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Precessional gear-box research regarding vibration activity behaviour

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Abstract. An ideal dynamic system in general and precessional transmissions in particular should not generate any vibration, because vibration is equal with loss of energy and bigger sound level emission. In our previously research we were focused on different vibro-acoustical aspects regarding kinematical and power precessional planetary gear-box when precessional reducer is minimal and maximal filled with cooling and lubrication liquid at different operational speed (power precessional transmission K-H-V Type) and vibro-acoustical behaviour for kinematical precessional transmission 2K-H Type. In this paper I will analyse vibration behaviour for power precessional gearbox 2K-H Type regarding vibrations that occurs at bearings and main shaft misalignment. Vibration research and analysis will be made using GUNT PT500 Machinery Diagnostic System. Data acquisition will be made using acceleration sensor type IMI603C01 for FFT analysis in GUNT PT500.04 software. Obtained results will be compared with German standard VDI-2058 "Limit value for vibration severity".

1. Introduction

The purpose of modern-day machines in general and gearbox in particular is to carry out needs-based on maintenance, good working conditions and to minimize the repair and other servicing downtimes and dysfunctionalities. This increases the overall equipment effectiveness and optimizes the cost. The mechanical condition of a machine or a machine component can be accurately diagnosed from the nature and extend of vibration they generate. The aim is to detect damage as it occurs, allowing scheduled repairs or maintenance to be carried out in time [1].

Vibration in planetary precessional gear box occurs at bearings, gear wheels, misaligned shafts, imbalance rotating parts, couplings. If damage occurs, not only the dynamic processes change, but also the forces that act on system components [4].

2. Vibration generation sources in the planetary precessional gear

Precessional planetary transmission is a mechanical system subjected to mechanical oscillations generating vibrations and noise and can be divided into the following groups: dimensional deviations of sliding contact elements, dimensional deviations at machine parts that make rolling contact, static and dynamic imbalance and assembly errors vibration [1].

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2.1. Dimensional deviation of sliding contact elements
Precessional gear units that engage with the engaging frequency $\omega_z = z \cdot \omega_1$ where z teeth number and ω_1 the angular velocity of the main shaft, are a source of vibration and noise and a transmission quality indicator. The roles of the satellite, which form a kinematic twist-axle roller, are also a source of vibration:

- dimensional and shape deviations of the rollers and axles;
- changing the position of the rollers in the solicited and unsolicited area of the satellite crowns as well as the stiffness of the contacts;
- uneven motion of tapered rollers as a result of different stresses depending on the position.

2.2. The Dimensional deviation at machine parts that make rolling contact
Precessional planetary transmission typically includes 3 pairs of bearings: the main shaft bearing, the crankshaft, which support the precession and rotation movement of the satellite shaft, and the driven shaft. The separate level of vibration and bearing noise influences the general level of pre-planetary planetary transmission and its competitiveness. The bearings act through different effects (direct or indirect) at the vibration and noise level of other elements (shafts, satellite block, housing) [4].

The roller bearing contact may have the following causes:

- changing the position of the rolling elements (rollers or balls) in the loaded or unloaded area of the bearings, in relation to the dimensional deviations and the number of rolling elements. Also, periodically modifying the stiffness of the contacts and the system by favouring the occurrence of parametric type vibrations;
- non-uniform motion of the rolling body due to different and complex loads (especially in the satellite block bearings) depending on the position; this uneven motion and strain also leads to friction and collisions of the wheel bodies or cages;
- making roll-over contacts on surfaces with dimensional, shape and position deviations: diameters, frontal or radial tread patterns, eccentricity, ovality, corrugation, roughness;
- the movement of rolling body over impurities placed on contact surfaces or localized defects or damage (Pitting tipping, abrasive wear, fingerprints, etc.)

2.3. Static and dynamic imbalance
When the centre of mass of a moving or rotating element does not coincide with the centre of rotation (or precession), an imbalance is created, which may be in a plane called static or multi-plane imbalance, known as dynamic imbalance. Generally, in any machine, the shafts have a small imbalance that will generate a sinusoidal vibration with a frequency equal to that of the rotation motion.

The central deviation of the masses of the satellite block from the precession centre "O" with an "a" value generates phasic vibrations (Figure 1). Solution: static balancing of the satellite block at the design stage.

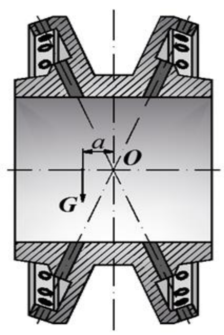

Figure 1. Satellite block imbalance

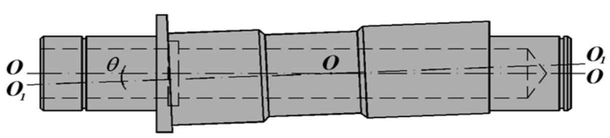

Figure 2. The crank shaft imbalance