Design Method for Optimizing Contact Ratio of Hypoid Gears

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1. Abstract

It proposed a method in which the pitch angle is determined from performance (mainly contact ratio) by that makes it use what any pitch angle can be chosen, based on the theory of new tooth geometry. In this study, the total contact ratio (simply referred to as the contact ratio below) is defined such that the number of lines of contact in the tooth surface is divided by the number in one pitch. Based on the new tooth geometry, the angle of the line of contact is determined on the space regardless of the gear pitch angle. When the tooth surface area was defined, the length of contact of one tooth surface is changed by the gear pitch angle. In other words, the contact ratio is able to increase or decrease by changing the gear pitch angle. Because the angles of the line of contact of the gear concave and convex side are different, the tendency of changing contact ratios is opposite. The balance of contact ratios of the gear convex and concave side is able to change.

By using this proposed method, the design area is expanded because the gear pitch angle is able to change as the design parameter, and it is possible that the three main performances coexist at high level.

2. contents

In the conventional method, when the gear dimension was determined, the curvature of tooth length is solved from the condition that is matched to curvature of cutter. On the other hand, in the new tooth geometry the gear pitch angle is an added design parameter by using the idea of surface of action. It makes it possible that the contact ratios are optimized.

As shown in Fig.1, in the conventional method, the gear pitch angle is determined uniquely. The contact ratio of the gear concave side is larger than that of the gear convex side, and the balance of contact ratios is not able to change. The contact ratio is controlled only by spiral angle. But in this method, since the gear pitch angle becomes a design parameter, all area of Fig.1 is able to be designed. And the balance of contact ratios of the gear convex and concave side is able to change. For example, the change from ● to ★, the selection of ☆ by changing the gear pitch angle after reducing spiral angle(from △ to ◇).

The example that the three important performances (strength, Noise and Vibration and efficiency) coexist is introduced.

The gear C' is designed using this method as shown in Fig.2. The gear C is designed using the conventional method. To secure the criterion of Noise and Vibration of gear C, the lower limit value of the contact ratio is set to M_{CD}. As shown in Fig.3, gear C has a margin for this lower limit value. The gear D is designed using this margin to reduce the spiral angle. As shown in Fig.4, the messing loss was reduced 7%, because reduction of spiral angle is useful to improving efficiency.

3. conclusion

Improving the fuel economy with keeping the quietness is required. This method is very useful and landmark because this method makes it possible that the performances both Noise and Vibration and efficiency coexist.

The Hypoid gears designed by this method applied to LEXUS IS announced in 2013. And all of the hypoid gears for the cars type of passenger of TOYOTA and LEXUS will be designed by this method.

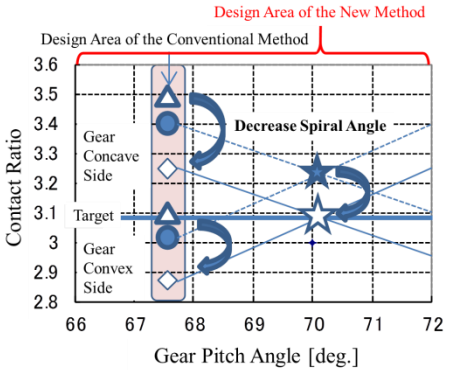

Fig.1 Relationship between gears pitch angle and contact ratio

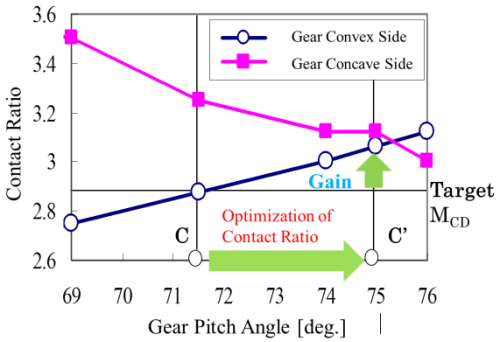

Fig.2 Design example 1 gear pitch angle and contact ratio

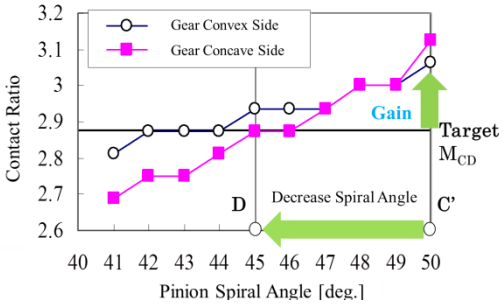

Fig.3 Design example 2 spiral angle and contact ratio

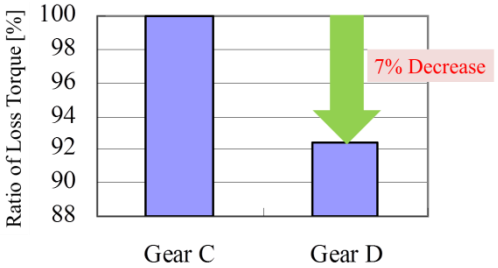

Fig.4 Design example result of ratio of loss torque