DESIGN OF POLYMER GEARS FOR AUXILIARY POWER TRANSMISSION SYSTEMS OF AUTOMOTIVE VEHICLES

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Abstract

The polymer gears owing to their advantages are used in auxiliary power transmission systems of automotive vehicles. For example, the gears occur in transmissions of drives of car wipers or drives of car windows. The polymer gears are mainly used owing to lower production cost than in steel gears. The better silent-running and corrosion resistance are their other advantages in comparison with steel gears. Unfortunately, the polymer gears are not devoid of disadvantages. The main disadvantages are the lower efficiency and the lower capacity and what follows – the bigger dimensions. The conservative attitude of design of polymer gears is still noticeable. As a rule, such gears resemble steel gears, but the polymer gears are designed with bigger module. The most probably owing costs and lack of proper design recommendations, for design of polymer gears is used geometry of classic steel gears, because the procedure of analytical strength calculations for classic gears is well-know. The gears made from polymers are built in the mould matrices. In constructions of many mechanisms, the gears can be replaced in case of consumption or damage, so the construction of such gears that can be produced in the machine shop equipped with gear generating machine for standard gears, was justified. Nowadays, the constructions of mechanisms used in automotive vehicles are often not even dismountable, but the whole mechanism is changed. It is worth changing the attitude to design of such transmissions. The method of gears production gives many opportunities. The production of gears with complicated geometry, also such geometry that is impossible to obtain using traditional methods of machining, is possible in the mould matrices.

Keywords: *polymer gears, auxiliary power transmission systems*

1. Introduction

The polymer gears are used in auxiliary power transmission systems of automotive vehicles because of their advantages. Such gears are used for example in transmissions of drives of car windows or drives of car wipers. The polymer gears are mainly used because of their lower production costs than production of steel gears. The other advantages of polymer gears in comparison with steel gears are better silent running and corrosion resistance. Unfortunately, the polymer transmissions are not deprived of some disadvantages. One of the most important is lower efficiency and lower capacity. The bigger dimensions in case of the same power transfer as is in the steel transmission are also unwanted disadvantages.

The conservatism of design of such gears is still noticeable. The polymer gears are design similar to steel gears, except that they are produced with bigger module. Probably owing to costs and lack of appropriate design recommendations, the classic geometry of steel gears is still used in course of design, for which the course of analytical strength calculations is well known.

In case of wear or damage, gears in many mechanisms can be exchanged. Therefore, gears are constructed as such that are possible to make in shop equipped only in gear generating machine. Nowadays the constructions of mechanisms used in the automotive vehicles, are not even demountable, the all mechanisms are exchanged.

The losses of energy are considerable problem and they arise because of exploitation of low-efficiency transmission. Many energies change their form into heat. Perhaps the energy losses are not so enormous, but in case of long-term exploitation of car window lifters or mechanisms of windshield wipers, the reduction of these losses should be taken into consideration. At present, it is only ecological fashion, but maybe in the future it will be more serious problem. Especially as such design methods and tools used in polymer transmissions design are available that enable to reduce energy loss. Of course, this problem does not concern only automotive industry, but also any machines and devices in which are used polymer transmissions. The production of metal gears is more expensive and requires more energy than similar polymer gears. The polymer gears are made in matrices and this method gives huge possibilities to modification of tooting.

Of course the metal and polymer gears can be recycled, but the metal gears need to be lubricated which hinders the recycling process, and may lead to environmental pollution.

The typical engine power of car wipers is 150W. In the Fig. 1 is shown the typical transmission of drives of car wipers. This is a worm gear. As shown, the body of transmission is ribbed to caring away of heat. The worm gears characterizes by low efficiency, so it is necessary to cooling.

Fig. 1. Engine with worm gear used in drives of car wipers

Owing to technological requirements, a worm of the typical transmission is mostly cut on the shaft of engine, whereas the worm wheel is made with polymer and its geometry is simplified to cylindrical gears with helical or even straight teeth (Fig. 2).

Fig. 2. Simplified worm wheel

This simplification it due to production a worm wheel in the matrix. In this case, the classic geometric worm wheel is non-technological, because of concave surface on which teeth are made. The shaping of correct geometric worm wheel would require usage of many costly sliders in the matrix.

As a matter of fact, the transmission shaped in such way moves the drive and works mostly correctly, but is really not perfect at all. The simplification of teeth causes an unfavourable change in the tooth contact, reducing the tooth contact ratio, and what fallows increasing noise and decreasing efficiency.

In simplification, the efficiency of worm gear ranges from 30-40%. It means that with 150W power of engine, about 90-105W is lost. Frequently the failures of overheated mechanisms of car wipers happen. It is due to construction of wheel case, which is unable to carry away large amount of heat.

It is possible to use transmissions working on a similar rule, with the same ratio, however, different construction of worm wheel. The different worm wheels are shown in Fig. 3.

