A hypoid gear pair tribo-dynamic model taking into account the rheological behaviour of fully formulated gear lubricants

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Leonidas Paouris, Stephanos Theodossiades, Ramin Rahmani, Gregory Hunt

Abstract: A fully coupled tribo-dynamic model, capable of predicting the inefficiency and dynamic response of automotive differential hypoid gear pairs, is presented in this study. A gear dynamics solver is coupled with an analytical friction solver, which calculates the viscous shear, as well as the boundary conjunctional friction force. The time varying geometry and contact characteristics of the hypoid gear pair are taken into account by using realistic data available in the literature. The rheological models employed cover a range of two different behaviors: Newtonian and non-Newtonian Eyring (shear thinning). The Chittenden-Dowson equation is used to calculate the central film thickness of the elasto-hydrodynamic teeth conjunctions. The boundary friction force is calculated using the Greenwood & Tripp model. Finally, the actual surface topography of a run-in hypoid gear is obtained using a stylus profilometer. The results indicate an overestimation of the viscous friction by the Newtonian model, as opposed with the non-Newtonian model, mainly due to shear thinning effects. Comparative studies are performed for different operating conditions, namely near or away from resonance, as well as for conditions corresponding to a non-linear sub-harmonic resonance. The frictional damping effect on the dynamic transmission error, which is an indication of the NVH response of the gear pair, is also examined.

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[1] Leonidas Paouris, M.Sc. (Ph.D. student): Loughborough University, Wolfson School of Mechanical & Manufacturing Engineering, University Road, Loughborough, Leicestershire, LE11 3TU, UNITED KINGDOM (L.Paouris@lboro.ac.uk), the author presented this work at the conference.

[2] Stephanos Theodossiades, Professor: Loughborough University, Wolfson School of Mechanical & Manufacturing Engineering, University Road, Loughborough, Leicestershire, LE11 3TU, UNITED KINGDOM (S.Theodossiades@lboro.ac.uk).

[3] Ramin Rahmani, Ph.D.: Lecturer, Wolfson School of Mechanical & Manufacturing Engineering, University Road, Loughborough University, Loughborough, Leicestershire LE11 3TU, UNITED KINGDOM (R.Rahmani@lboro.ac.uk).

[4] Gregory Hunt, Ph.D.: Research Chemist, The Knowle, Nether Lane, Hazelwood Derby, Derbyshire DE56 4AN, UNITED KINGDOM (Gregory.Hunt@Lubrizol.com).