RESEARCH CONCERNING INFLUENCE OF WORM FACE GEAR FINISHING PROCESS UPON NOISE AND VIBRATION LEVEL

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ABSTRACT

A study was performed to evaluate noise and vibration level of worm face gear finish. Vibration and noise monitoring data were gathered from 6 sets of worm plane gears run during a evaluation study. A drop o vibration level was successful recording, noise level remain almost the same as noise level record before finishing process was perform. A solution for fly cutter hobbing's particular problem was propose.

Keywords: W*orm face gears, lapping, hardenning, roughness, noise, vibration*

1. Introduction

The subject of this research is evaluate noise and vibration level of plain worm gears, with special attention given to the influence of surface roughness. Gear teeth working surfaces are subjected to repeated rolling and sliding contacts. For operating conditions common for power transmission applications, the loads are sufficient to cause eventual fatigue of the surface. This research project sought to provide a technical and economical arguments for worm plane gears finish. This subject is today a subject of debate.

2. General guide line

Worm plain gears can be produce using multiple methods: using a conical milling cutter, using a grinding wheel dressed with double conical form or single point tool in lathe known as a fly cutter.

Figure 1: Hobbing of worm plain wheels by fly cutters

Present in this paper worm plain gears was hobbed by fly cutter with tangential hobbing *as show in figure 1 . This method of generation of worm gears produce also an unwanted side effects.

Because fly cutter is a single-point cutting tool similar to a lathe tool mounted in a special holder on enter and exit surface area appear a lot o micro scratches. Fly cutters are rotary tools that use one or more single-point tools for plane surfacing.

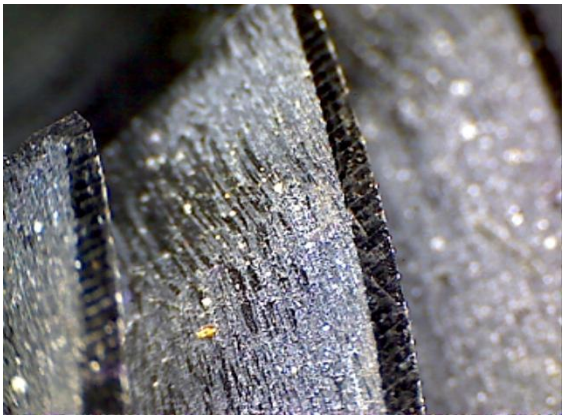

Figure 2 – Surface detail with scratch

The main current in today technical field consider "worm gear drives with cylindrical worm still an example of example of gear drives for which a satisfactory bearing contact is obtained by lapping under a load in gear drive house. However, such lapping is expensive in terms of time and is not sufficiently effective"[1].

We and other researchers[4] consider this point of view not entire true. In particular case of hardened steel worm plain gears hobbed by fly cutter present in this paper finishing process it is 100% desirable.

3. Apparatus

Test facility. The experiments reported in

this report were tested at University Petru Maior Târgu Mureș Tools Parts Laboratory. An overview sketch of the facility is shown in Figure 3.

This type of facility it is commonly use by NASA Glenn Research Center's for gear testing [6],[7],[8],[9],[10]. They use this facility for duration and endurance tests.

The drive tested form set from 1 worm plain

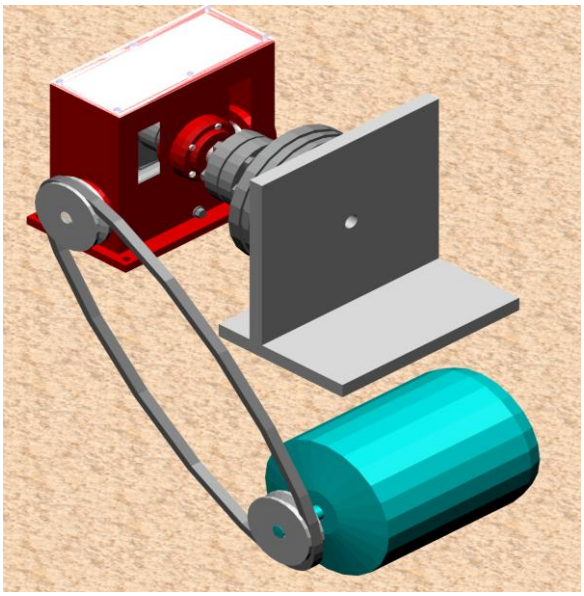

Figure 3 . Test facility overview

gear and one cylindrical pinion.