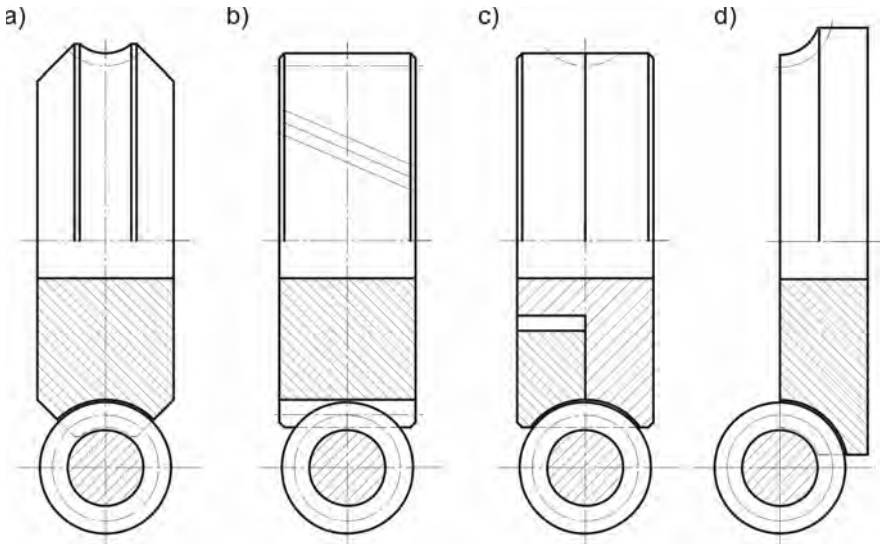

Fig. 3. Construction of worm gears and similar; a – classic, b – with worm wheel simplified to cylindrical gear, c – with split worm wheel, d – intermediate between worm wheel and spiroid gear

It is possible to make the sectional worm wheel (Fig. 3c), however, it involves the necessity of production of two matrices on the components and the difficulty with matching these parts [1]. The better solution is construction intermediate between worm and spiroidal head-on transmission (Fig. 3d). It has similar properties as the worm transmission [2], but its geometry enables the execution of the transmission in the classical matrix without sliders. Additionally the transmission characterizes by possibility of elimination of clearances by axial displacement towards worm. The CAD model of such transmission is shown in Fig. 4 and 5 – functional prototype designed for testing made using Rapid Prototyping technique.

The model made using Rapid Prototyping technique can be tested [3-6], determined the tooth contact, also load and stress distribution in the wheels.

The preliminary research carried out on the testbed is promising. Besides higher efficiency in relation to simplified transmission, the noise decreases considerable. The experimental research of tooth contact also show that the noise does not significantly change during the rotation of the transmission (size of tooth contact "flashes" in the simplified transmission, which is the cause of irregular working and increased noise).

Such transmission characterizes by similar or even somewhat higher efficiency than classic worm transmission, and in relation to similar transmission, its efficiency is higher by about 40%. The other advantage is ability to produce it in the matrix.

Fig. 4. Intermediate transmission between worm gear and spiroid gear – CAD model

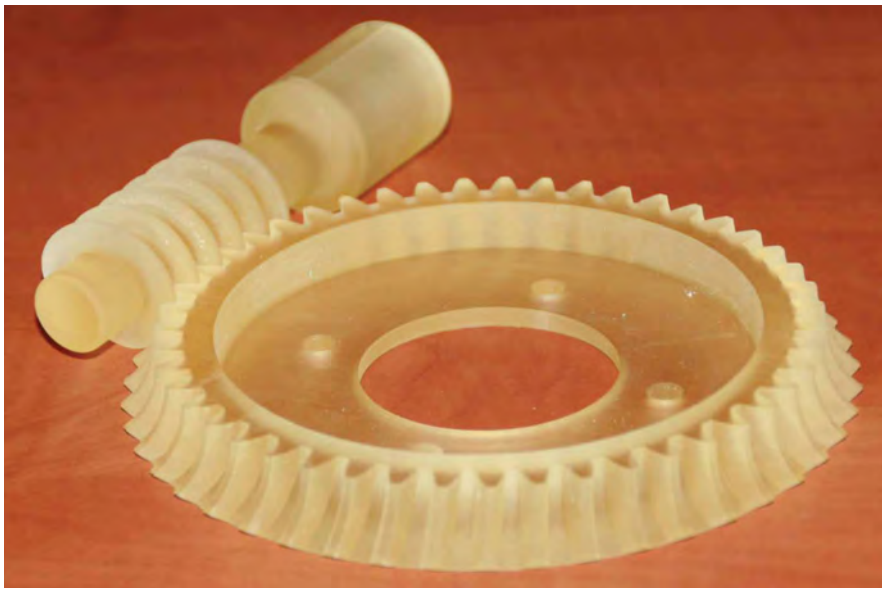

Fig. 5. Intermediate transmission between worm gear and spiroid gear – functional prototype

4. Conclusions

It is worth changing the approach to design of polymer transmissions (and not only in auxiliary drives of mechanisms in the electromechanical industry). A method of wheel production gives the huge opportunities. The matrices enable to make the complicated geometry, also that which is not possible to obtain using traditional methods of machining. The modifications of geometry of gears – tooth profile and flank pitch line (topographic modifications), enable to obtain better working conditions. It is also possible to construct conjugated tooth profiles significantly different from classic involute curve.

In the coming years due to outlined trend of increasing fuel prices, the considerable meaning will have the energy saving made in every possible mechanism of car.

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