DYNAMIC TRANSMISSION ERROR MEASUREMENTS

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The paper deals with the dynamic transmission error (TE) measurements of a simple gear set at gearbox operational conditions that means under load and during rotation. The analysis method is focused on the processing of impulse signals generated by incremental rotary encoders attached to the gears in mesh. The analysis technique benefits from demodulation of a phase-modulated signal. The theory is illustrated by experiments with a car gearbox and measurement errors are discussed.

Key words: *gears, transmission error, measurement, Fourier Transform, Hilbert Transform, Hilbert transformer, analytic signal*

1. Introduction

Mechanical power is transmitted from a driving gear to the driven gear by means of force F_{T} acting along the line of action. This force is balanced by the same and antiparallel force F_{S} acting at the shaft support point. The simultaneous acting of the force couple F_{T} and F_{S} to the driven gear results in torque, see Figure 1. The teeth contact stiffness is not a constant but it is oscillating in synchronism with toothmeshing frequency due to the variation of the number of tooth pairs in contact and moving the teeth contact point along the tooth flank. The variation of the tooth contact stiffness causes the self excited angular vibration of the driven gear, which results in the time varying forces F_{T} and F_{S}. The force acting at the shaft support is dynamic as well and excites the vibration of the gearbox housing and consequently radiating noise.

Therefore, noise and vibration problems in gearing are mainly concerned with the smoothness of the drive. The parameter that is employed to measure smoothness is the Transmission Error (TE) [1]. This parameter can be expressed as a linear displacement at a base circle radius defined by the difference of the output gear's position from where it would be if the gear teeth were perfect and infinitely stiff. Many references have attested to the fact that a major goal in reducing gear noise is to reduce the transmission error of a gear set. Experiments [2] show that decreasing TE by 10 dB results in decreasing transmission sound level by 7 dB.

This paper is focused at the problem of TE measurement as a part of the experimental study of the tooth contact dynamics. These measurements can contribute not only to the theoretical modeling, which is well developed, for instance, by [3], but to gear design improvements [4]. Low noise, high load capacity and long time servicing gears are a result of employing the high contact ratio tooth design. The effect of improving design can be experimentally tested by TE measurements. The introductory chapters deal with the

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