Power planetary precessional transmission research regarding acoustical behaviour

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Abstract. In planetary precessional reducers vibration can appear at bearings, gears, misaligned shafts, unbalanced rotors, couplings. Changes in dynamic process affects not only normal behaviours of mechanical systems but also acoustical behaviour. Regarding this aspects, regular acoustical measurements during the operating speed provide information about any necessary repairs or maintenance. Here vibration research was made by using Bruek&Kjaer Sound Level Meter 2250 Light to record Noise Rating for evaluation of global noise in dB according to ISO TC-43.

1. Introduction

Taking into account the harmful activity of noise, in order to prevent illnesses and accidents at work and to ensure the conditions for achieving acoustic comfort, rules have been developed on limiting the acoustic power of equipment and installations and limiting maximum sound intensity levels to values it is considered that the action of the noises is not harmful or does not disturb [1].

At the beginning, the parameter chosen for the elaboration of the noise limitation norms was chosen the level of loudness in the phones, but alone was not enough to appreciate the harmful effect of the noise. Therefore, a second parameter was chosen, frequency. By representing the variation of the sound pressure level as a function of frequency, the noise curves resulted. The rules were developed according to the workplace resulting in separate rules for industrial noise, noise in homes and cities, noise in transport [7].

1.1. Noise assessment methods

For the evaluation of noise and within acceptable limits, several types of such curves were established:
NC (Noise Criteria), RC (Room Criteria), NR (Noise Rating).
NC (Noise Criteria) and RC (Room Criteria) are mainly used in the United States.
NR (Noise Rating) curves are used in Europe, in Romania being called Cz noise curves.
Noise evaluation can also be done globally in dB (A).

NR (Noise Rating) are used to evaluate noise according to ISO and are mainly used in Europe. The Technical Committee No. 43 of the International Organization for Standardization (ISO-TC 43) adopted the system for evaluating the intensity level of a noise through a series of curves developed in the eight-octave bands between 63 and 8000 Hz, considered to represent the levels of intensity producing the same physiological discomfort. These curves, called noise curves Cz (or NR) (according to SR 6156:2020 and partial in SR EN ISO 717-1:2013 standards) are highlighted by a number

between 0 and 130 - the number that defines a certain noise curve, corresponds to the sound pressure level, measured in dB, of a 1000 Hz sound.

The Cz curves are given in Figure 1 by sound pressure levels corresponding to 1/1 octave frequency bands.

The steps for evaluating the noise level using the Cz curves are the following:

- the noise level in octave bands is determined;
- draw the working curve, joining the points obtained by measurements;
- the Cz curve for the system for which the measurements were made is the real NC curve that is interested in the highest point of the theoretical curve [1,7].

