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Experimental Research on Vibrations of Double Harmonic Gear Transmission

Sava Ianici, Draghiţa Ianici

Gears transmission can be important sources of vibration in the mechanical system structures and can have a significant share in the overall vibration level. The current trend of significant increase in powers and speeds transmitted by modern mechanical systems, along with the size reduction, may cause a worsening of the behaviour of transmissions with gears in terms of vibration, especially when the optimization criteria were not respected in the design, execution and installation phase. This paper presents a study of vibrations that occur in a double harmonic gear transmission (DHGT), based on experimental research. The experimental researches revealed that in a double harmonic gear transmission the vibrations are initiated and develop in the multipara harmonics engagement of the teeth and in the kinematic couplings materialized between the wave generator and the flexible toothed wheel. These vibrations are later transmitted by means of the shafts and bearings to the transmission housing, respectively, through the walls of it, propagating in the air.

Keywords: *double harmonic gear transmission, flexible wheel, vibration, amplitude, experimental research*

1. Introduction

Radial harmonic gear transmission have been imposed over the last period of time through the most diverse applications in almost all domains of peak technique (construction of industrial robots, ships and cosmic rockets, airplanes and helicopters, radar antennas, motoreducers, servomechanisms, etc.) [1, 2, 3, 4, 5, 6, 7, 10, 11, 15, 16, 17].

In the category of radial harmonic gear transmissions are included the double harmonic gear transmission (Figure 1), which contains the following elements: 1 – the wave generator, 2 – the flexible toothed wheel. 3 – the rigid toothed wheel, 4 – the rigid mobile wheel.

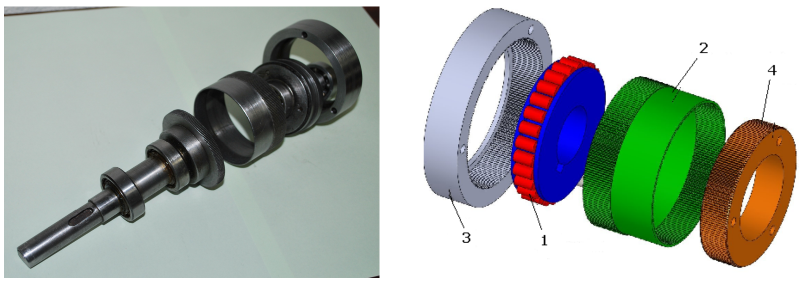

Figure 1. Double harmonic gear transmission

The flexible toothed wheel has the shape of a short circular tube with a thin wall, which is open at both ends and has at each end a toothed crown placed on one side (on the outside or on the inside) [8, 9, 12].

Knowing the vibrational behaviour of double harmonic gear transmission important in order to avoid the resonant operating range when one of the excitation frequencies coincides with one of its own frequencies, and the amplitude of the vibrations can increase significantly, sometimes even with a destructive effect.

The paper presents a detailed study of the vibratory phenomena occurring during the operation of a double harmonic gear transmission.

2. Experimental installation and equipment

The experimental research of vibrations, developed in the dynamic regime of double harmonic gear transmission, was carried out by the use of experimental installation, whose picture is presented in Figure 2.

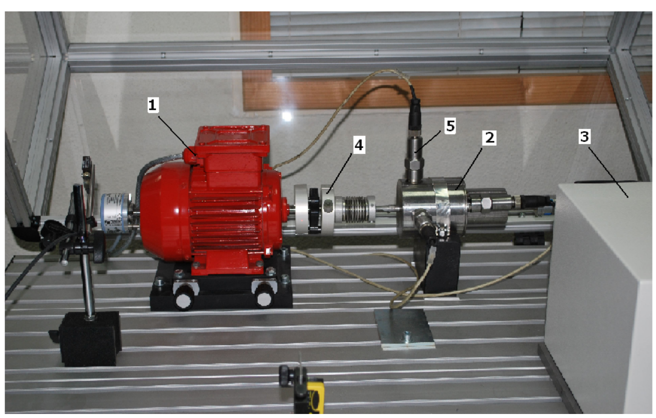

Figure 2. Experimental installation

The experimental installation is composed of: 1 – the asynchronous electric motor with frequency converter, 2 – the double harmonic gear transmission, 3 – the magnetic particle brake, 4 – the special elastic coupling, 5 – the vibration sensors (accelerometers) with magnetic fastening and measuring system [13, 14].

