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Experimental Research Concerning the Contact Patch of the Double Worm Face Gear

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Abstract

This paper aims to present the results of an experiment linked to positioning and the contact patch size of a double worm face gear. The worm face gear tested is provided with one-piece double worm face wheel that involves specific adjustment difficulties. Couple of used materials is the hard steel for the worm and the gray cast iron for the wheel. We mention technological conditions for obtaining the worm and the worm wheel. The contact patch completeness check gear flanks results was done on a test stand using training gear on both sides of succession worm knowing the fact that they show different pressure angles. The contact patch has different values obtained on the two sides of the flanks, the smaller pressure angle ensuring better conditions of engagement.

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Keywords: double worm face gear; spiroid gearing; contact patch; roughness; speed reducer.

1. Introduction

Double worm face gear is among the newest gear constructive solution [1,2,3,4,5,6,7]. This solution consists from a worm that acts together two worm face wheels. Because the auger can be achieved in conical or cylindrical gear variant can be achieved with tapered worm face wheels, respectively worm face wheel plane. The cylindrical

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worm constructive version and worm face wheel provides in less costly technical conditions acceptable performance for certain types applications.

Worm gear units can be made with separate dual front worm wheels or monoblock dual front worm wheels. The performances of the crossed axes gear family are directly related to dimensional parameters of components and assembly possibilities to control their carcasses in ensuring their mutual positioning and the size of the oil bath needed for lubrication and their cooling during operation. An important checking parameter to ensure the best possible operating conditions is the contact patch between the surfaces of the worm and worm wheel tooth flanks running.

a)  b) 

Fig. 1 (a) Double worm face gear ; (b) One-piece double worm face wheel.

The size and positioning of the contact patch is influenced by several factors such as the execution accuracy and the assembling adjustment possibilities. The paper highlight the elements related to both aspects. For worm face gears with worm-wheels mutual separate made of worm-worm wheel position on both sides of the worm which ensures the positioning and the size of the contact patch the adjustment can be carried out independently. The worm wheel gear that uses double one-piece this adjustment is limited by the space and the fact that moving the wheel in an axial direction imply a shift in the same direction identical to the other wheels.

There are no known concerns related to the contact patch of this type of gears, they are present only in the case of simple worm face gear [5,8,9,10,11,12].

2. Experimental research

The experiment conducted which aimed to study the contact patch distribution of a double worm face gear which is made as one-piece wheels was using such a reducing gear mounted in the housing. The actual case that was materialized consisted from a gear with the following characteristics: worm z1 = 1, type of worm ZA, axial modulus = 2,5mm, worm wheel z2 = 47, 30º and 10º pressure angle, A = 56 mm center distance, worm material 42CrMo11 hardened steel (nitride) after treatment with hardness of 423 HV, wheel material Fc250 cast iron, hardness 228 HB.

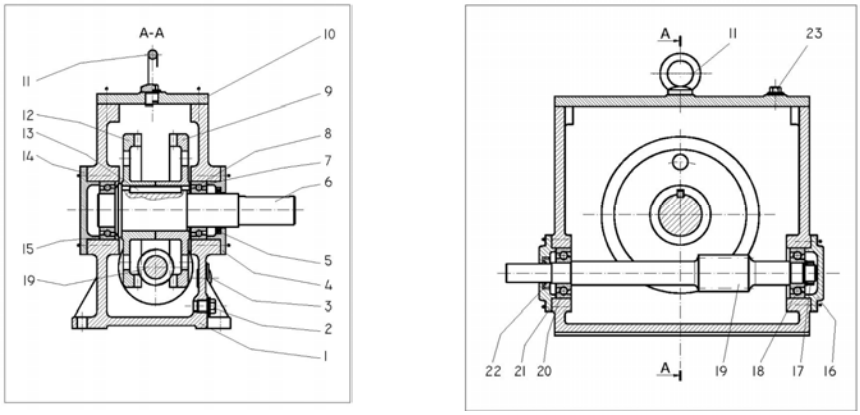
The worm has flanks obtained by precision turning without rectified flanks. Double one-piece worm wheel was hobbed with a hob on a FD 500 UM Cugir milling machine, using tangentially advanced methods [17] with 17 m/ min cutting speed and S_T = 0.1 mm / rot tangential advance.