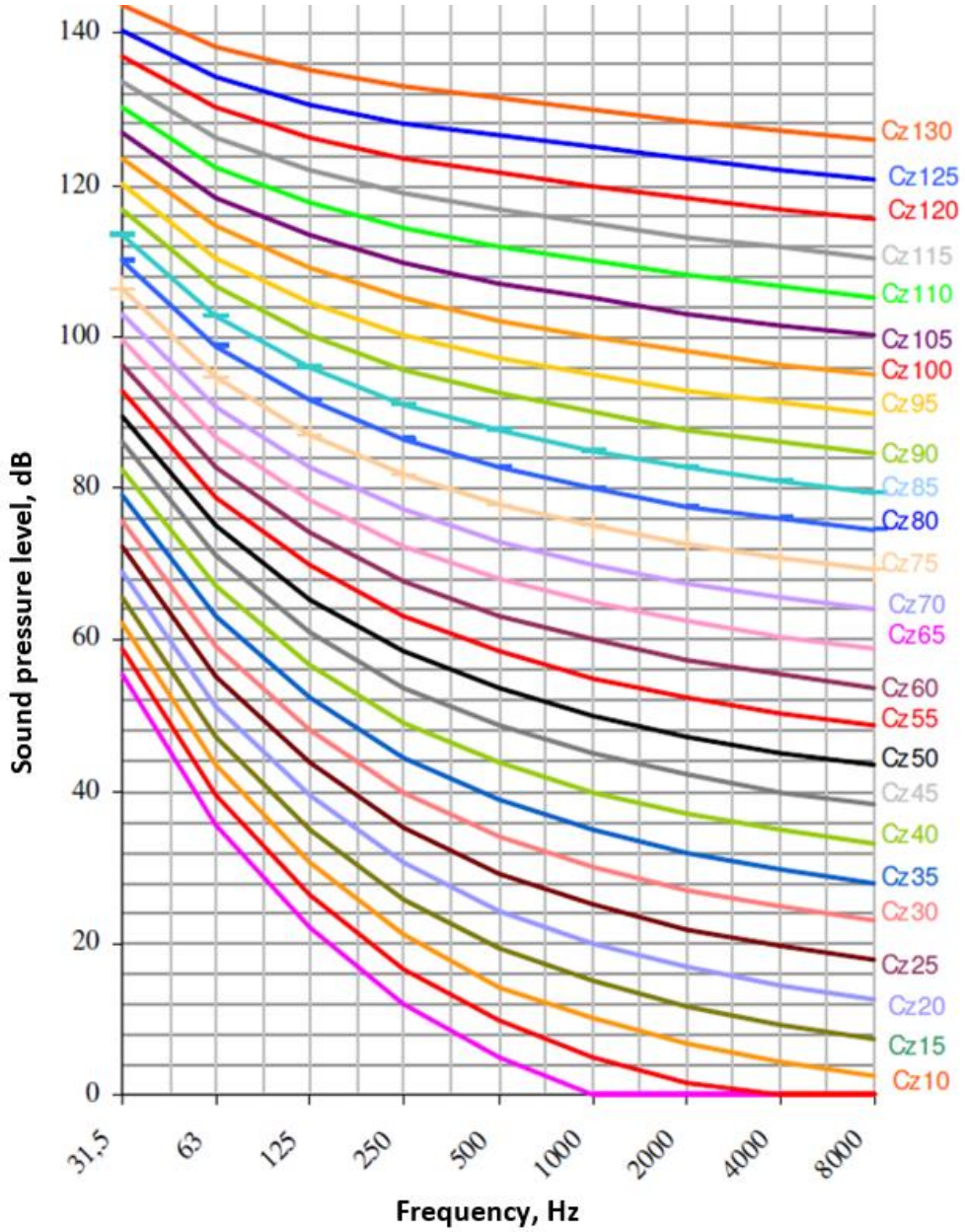

Figure 1. Noise curves Cz.

1.2. Equipment used to measure noise levels.

In a first stage of the analysis of the vibroacoustic behaviour of the precessional planetary gearboxes, quantitative noise level measurements were performed, using a Brüel & Kjær Type 2250 Light noise level meter (Figure 2) [6].

Figure 2. Sound Level Meter Bruel&Kjaer 2250 Light.

Figure 3 shows the typical window for measuring noise curves using the 2250 Light sound level meter, and in Figure 4 the data obtained for the sound pressure level [dB] for the average frequencies [6]:

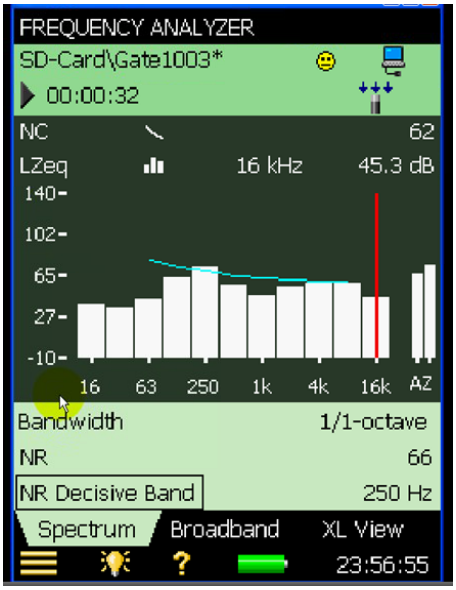

Figure 3. Typical window for measuring noise curves using 2250 Light sound level meter.

