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Comparative Study of Reducing the Vibration Level of a Cylindrical Gear Transmissions by Increasing the Manufacturing Precision of the Gears, Respective by Applying of Fluoropolymer Coating on the Gear Teeth

The current trend in the construction of gearboxes, regarding the speed increase, favors the increase of the dynamic loads and, consequentially of the vibration level. Therefore, the vibration reduction of gear transmissions finds a growing interest, representing an element of fight against environmental pollution.

Keywords: *gearbox, vibration, flouropolymer coating*

1. Introduction

Coating technologies with controlled microns- layer thickness, of fluoropolymer material, are providing superior tribologically properties of metal surfaces under poor lubrication or dry friction.

The advantage of these technologies is the fact that they can be applied on new metallic layers or, if necessary, on used surfaces, being a reconditioning technology, which brings an important contribution on saving materials and workmanship. Furthermore, these technologies are ecologically ones.

Currently, the fluoropolymer composite materials have become widespread due to the realization of high performance dispersions. These dispersions are made of composite particles which are suspended in an aqueous or organic dispersant. The composite particles are containing materials from the fluoropolymer family (PTFE, PFA) and filler materials (molybdenum disulfide, silicone products, etc.), embedded in a binder, in order to ensure certain properties. Fluoropolymer dispersions are applied by spraying or immersion, on metallic surfaces, which have been prior adequately prepared, in order to ensure a proper adherence. After applying, follows a heat treatment, then drying and if necessary an application of another layer of fluoropolymer dispersion, ending with a heat treatment at a temperature higher than the drying temperature. Finally, results a fluoropolymer film, which combines the good antifriction and antiadherent properties of the fluoropolymer materials but, unlike them, a good wear resistance, conferred by the nature of the used binder. Nowadays, in the construction of engines, are used parts with active surfaces which are covered (coated) with fluoropolymer materials in order to improve the friction coefficients and to reduce wear and noise.

2. Fluoropolimer coating applied on cylindrical gears

In this research, in order to improve the tribological behavior of gears, was used a Xylan 1052 dispersion, produced by Whitford Plastics Ltd, UK, which was applied on the flanks of the matting gears. Xylan 1052 is a fluoropolymer coating material, which was developed in order to combine the attributes of a high hardness at high temperatures with an excellent resistance to abrasion and wear. The fluoropolymer film resulted after a proper heat treatment of the applied coating, can work, as indicated by the manufacturer, at a maximum contact pressure of 343 N/mm^2.

This material was sprayed in two layers, with a thickness of 12-20 μm. According to the manufacturer, the obtained fluoropolymer layer has a good resistance to a range of operating temperatures between -195 to 285° C.

Experimental tests were made on the test rig described in [3], using pairs of gears, as follows:

a) Gear pair (pinion + spur gear) with teeth manufactured by milling in a precision class 8, according to DIN 3961;

b) Gear pair (pinion + spur gear) with teeth manufactured by grinding in a precision class 6, according to DIN 3961;

c) Gear pair (pinion + spur gear) with teeth manufactured by milling in a precision class 8, according to DIN 3961 and additional coated with 2 layers of each 20 μm of Xylan 1052 dispersion.

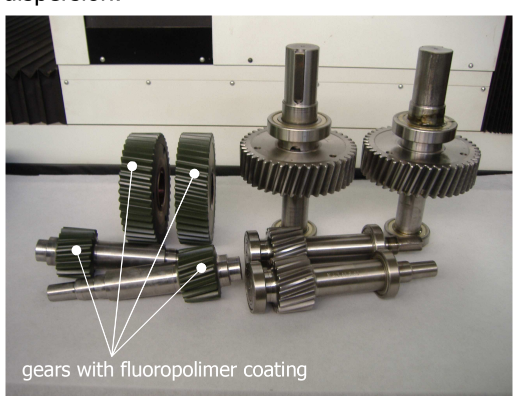

Figure 1. Gear pairs with and without a fluoropolymer coating.

Figure 1 presents, for comparative viewing, usual gear pairs and, gear pairs with teeth on which have been applied a fluoropolymer coating.

For vibration measurement, accelerometers were placed on the bearings of the input shaft, respective output shaft of the gearbox. Data collection was done on six different speeds of the electrical motor: n_1 = 1.000, 1,100, 1,200, 1,300, 1,400 and 1,500 rpm, by maintaining constant (T_2= 38.5 Nm) the transmitted torque.

The variation of the vibration speed measured on the bearing of the input shaft (high speed shaft) is shown for the above mentioned gear pairs in figure 2.

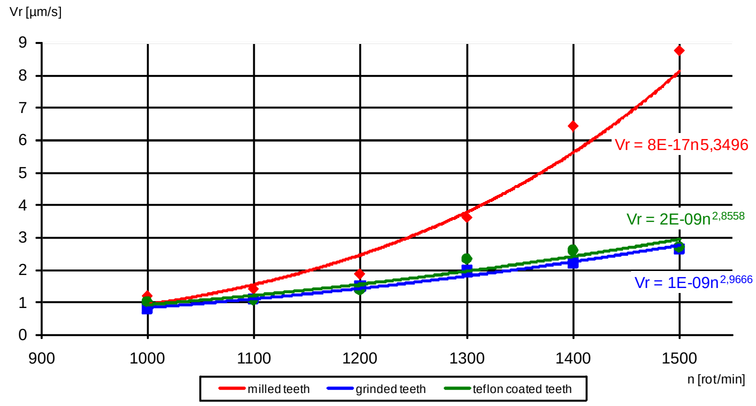

Figure 2. Variation of the vibration speed measured on the three gear pairs.

It was concluded that there are two methods for reducing the vibration level of a cylindrical gear transmission with almost the same results:

- by increasing the manufacturing precision (by grinding the teeth) of the gears from 8 to 6 (reduction of **70,02 %**);

- by applying two layers of fluropolimer coatings on the gear teeth machined by milling in a precision class 8, according to DIN 3961 (reduction of **69,22 %**).

4. Conclusion

It has been identified two ways to reduce the vibration level of a cylindrical gearbox, leading to almost identical results:

- Increasing the accuracy grade of the gears from 8 to 6, by grinding them;

- Coating the teeth with two fluoropolymer layers of each 20 µm thickness (Teflon coating).

Teflon coating has, however, beyond the advantage of significantly vibration reduction of gear transmissions, the disadvantage that the applied layers are supporting, according to the manufacturers prescriptions, a maximum contact stress of 343 N/ mm².

Therefore the decision regarding the method for reducing the vibration level of a gear transmission has to be taken in relationship with the transmitted load:

- For the transmissions where the gears are supporting unsignificant loads (the contact stress desn't exceed 343 N/ mm ^{2}), such as those used as kinematic transmissions, it is recommended to apply a teflon coating of the teeth in order to reduce the vibration level of the gearbox;
- For the gearboxes which are transmitting higher loads, it is recommended to increase the accuracy grade of the gears in order to reduce the vibration level.

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