

EFFECTS OF FRICTION ON VIBRATION OF GEAR TRANSMISSION SYSTEMS

Sasanka Sekhar Ghosh

Supervisor: Dr. Goutam Chakraborty

Dynamics of Machine Laboratory, Department of Mechanical Engineering

Friction is believed to play a major role in producing vibration and noise in gear transmission system. During meshing, the gear and pinion undergo rolling and sliding action, except at the pitch point, where pure rolling takes place. In this thesis the effects of both rolling and sliding friction on the dynamics of spur and helical gears are investigated. The effects of friction on dynamic transmission error, vibration responses along the line of action, off-line of action and axial direction and bearing forces along these directions are also studied in time and frequency domain. The multi-degree-of-freedom models developed by He et al. (2007a, 2007b) are extensively used with certain modification mainly to include rolling resistance, static transmission error. Since rolling resistance is considerably smaller than sliding friction, the former is usually neglected in gear dynamics. The present study shows that the rolling resistance has profound effect on reducing the overall efficiency of the gear transmission system. Its influences on dynamic transmission error (DTE), dynamic mesh forces are quite small, although the effect of rolling resistance on the power loss is considerable. The effects of sliding friction have been studied by incorporating the friction force using different models proposed by various researchers. The sliding friction affects the dynamic force mainly along the off-line of action (OLOA) direction. In this thesis an attempt is made to get an optimum tooth profile modification considering the strength, durability and noise. This optimal modification is found by minimizing a suitable objective function that includes the maximum values of the gear tooth force, peak to peak value of bearing force on pinion shaft along the direction of line of action (LOA), as well as along the off-line of action (OLOA).

It is known that gear vibration becomes more vigorous when the rotational speed belongs to certain range of operating speed. The cause of this large amplitude oscillation is the dynamic instability due to parametric excitation. The problem of parametric instability of a spur gear system has been studied analytically by applying harmonic balance method as well as numerically by using the Floquet theory.

In all the above cases, care has been taken to compare the results of numerical simulation and analytical results with the experimental values as far as available in literature.

Keywords: Time-varying Mesh Stiffness, Static Transmission Error (STE), Dynamic Transmission Error (DTE), Sliding Friction, Rolling Resistance, Parametric Instability, Optimal Tooth Profile Modification, Profile and Pitch Error.