

TOOTH CONTACT ANALYSIS OF HYPOID GEAR TRANSMISSION PROTOTYPES MANUFACTURING WITH VACUUM CASTING METHODS

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Abstract

The article presents the experimental method of instantaneous contact area in hypoid gear transmission. The prototypes of hypoid gear have been made with one of the rapid prototyping method – Vacuum Casting process. This method permits to manufacture gear wheel with very complicated tooth profile in silicone tool (form or matrix) created in vacuum chamber with reduced pressure. Silicone matrix allows creating prototype in casting process or low pressure process. Silicone matrix has been made on the basis of gear transmission of car transmission system. Gears were made of transparent polymer materials to enable observation of the instantaneous contact area.

The instantaneous contact area is that tooth flank surface area, which is in contact with mating surface of another tooth at a specific moment. Correct mating of gears and their kinematic precision depend on the shape and size of instantaneous contact area, as well as on changes during gear's rotation. Contact between gear surfaces of geometrically ideal gearbox occurs at a point or line, but, because of a deformability of mating teeth flanks, in reality it is always a certain surface. The method of tooth contact area as described in the paper, permits a dynamic determination of the gearbox mating area. Existing experimental methods permit only a static observation of the mating area.

Keywords: *Tooth Contact Analysis, Vacuum Casting, hypoid gears*

1. Introduction

One of the parameters described correct work of gear transmission is the instantaneous contact area. The instantaneous contact area is the surface on a tooth flank of the gear, where the contact between this surface and the other mating gear occurs at a given moment. Correctness of mating gear pair and kinematic precision of gear transmission depend on shape and size of instantaneous contact area and its changes rotation of gears. The Boolean sum of instantaneous contact areas on tooth surface gives so-called mating area. The mating area is often well-visible on the worked flank.

There are a few methods to describe contact area in gear transmission. Most of them depend on research of ready gear on the special testbeds. There are currently conducted the researches, which enable to do the contact area analyze of gears models in 3D-CAD environments using physical models made with Rapid Prototyping techniques [2-3, 11]. In this case can be made prototypes with additive method RP (for example stereolithography is one of the most precisely method [4]) directly (CAD model) or indirectly (Vacuum Casting) [8, 12]. Using indirectly method, silicon matrix can be made on the basis of RP model or the real gear transmission (Fig. 1).



Fig. 1. Test hypoid gear transmission

2. Silicon matrices and test model of gear transmission

Vacuum Casting (VC) method belongs to groups of Rapid Tooling (RT) method and consists in made silicon matrix and model under reduced pressure in vacuum chamber (Fig. 2). The process of matrix creation consists of following stages: preparation of model, drawing up matrix construction, preparation of matrix casing and filling its up with silicon, cutting matrix and removing model system [5-7].



Fig. 2. Vacuum chamber

Fig. 3 shows silicone matrix, which was made using gear wheel of the real gear transmission.

