ABSTRACT

The objective of this research is to propose a torsional vibration model and a signal based monitoring system for a multi-stage helical gearbox, which is a multi-stage automotive transmission gearbox with three helical gears under synchro-meshed conditions.

A relation between the current drawn by an induction motor; driving the gearbox; and the torque function or torsional vibration at its shaft is derived in order to show the relation between the two proposed technique. The torsional vibration model of the gearbox contains various non-linear parameters like gear mesh stiffness and damping at each gear pair and frictional torques at each gears. A simple algorithm is proposed to determine the parameters for various defective cases of gears. These parameters are approximated as Fourier series functions. Out of two solution techniques, viz. Floquet theory and Harmonic Balance Method (HBM), HBM is found to be suitable for solving the second order non-linear differential equations arising in the model. It is inferred from the simulation result that each defective conditions can be separated from the defect-free gears by considering Dynamic Transmission Error as a measure of vibration response.

The signal based fault detection technique uses an experimental set up where an induction motor is used to drive the gearbox and a DC generator is used to apply or remove loads. Three signals viz. vibration, noise and motor current signature are investigated for detecting a number of defective cases under steady and transient load conditions. The signals are analyzed using various signal processing and statistical techniques. It is observed that FFT analysis of vibration and noise signature are sufficient to detect defects in the gearbox. But FFT analysis and Demodulation were not efficient in tracing the gear mesh frequencies in the current signature. But a corrected Multiresolution Fourier Transform (MFT) can trace the gear mesh frequencies in current. Any change in the probability distributions of amplitudes of vibration and current signature with defects and loads is effectively monitored using D-stat, the statistic of Kolmogorov-Smirnov (KS) Test. A monitoring scheme is proposed that can be extended to any other type of gear systems.