In order to study the vibrations occurring in the double harmonic gear transmission, the electric measurement method was used, which has a number of advantages: high precision and sensitivity, the possibility of using small size collectors, possibility of remote measurement and control, the possibility of amplification and automatic processing of the results. The indicator or recorder device has been able to directly obtain by indicating or recording the characteristics of the studied signal.

The transmission vibration measurement system consists of the following elements: transducer, preamplifier, analyzer, filters and recording and indicating apparatus.

For measuring the speed of the transmission input shaft, a laser speed sensor was used, type QS 30 LDQ, which can measure speeds up to 120.000 [rpm], sensing the distance of max. 2 m produced by Banner.

The vibrations were measured in three orthogonal directions between them (two radials and one axial) with the help of three vibration sensors (accelerometers) with magnetic fastening, having the following characteristics: serial number 066921 with a sensitivity of 533.3 mV/g, serial number 066922 with a sensitivity of 546.1 mV/g, and serial number 066923 with a sensitivity of 497.5 mV/g. Compact and light construction is the result of an improved design provided by Hansford Sensors. The measuring range is ± 500 (± 5) m/s^2.

Measurement and accelerometer feeding are performed by means of 3 connecting cables type AO 0526 D 100.

The data acquisition unit is VPA 323 – product of Digitline, which has 12 input channels with individual galvanic separation (9 inputs – voltage and 3 current inputs) and 16 other inputs for process parameters.

3. Experimental research of the vibration of the DHGT

The experimental investigations aimed to measure the low dynamic responses of double harmonic gear transmission, in order to compare them with the admissible limits established by international standards and norms.

Thus, the measurements aimed to record and analyze the evolution over time of the vibrational phenomena produced during the operation of the DHGT, by determining the amplitudes of the vibration accelerations in the case of considering the three steps of the charging of the transmission: M_{t4} = 1; 5; 10 [N·m] and four speed steps: n_1 = 500; 750; 1000; 1500 [rpm].

In Figures 3 – 5 are the variation charts of vibration acceleration amplitudes for all 12 considered modes of operation of double harmonic gear transmission, depending on the step of the torque (M_{t4}) and the input speed (n_1), respectively.