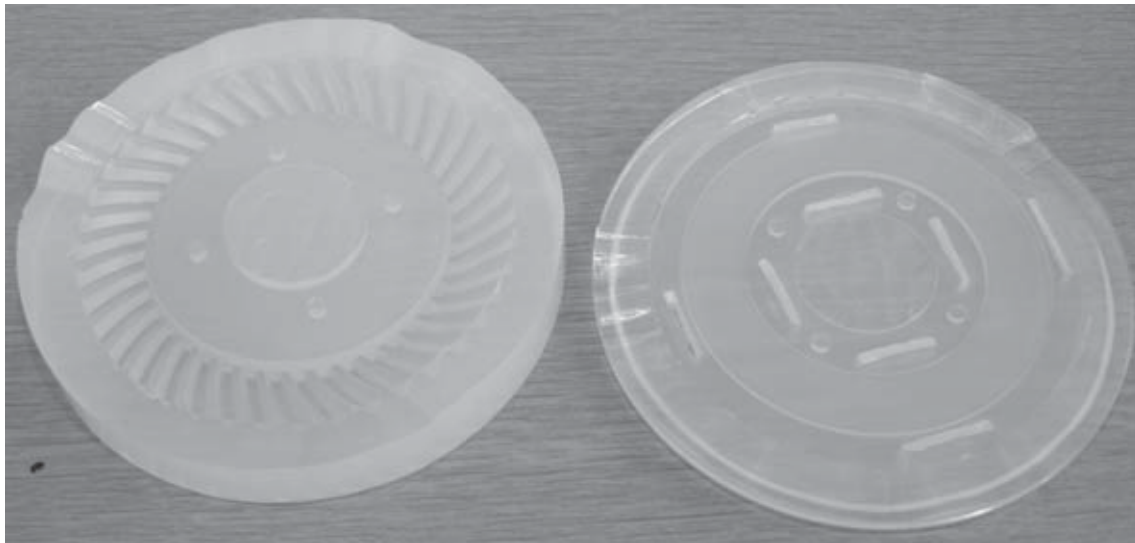


Fig. 3. Silicone form of test hypoid gear

The silicone matrices enable to make casting model of polymer resin. On the Fig. 4 is shown the test models of gears. These models were casted of Epidian 53 resin in the silicone form, which was earlier made. This kind of resin is recommended for making these type of research prototypes [10]. Additionally, an optical effect occurs in this resin, so it can be used for elastooptical method of stress analyse [13].

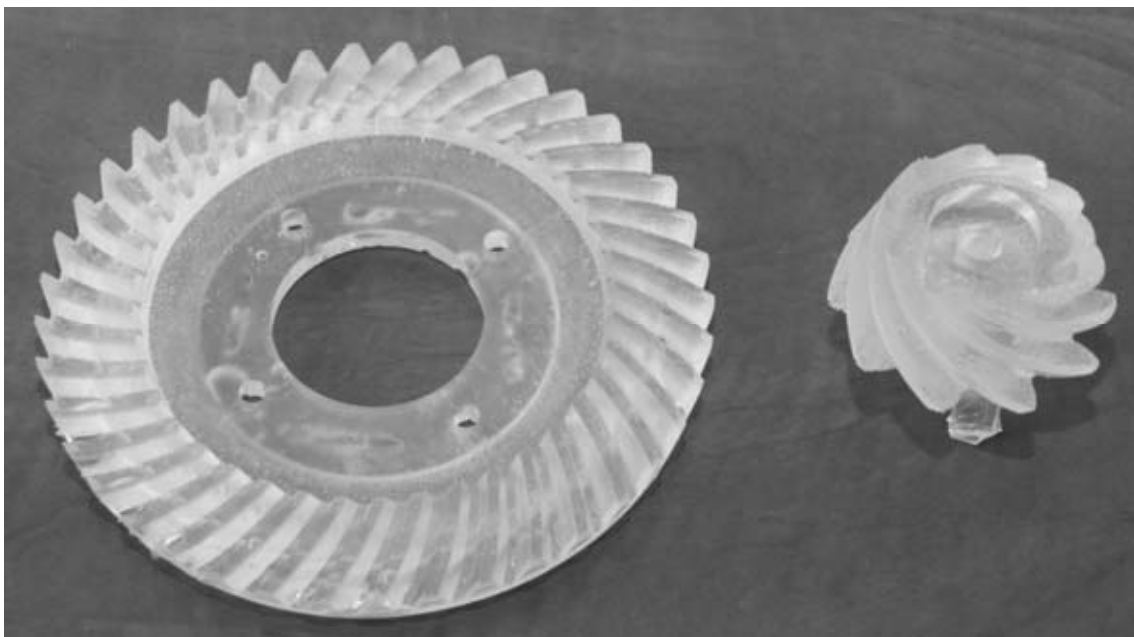


Fig. 4. Test gears models made of Epidian 53 resin

The cast was made in vacuum cast. The reduced pressure is conducive to precisely form filling [1].

