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Research Article

EFFECT OF THE NARROWING ANGLE IN BEVELIOD GEAR ON THE TEMPERATURE PROFILE ON THE ACTIVE FLANK OF TOOTH

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ABSTRACT
This paper contains a description of the test bench to research the temperature distribution in gears made of a plastic polymer. The paper presents the research results of the change and the temperature distribution on the side surface of the Beveloid tooth gear. The research were performed for a series of Beveloid gears with different values of narrowing angle.

Keywords: Beveloid gear, temperature profile, narrowing angle.

INTRODUCTION

The gears are very often used in the transmission of torque. They are used in almost all industries. One of the areas in which they play a huge role is the electrical engineering industry and especially in production of household appliances, where most gears of nearly all types and varieties of wheel teeth are applied.

Nonetheless, gears in household appliances are mostly made of plastics i.e. materials which are far more susceptible to heat. The problem of overheating the gears of plastics is one of the biggest problems household appliances designers meet upon construction.

There have been numerous efforts made to reduce the excessive heating up of the gears for example, by introducing additional components to trigger a forced air flow inside the device or achieved through an appropriate gears geometry (less susceptible to heat during work).

RESEARCH

The preliminary research shows that one of the gears varieties that are less susceptible to heating are the Beveloid gears. Beveloid gears are shaped by a gear tool (with constant width of a tooth face) on the rotation surface of the truncated roller. These gears are in the mid-section of the toothed-wheel rim and have a geometry identical to the spur gear (Figure 1).

Variable thickness of the teeth geometry is a result of using a tool with a constant tooth space width (Figure 2).

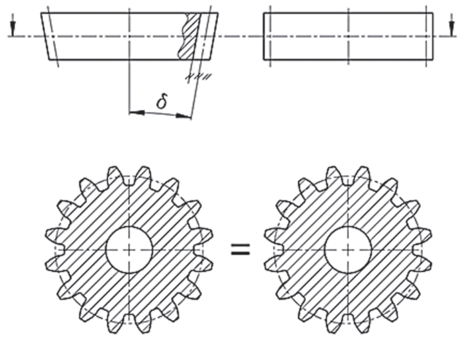

Fig. 1. Comparison of Beveloid gear geometry with a spur gear

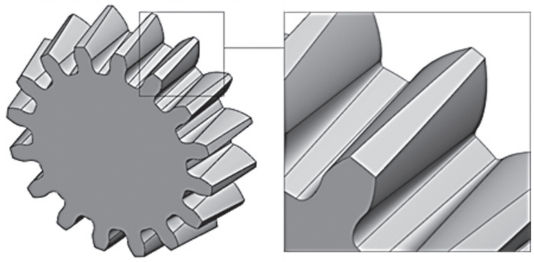

Fig. 2. The shape of the tooth space in Beveloid gear

With this solution 3 variants of the gear mate and the possibility to a certain extent regulation of the angle between the gearing is obtained:

- Beveloid gears mate with axes parallel (Figure 3),
- Beveloid gear mate with spur gear – we can obtain an angle between the gears axes (Figure 4),
- Beveloid gears mate with angled axes (Figure 5).

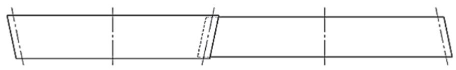

Fig. 3. Beveloid gears with parallel axes

$\Sigma = \delta$

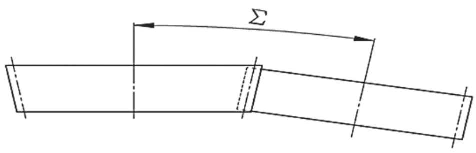

Fig. 4. Beveloid gear with spur gear

$\Sigma = 2\delta$

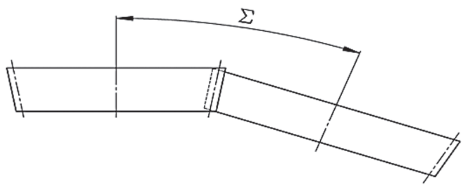

Fig. 5. Beveloid gears with angeled axes

On the basis of the conducted analyses, the following relation has been developed, which allows to determine the maximum allowable narrowing angle of Beveloid gear (equ. 1).

$$\delta_{max} = arctan\frac{2{,}5 + z(\cos(\alpha) - 1)}{\psi z} \qquad (1)$$

where: z – number of teeth,
α – pressure angle,
ψ – factor face width of gear.

It can be observed that the smaller number of teeth and the lower width of the toothed-wheel rim, the greater the narrowing angle value is (Figure 6). This information will help in the future to produce gears for different variants of arrangements of gearing, such as atypical planetary gear.

One of the criteria of quality of gears, is the quantities of heat emission during gearing. In order to conduct such an analysis, a deducted test stand has been designed and manufactured (Figure 7).

The test stand consists of a speed controller (1) to control the electric motor (2) slide guides (3) for fine adjustment gear mate (4), the disc brake (5) to cause the counter-torque, high-precision thermal imaging camera FLIR SC5000 type (6) (Figure 8), shield with aluminum insert (7) to isolate the influence of temperature of the engine.

