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Gear shocks : non linear dynamic model and parametric identification

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ABSTRACT

This paper develops an experimental and numerical study of dynamic phenomena involving gear shocks with one loose gear (non engaged gear pair) inside an automotive gearbox. The idle gear noise generated by those shocks is particularly ill perceived by consumers. This noise can appear while either the gears are engaged or in neutral.

The aim of the present study is to define a simple and realistic model of contact able to describe dynamic shocks between gears with invariant parameters for several frequencies, levels and kinds of excitations. In a higher point of view, this model had been developed for the synthesis of dynamic excitation source in vibroacoustic modeling of gearboxes and for a better understanding of measurements in gearboxes. The method presented in this paper combines both signal processing techniques and topological approaches of contacts in multibody modeling. A large experimental campaign had been performed during this study for checking and improving dynamic models. The design and the manufacture of the test bench and the use of special tools in signal processing has allowed managing a phenomenological and parametric study for the dynamic behavior of a pair of gears in a gearbox while outlining a specific approach of shocks which are sources of the idle gear noise.

The first step of this study is to develop experimental and signal processing tools which clarify the underlying phenomena. Particular attention is given to the relationship between the drive shaft excitation and the energy and nature of shocks. A specific test bench had been designed for this study. This test bench and a validation campaign are presented in the first part of the paper. A presentation and commentary of an experimental campaign follows.

The second step consists in the topological modeling of contact. This approach defines the contact between two solids using a single degree of freedom non linear elastic and dissipative model. Simulations confirm the accuracy of the model for several kinds of excitations.

The model and the most important simulation’s results:

- The built model is a non linear single degree of freedom in rotation composed of 9 independent and invariant parameters.
- The identification of each parameter was performed with an analytic and

numerical approach or by measurement on a single dynamic test. All simulations were carried out with the same set of parameters and reveal a very close fit with experimental measurements this applies as well to the entire field of idle gear noise in terms of acceleration magnitudes and frequencies. Kinematically, shocks are predicted in magnitude, duration, number and decreasing.

Several simulations were performed and reveal important points in accordance with experimental measurement:

– The energy level of shocks mainly depends on the acceleration level of the main shaft (without any actual dependence on the excitation frequency),

– The number of shocks strongly depends on the angular displacement of the main shaft (without any actual dependence on the excitation frequency),

– The excitation level at which shocks appear is identified, predicted and closely connected with the acoustic phenomenon called idle gear noise.

At this point, the study is oriented and conducted to undertake a vibroacoustic model of the gear box based on this study of a single couple of gears. The aim of this work is to show the predictable vibroacoustic behavior of a complete gear box with a small number of (non linear) Degrees of Freedom.

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