3. Testbed research of tooth contact and mating area

The testbed research was carried out on the special constructed placed (Fig. 5). This used testbed enables to mount gear pair of hypoid gear transmission and load static moment.

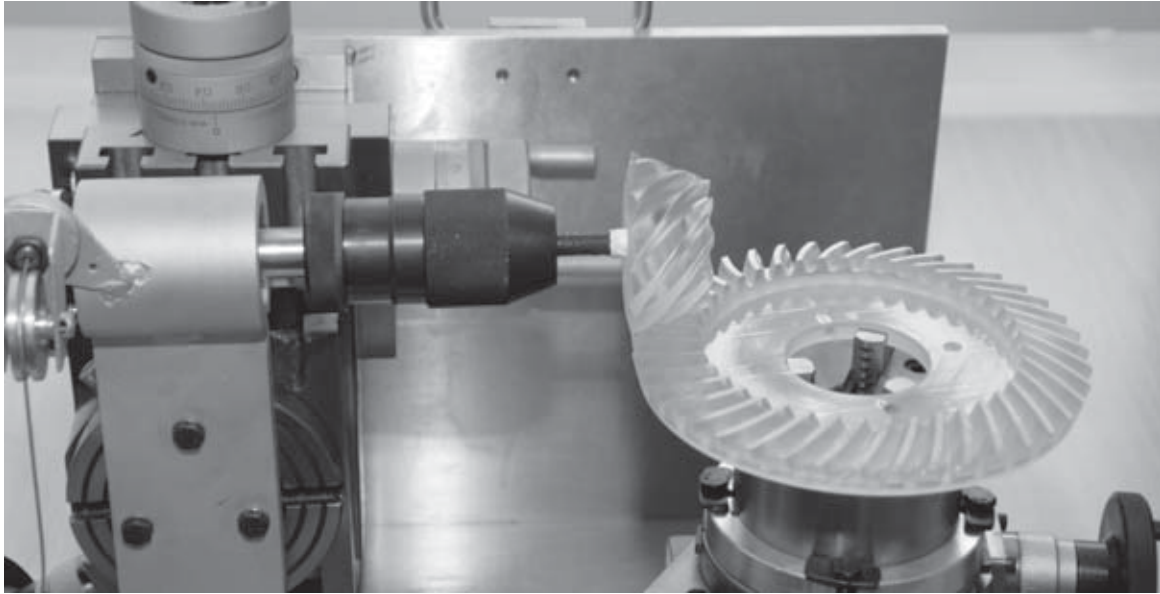


Fig. 5. Model of hypoid gear transmission mounted on testbed

In order to characterize tooth contact, one gear of gear transmission was coated with substances, which allow to visualization of tooth contact and mating area (Fig. 6).



Fig. 6. Contact area of test hypoid gear transmission

The tooth contact is visible directly through transparent resin. Because of gear's rotation, when the gear transmission is loaded by moment, the colourful mating area is remained on the surface of the gear without dye.

4. Conclusions

The tooth contact's researches in toothed gear pairs enable to preliminary qualitative analyze of correctness of their work. The researches should be also conducted in order to check operated properties of gear transmission. On the basis of instantaneous contact area, precisely express – its changes during gear's rotation in gear transmission, the conclusions about smoothness of gear transmission's working can be drawn [9]. Also it is possible to specify the geometric changes, which occur in the gear transmission as a result of long-lasting utilization in real working conditions, for example in driving axle of lorry. In this case the gear transmissions with specific mileage must be put to research.

The research of mating area in metal gear transmissions is expensive and burdensome. The alternative solution is that, when the copy of metal gear transmission, which is made by vacuum casting method, is used. There is used the principle of model's similarity.

The further researches will be head for characterize tooth contact and mating area in gear transmission working with specific rotational speed. In this case it is necessary to build the testbed equipped with fast camera, which enables to indirectly observe the instantaneous contact area.

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