a)  b) 

Fig. 2. (a) One-piece double worm face wheel hobbing; (b) Speed reducers whit double worm face gear

By using the above technology teeth flanks roughness was in the range from 3.2 to 6.3 μm Ra. Establishing the value of the roughness could only be approximate method using a digital microscope, which allowed imaging and then use roughness standards control at TAPFA Research Center.

The designed gearbox in which has been mounted the worm gear with double worm face wheel is shown in Fig.3. [4, 15]. Both shaft and worm wheel bearings are seated on angular contact bearings. Adjustment of the axial position of the wheel can be placed using thin margins between the wheel and bearing shaft that is fixed wheel. The limits are in very tight control being limited by the play between the flanks of the worm and wheel tooth flanks.



1. gearbox ; 2. oil-screw drain plug; 3. oil level; 4. cover's bearing1; 5. shaft seal; 6.shaft ; 7. bearing1; 8. screw ; 9. double face worm gear ; 10. cover's gearbox; 11. lifting ring; 12. double face worm gear; 13. rectangular up; 14. cover's bearing2; 15. bearing2; 16. cover's bearing3; 17. lock nut; 18. bearing3; 19. worm; 20. bearing4; 21. cover's bearing4; 22. shaft seal; 23. oil-screw filling plug

Fig 3. Speed reducers with double worm face gear-Details

Speed reducer has been mounted on the test stand of the Research Center TAPFA of the Petru Maior University and then subjected to a minimum load on the output shaft. [13,14].

3. The analysis of results

For worm face gears, as well as all worm gears, the contact patch between worm flanks and worm wheel loaders, are an important indicator and complex at the same time of engagement.

For experiments conducted for this research was determined the contact patch after the gear unit housing ready for the lift experiment, [14] taking as reference the resulting contact patch after running for 10 minutes at minimum charge level ensured by the tests bed.

Fig. 4. The contact patch-flank 10°

The contact patch was determined using the both flanks sides of the worm bearing successively at 30° and 10° respectively. In Fig. 4 and Fig. 5 are shown the focal resulted contact patches. It can be seen a contact patch intermittently distributed along the side wall on a portion of about 50% and 55% of the area of the tooth flank with 30° of 75% of the pressure angle - 80% of the area of the tooth flank with pressure 10° angle.

Fig. 5. The contact patch-flank 30°.

The intermittently distribution of the contact patch largely is due to the deviations from the worm pitch, which is not rectified, suffered some deformation after heat treatment that were not corrected. The resulting distribution is net favorable to the usage as active flank of 10°.

The experiment did not follow the evolution of the contact patch for a large number of operating hours. It can be assumed that wear of the wheel flanks, which have a hardness less than of the worm flanks, could lead to improve the contact patch by joining the flanks.

Experiments conducted by lapping the flanks showed an improvement of contact between the flanks.[16,18].

4. Conclusions

Experimental research on speed gearboxes equipped with double worm face gears using double one-piece worm wheel presented in the paper, highlighted a number of issues and conclusions that are concentrated in the following:

- Adjusting the clearance between the worm flanks and flanks of the two crowns double toothed wheel is performed in difficult conditions compared with simple front worm gear, which has a detrimental effect on the position and size of the contact patch engagement results;
- Accuracy of the worm pitch from the gear bears a major influence on the continuity of the wheel tooth flank contact patch;
- A smaller angle pressure in case of the worm gear flank lead to a good contact patch. Incidentally this is generally a recommendation for the users of the worm face gears on choosing the working sense during the long term operation;
- During long term operation, the worm face gear with worm in steel and wheel in cast iron, the contact patch will vary due to worm wheel flanks which have a lower hardness;
- An operation lapping worm face wheel flanks could result in a noticeable improvement of the contact patch ;

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