Torque is supplied in pre-load through shaft brakes FAT120. The desire level of torque is achieved by adjusting an electric supply command panel. A electric motor, connected to the loop by V-Belts and pulleys. The electric motor has capability to operate at 1500 rpm pinion speed.

Table 1. Remarkable constants

Constant	Value
Axial modulus	2,5
Tooth number	47/1
Type of worm	ZA
Directions	Left
Diameter pitch	7,85
Center distance	56
Shaft angle	90
Pressure angle	30
Pinion material	42 MoCr11
Wheel material	42 MoCr11
Pinion hardness after heat treatment nitriding	423 HV (400 HB)
Wheel hardness after heat treatment nitriding	697 HV (650 HB)

Electrical motor it is also control by a turning-switch how determine direction of turning left or right.

Test gears. The design parameters for pinions and face gears used in the test are given in Table 1.

4. Gear evaluation instrumentation(s)

Vibration level was recorded with a SPM Vibrameter VIB-10. The evaluation of machine condition is based on a single parameter, vibration severity. This means that the instrument needs to display only one measured value, which reduces its cost and makes it easy to handle. Resolution: 0.1 mm/s. Accuracy 2% ± 0.2 mm/s [2].

Vibration data were acquired once every three minute during the tests from the front side and

Figure 4 – Test gear box with test instrumentation

from rear side of gear box.

Noise level was recorded with a VOLTCRAFT SL-50. Resolution: 0.1 dB. Accuracy 3,5 dB [3]. Noise data were acquired once every three minute during the tests from the front side and from rear side of gear box.

Instrumentation use in this test it is shown in figure 4 in from view.

Addition data was acquire regard temperature.

5. Test procedure

For each of 6 sets tested detailed installation and break-in run procedures were followed to produce acceptable contact patterns and backlash. Both wheels and pinions was manufacture from 42MoCr11 heat treatment steel's and handed by gas nitriding (see Table1).

After acceptable installation, the pre-load through shaft brakes FAT120 was adjusted to produce 11 Nm torque.

Each pair pass 3 test stage: first stage was grinding, second stage finishing process, third stage evaluation.

Rotation direction was switch by electrical motor's switch and both side of tooth flanks was lapped.

Finishing method chose is lapping with water base solution. Lapping is a machining operation in with two surface is rubbing together. This involves rubbing a brittle material as silicate carbide [5].

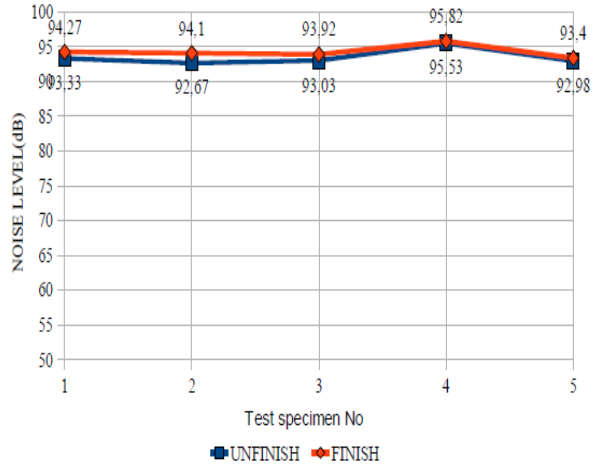

Figure 5: Noise level chart of 10 degree flanks

Worm plain wheels was lapped for 10 minute each. This solution it is a economical orientated solution. Solution is a mix solution of silicate carbide and water glass (sodium silicate). Solution has 1,3-1,5 viscosity and 11-12,5 pH (strong alkaline potential). An original lapping solution was tested. This solution contain sodium silicate, silicate carbide and a thixotropic agent commercial know as Aerosil.