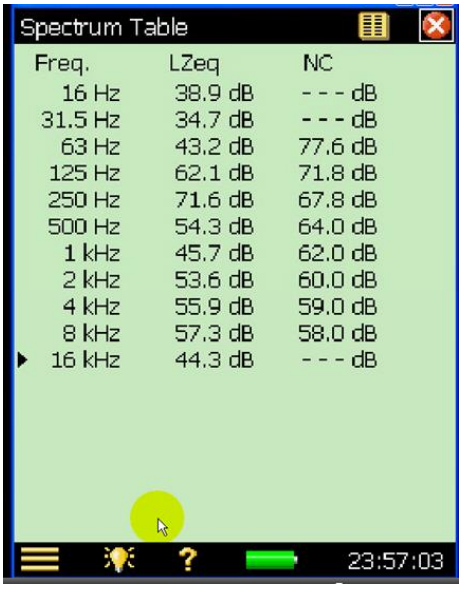

Figure 4. Data samples for the sound pressure level in dB for average frequencies.

With the data obtained Figure 4 we draw the noise curve Figure 5 the Cz curve for the system for which the measurements were made is the real NC curve that is interested in the highest point of the intersected curves, in this case the Cz 80 curve.

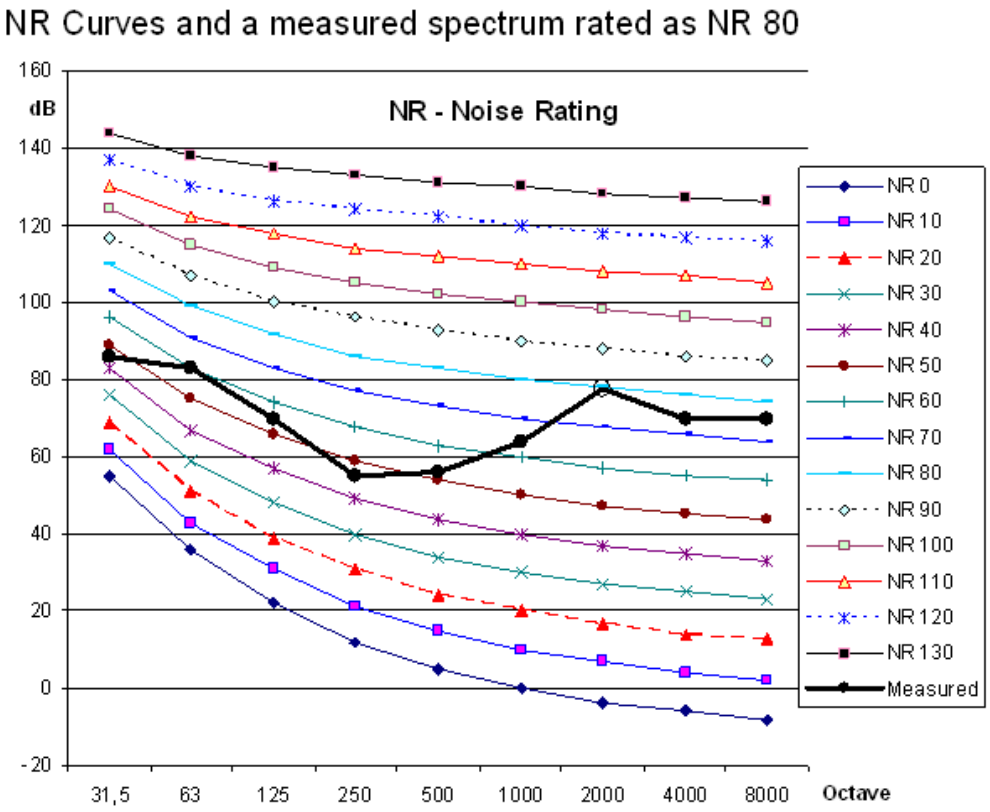

Figure 5. Highest intersected NR Curves - in this sample NR 80.

2. Acoustical research of the precessional planetary power reducer 2K-H Type

The experiments were performed on the test stand (Figure 6) in the laboratory "Fine Mechanics" of the department "Fundamentals of Machine Design" in a closed room with rigid floor [3,4].