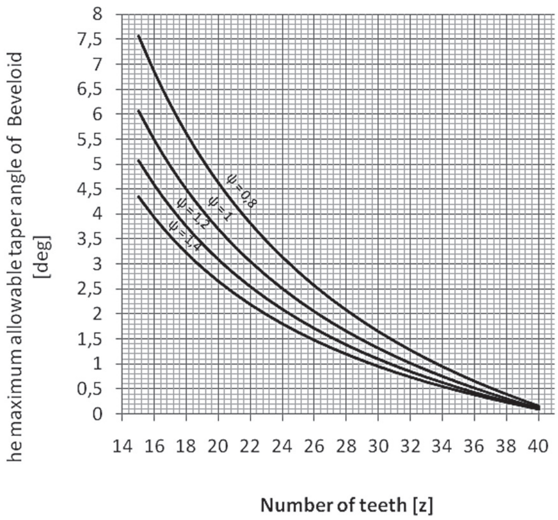

Fig. 6. Maximum allowable narrowing angle in Beveloid gears [deg]

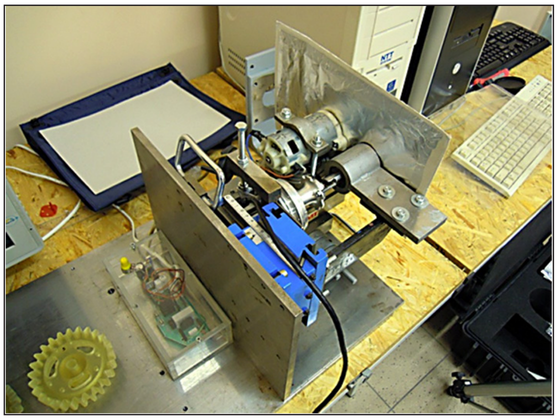

Fig. 7. Description of the test stand

Fig. 8. Thermal imaging camera type FLIR SC5000

Additionally, the device is equipped with a positioner (8) (Figure 9) which provides the temperature measurements that are always at the same gear mate position. There have been five pairs of Beveloid gears tested, each of different narrowing angle (0 °, 1.25 °, 2.5 °, 3.75 °, 5 °) (Figure 10).

The results of measurements have been developed using the "Altair" software version 5.90.001 (Figure 11).

CONCLUSIONS

Studies suggest that Beveloid gears possess decreased tendency to get overheat during mate than the spur gears (Figure 12). With the narrowing angle increase, the temperature measured on the surface of the gear mate was decreasing.

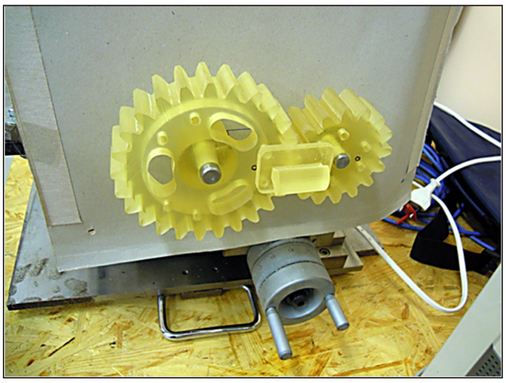

Fig. 9. The positioner of fine adjustment gears

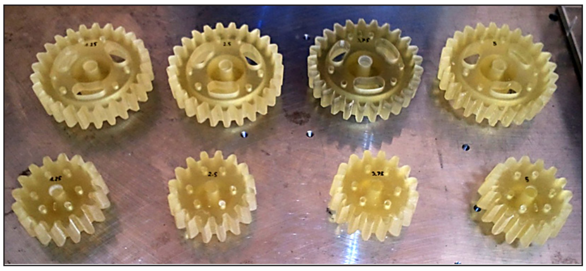

Fig. 10. Beveloid gears used in the experiment

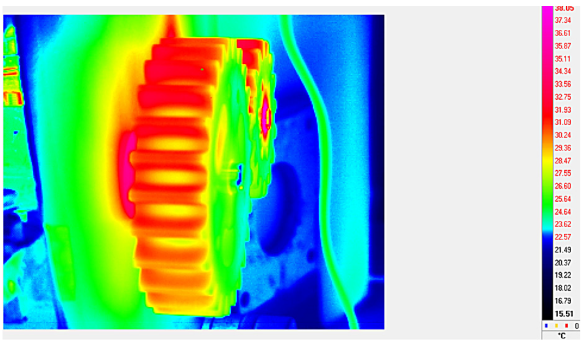

Fig. 11. The results of heat measurement

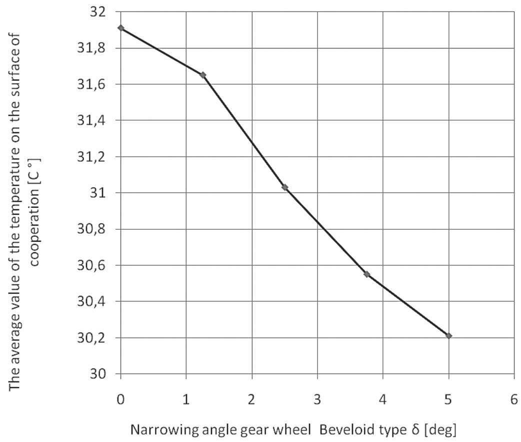

Fig. 12. The results of measurements, for the various gears, measured as the average surface temperature of gear mate

It may be conditioned by the geometry of Beveloid gear by which they are characterized with higher number of tooth contact ratio and smoother entrance into the engagement.

Nevertheless, the test stand itself needs to be modified, as it has been observed that the engine warm-up brings an unfavourable impact on the temperature measurement on the surface of the teeth, what consequently hinders the temperature reading on the pinion.

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