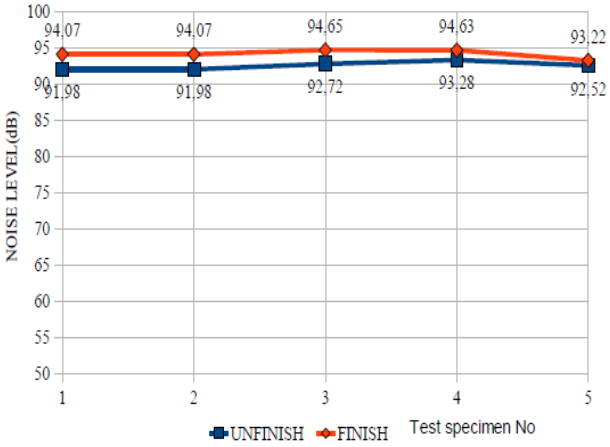

Figure 6: Noise level chart of 30 degree flanks

Solubility of lapping solution in water is 100% complete. Appearance is clear to cloudy with tiny black silicate carbide in suspension.

Lapping solution can be easy remove from gear box, pinions and wheels with flushing water.

6. Result and discussion

A summary of the results for the noise level test is given in figure 5 and 6. As it is show in table noise level remain almost the same a slight increase was recorded but in almost same domain. Increase of noise level it is under 2% in relative errors range of measure.

This increase of noise level can't be notice by human ear.

A summary of the results for the vibration level test is given in figure 7 and 8. As it is show in table vibration level lower after finishing process.

Vibration had a small variation among sets, ranging in mean values 7 mm/s before finishing and 5 mm/s after finishing. Vibration it decreased with 16% for 10 degree angle and 17% for 30 degree angle enter and exit area surface's scratches was almost complete remove as show in figure above.

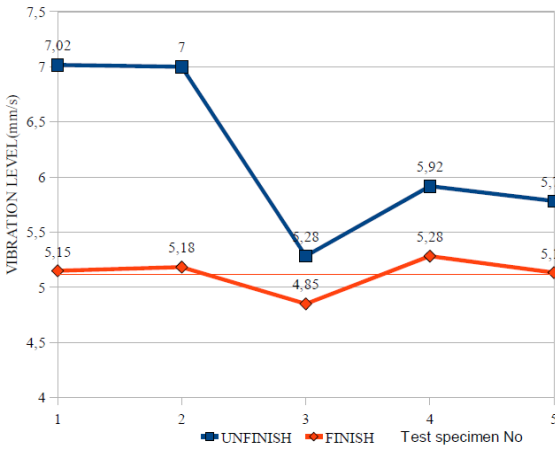

Figure 7: Vibration level chart of 10 degree flanks

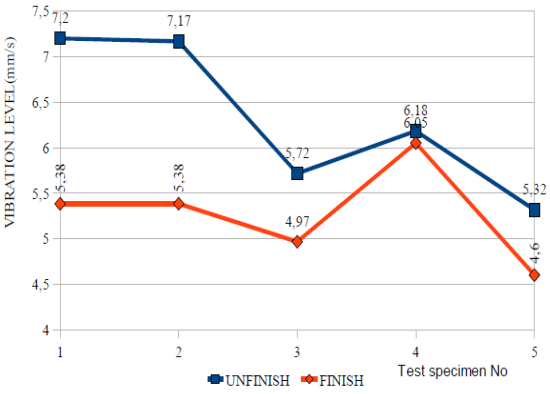

Figure 8: Vibration level chart for 30 degree angle

We also notice a difference between 10 and 30 degree angle direction running of 3% for vibration level (after finish). A very small difference consider angle difference.

For noise level we notice a difference smaller then 1% between noise level of 10 degree angle and noise level of 30 degree level.

Noise level after lapping remain almost the same because of increase contact area between wheel and pinion. This increase of contact pattern it is around 10-13% after finishing. Further study it is necessary to explain this phenomenon.

7. Conclusions

The objective of this study was to evaluate effectiveness of worm plain gear finish to decrease

level of vibration.

The following conclusion were obtained:

- Noise level remain almost the same was recorded only a slight increase with 2% procent.
- Vibration level was decrease with 16-17%.
- Lapping with water-base solution of sodium silicate and silicate carbide it prove a very cheap and easy to use solution for cost orientated manufacture.
- An original formula solution for lapping which contain a mix of solution of sodium silicate, silicate carbide and thixotropic agent was also tested
- Lapping finish prove eliminate effective enter's area surface scratches as shown in figure 9

Figure 9 : Scratches was effective removed

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