B. Cahill[a], R. Pullin[a], K.M. Holford[a]

[a] Cardiff School of Engineering, Cardiff University, The Parade, Cardiff, CF24 3AA

1. ABSTRACT

The detection of damage in gear systems remains a challenging area of research, with much research effort directed towards the application of techniques including vibration and acoustic emission to detect a range of failures such as micropitting and tooth root fatigue failure.

This paper presents the results of series of experiments designed to investigate the applicability of magnetoelastic sensing technology to the detection of damage in high performance spur gears. This sensing technology is relatively well established for the non-contact measurement of torque in shafts [1] and has more recently been extended to provide a signal which is directly proportional to the rate of change (RoC) of torque in the magnetised component [2].

The technology was fitted to a high speed (up to 15000 rpm) back-to-back gear pair test rig specially developed for this investigation. Gear pairs with a range of damage levels (essentially bent teeth of up to 20 microns deviation from involute, representative of damage caused by transient overloads) were compared to non-damaged gears in order to establish the link between signal characteristics and damage. An example of the signal over one complete shaft rotation from a gear with a single-tooth damage level of 8.7 µm is shown in Figure 1, where the meshing frequency can clearly be seen in the form of 27 pulses, one occurring each time a tooth enters the mesh. The damaged tooth, located at approximately 240° of shaft rotation, can be seen to produce a significant increase in RoC as it meshes. A range of signal processing techniques and metrics are used to characterise the signal produced by both healthy and damaged gears. The RoC monitoring technique is demonstrated to have the potential to detect very minor levels of tooth damage with high accuracy.

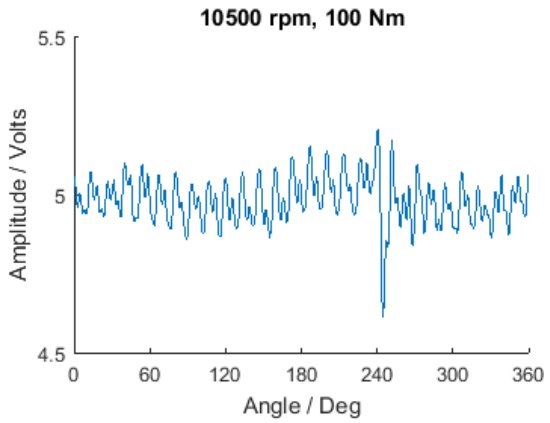

Figure 1: Example signal from a gear with tooth damage

[1] Bitar, S, Probst, J.S. & Garshelis, I.J., Development of a Magnetoelastic Torque Sensor for Formula 1 and CHAMP Car Racing Applications, SAE Paper 2000-01-0085, 2000.

[2] Kari, Ryan & Garshelis, I.J. & Wong, T.-H & Ghosh, R & Evans, D. Magnetoelastic rate of change of torque sensor-based health monitoring system for bearings in helicopter powertrains. Annual Forum Proceedings - AHS International. 2. 1608-1617, 2011.