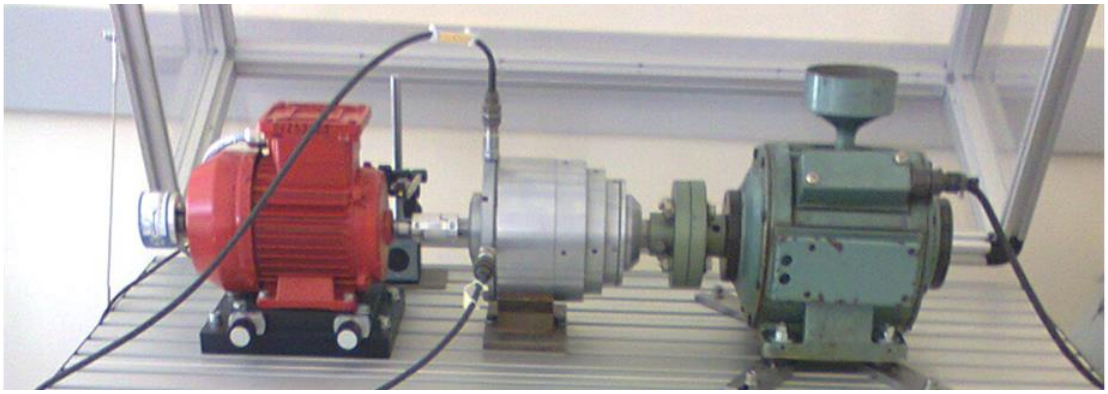

Figure 6. Experimental stand for vibro-acoustical research.

The experimental stand consists (Figure 7) from the test table made of aluminium profile GUNT PT500.01 provided with T-shaped channels, in which the electric motor is fixed with P = 0.36 kW at 1800 rpm operating speed, the precessional planetary reducer 2K-H with the ratio of transmission i = -10.5 and maximum torque T2 = 40 Nm, and electromagnetic brake type ПТ-6. The connection between the gearbox shafts and the electric motor was made by means of a compensating coupling with bolts, and the connection between the gearbox shaft and the brake by means of a coupling with elastic bushes [5].

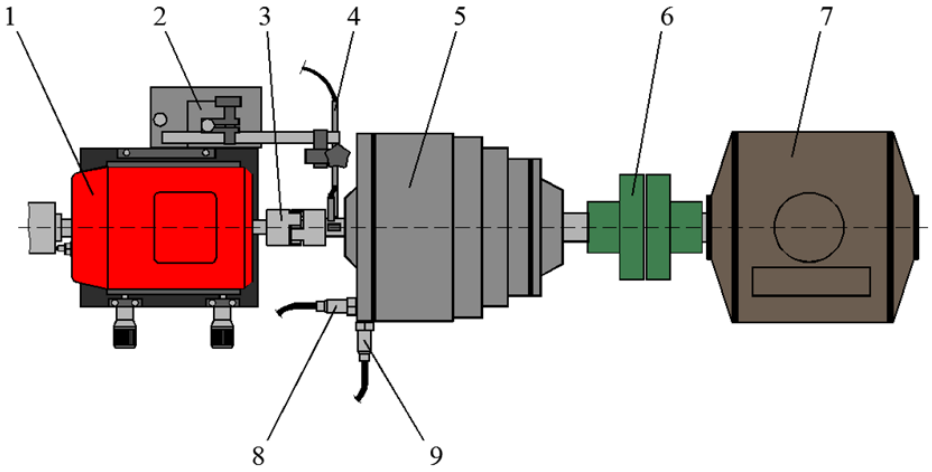

Figure 7. Research stand for the vibrodiagnosis for the 2K-H precession reducer: 1 - electric motor; 2 - magnet holder; 3 - compensating coupling with crabs; 4 - reference sensor; 5 - 2K-H reducer; 6 - coupling with elastic bushes; 7 - brake; 8 - acceleration sensor 1; 9 - acceleration sensor 2.

2.1. Determination of Cz noise curves.

A basic characteristic in order to estimate the acoustics of the reducers is the elaboration of the Cz noise curves. According to the standards and regulations regarding the maximum permissible values, the gearboxes must not exceed the Cz85 curve during operation. In this order, measurements were made with the Brüel & Kjaer 2250 Light sound level meter on the weighting curve (Z), in a closed room in the absence of any background noise (Figure 8) [1,2].

Figure 8. Measurement of Cz noise curves.

The values resulting from the measurements are presented in Figure 10 when the reducer operates (1800 rpm operating speed) without load (Nominal Torque) Tn = 0 Nm and in Figure 9 when the reducer operates under load Tn = 25 Nm. Thus, the noise emitted by the 2K-H precessional planetary gearbox reaches the Cz70 curve without load and the Cz65 curve under load.