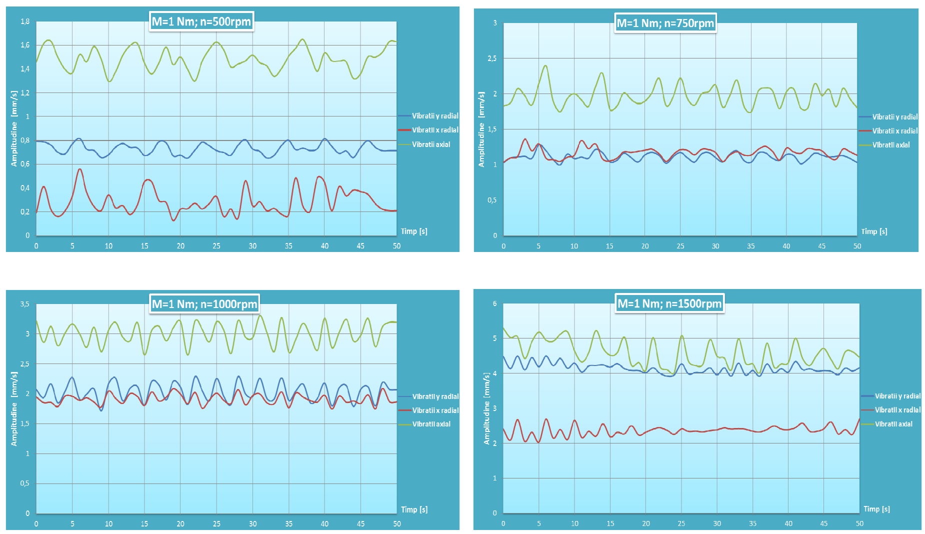

Figure 3. Diagrams of the vibration acceleration, M_{t4} = 1 N·m

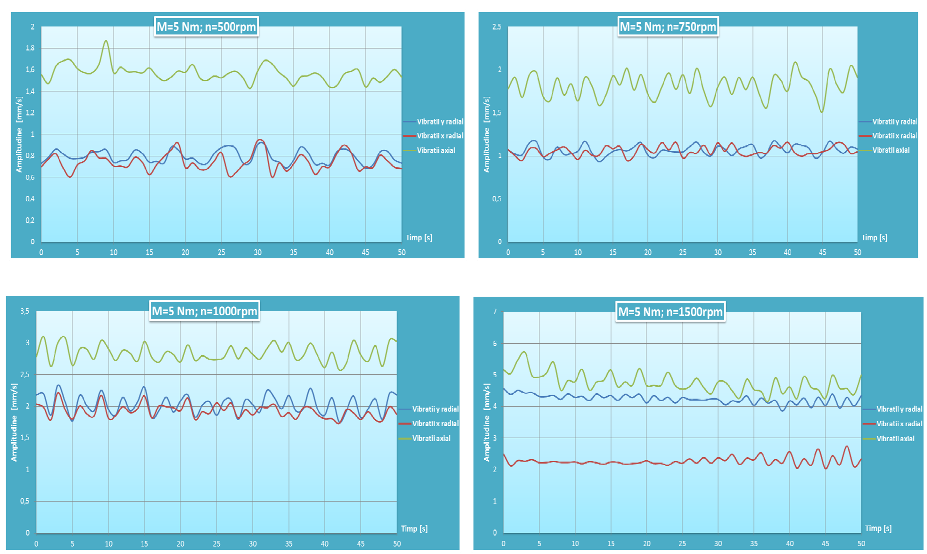

Figure 4. Diagrams of the vibration acceleration, M_{t4} = 5 N·m

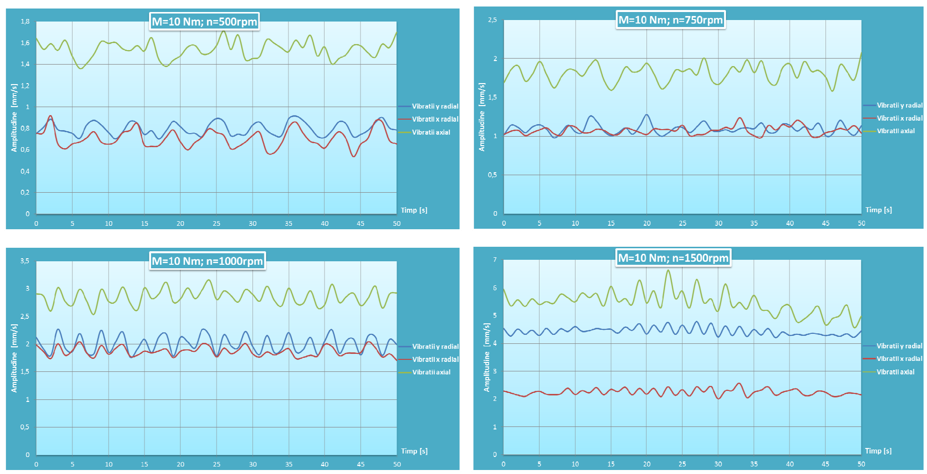

Figure 5. Diagrams of the vibration acceleration, M_{t4} = 10 N·m

4. Conclusion

From the analysis of the vibration acceleration amplitudes variation diagrams according to the charging M_{t4}, shown in Figures 3 – 5, it is noted that the radial and axial vibration amplitudes do not depend significantly on the charging, maintaining approximately constant for the range (0 ... 10) Nm.

It is also noted that the amplitudes have a slightly increasing character with the increase of the input speed n_1, and vibration along the axial direction is always more pronounced than those developed after the radial directions.

By comparing the measured values with the admissible limits, it is found that the vibrations that occur during the DHGT operation are not dangerous, having a low degree of severity.

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Addresses:

- Prof. Dr. Eng. Sava Ianici, "Eftimie Murgu" University of Reşiţa, Piaţa Traian Vuia, nr. 1-4, 320085, Reşiţa, s.ianici@uem.ro
- Lect. Dr. Eng. Draghiţa Ianici, "Eftimie Murgu" University of Reşiţa, Piaţa Traian Vuia, nr. 1-4, 320085, Reşiţa, d.ianici@uem.ro