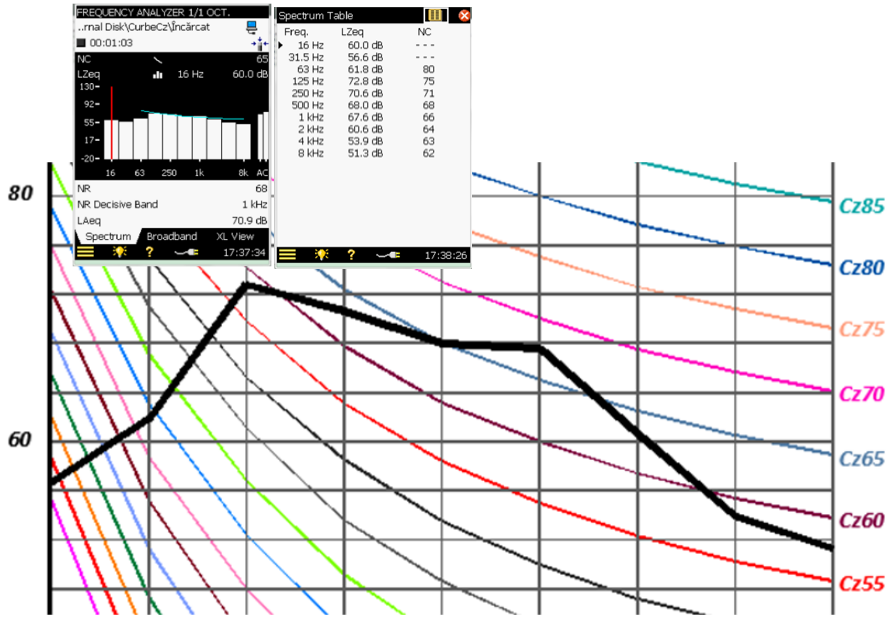

Figure 9. Cz65 curve for the case when the gearbox is operating under load.

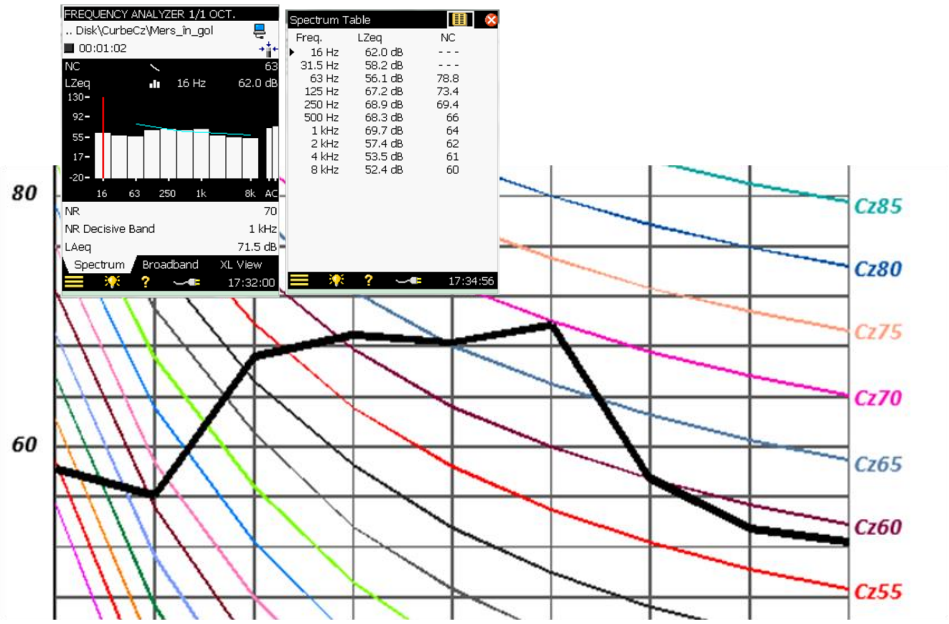

Figure 10. Cz70 curve for the case when the gearbox operates without load.

Conclusions

The results obtained recommend the 2K-H precessional planetary power reducer as a silent reducer with low vibration and noise emission.

Acknowledgments
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