Comparison of result of analytical and modeling software for critical section thickness, tip thickness of Asymmetric Spur Involute Gear Tooth

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Abstract

The main objective of this paper is to compare result obtain from analytical calculation and modeling software for critical section thickness and tip thickness of asymmetric spur involute gear tooth. Equations are developed for analytical calculation for critical section thickness & tip thickness of asymmetric spur involute gear tooth and estimate the critical section thickness and tip thickness. And validate the result with help of graph by comparing analytical calculation and modeling software for critical section thickness and tip thickness of asymmetric spur involute gear tooth.

Keywords: Critical section thickness, tip thickness, Asymmetric spur gear

1. Introduction

There has been a lot of research activity on spur gears with asymmetric teeth. New gear designs are needed because of the increasing performance requirements, such as high load capacity, high endurance, low cost, long life, and high speed. In some applications gears experience only unidirectional loading. In this instance, the geometry of the drive side does not have to be symmetric to the coast side. This allows for the design of gears with asymmetric teeth. These gears provide flexibility to designers due to their non-standard design. If they are correctly designed, they can make important contributions to the improvement of designs of gears.

In a standard symmetric gear, both left and right sides of a gear tooth profile have same bending and contact strength. However, in most practical cases, both the forward and backward rotations are not always used for power transmission. Therefore, two sides of the gear toot hare functionally different for most gears. Even if one side (drive side) is significantly loaded for longer periods, the opposite side (coast side) is unloaded or slightly loaded for short duration only. Thus Asymmetric tooth are well suited for cases where the torque is transmitted mainly, in one direction.

As the pressure angle on drive side increases, the bending stress reduces at critical section of asymmetric spur gear and Decision on maximum magnitude of drive side pressure angle is constraint by the safe contact ratio and tooth peaking effect (tip thickness). Its value is should be greater than equal to 0.2 times the module for the hardened gears. Bellow this value, tip thickness decreases and tip becomes too sharp, more and more pointed. This reduction in bending stress can translated into Increased Load Capacity (15-30%), Size and Weight Reduction (10-20%), Longer Life, Cost Reduction, Increased Reliability, Noise and Vibration reduction, Increased Gear Efficiency and Maintenance Cost Reduction.

Thickness of the critical section increases with increase in pressure angle, the bending stress reduces at critical section of asymmetric spur gear as critical section thickness increases. The gear becomes bigger and having more resistance to the load as critical section thickness increases. This way critical section thickness parameter is very important for bending stress.

2. Analytical solution of critical section thickness and tip thickness

Equations are developed for analytical calculation for critical section thickness & tip thickness of asymmetric spur involute gear tooth to estimate the critical section thickness and tip thickness.

Thickness of tooth at any radius r thickness of tooth is calculated by following equations.

$$S_r = S_{rd} + S_{rc}$$

Where,

$$S_{rd} = r.\alpha$$

$$S_{rc} = r.\alpha$$

$$\alpha = \frac{\pi}{2.z} + inv\phi - inv\phi_r$$

$$\phi_r = \cos^{-1}\left(\frac{r_p}{r}.\cos\phi\right)$$

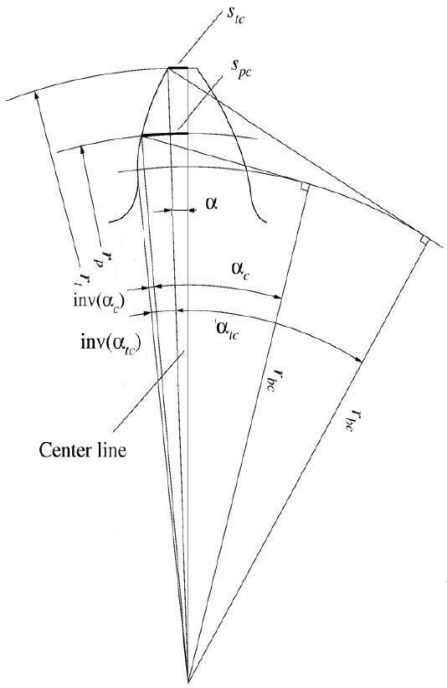

Fig. 1 Representation of angle α at tip radius

For this analysis solutions following gear tooth parameters are used. Gears are used to transmit a power of 18KW at 1600 rpm.

Gear tooth parameter

Sr. No.	Description	Value
1	Pressure angle, Coast side	200 fixed
2	Pressure angle, Drive side	200 – 400 increment by 20
3	Number of teeth	25 and 47
4	Module	4 mm

Table 1 Gear tooth parameter

With help of above equation obtained the tip thickness and critical section thickness of asymmetric spur gear tooth which are listed in bellow table.

Sr.No.	Asymmetric gear of different pressure angle of drive side profile	Tip thickness of spur gear in mm	Critical thickness in mm
1	20	2.662812431	7.770234788
2	22	2.530329326	7.953000430
3	24	2.390176814	8.115205444
4	26	2.242216251	8.271424667
5	28	2.086155863	8.426176879
6	30	1.921555886	8.581968613
7	32	1.747827740	8.740556189
8	34	1.564227332	8.903373338
9	36	1.369842319	9.071725278
10	38	1.163572744	9.246897198
11	40	0.944104088	9.430227550

Table 2. Critical section thickness and tip thickness obtained from analytical calculation

3. Modeling software solution of critical section thickness and tip thickness

In pro-e software different model of spur gear with different pressure angle on drive side profile are generated. From these models obtained the tip thickness and critical section thickness of spur gear tooth which are listed in bellow table.

Sr.No.	Asymmetric gear of different pressure angle of drive side profile	Tip thickness of spur gear in mm	Critical thickness in mm
1	20	2.66	7.48
2	22	2.53	7.62
3	24	2.40	7.75
4	26	2.25	7.90
5	28	2.10	8.04
6	30	1.92	8.17
7	32	1.74	8.33
8	34	1.61	8.48
9	36	1.32	8.63
10	38	1.11	8.79
11	40	0.86	8.97

Table 3. Critical section thickness and tip thickness obtained from modeling software.

4. Results & Discussions

From above data tip thickness Vs pressure angle on drive side of asymmetric spur gear graph is developed to compare data obtained from analytical calculation and software data

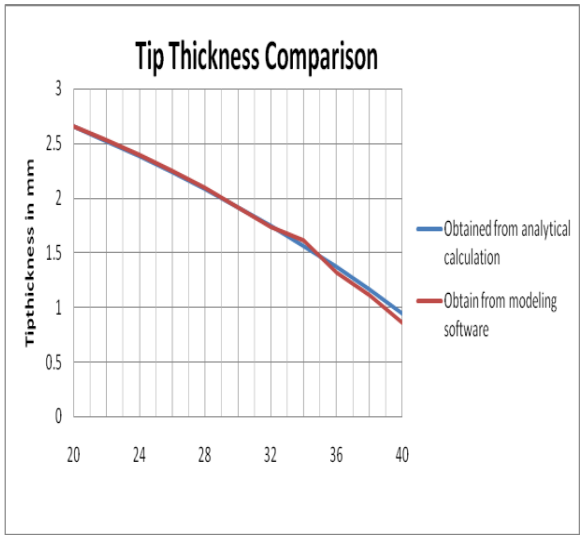

Fig. 2 Graph tip thickness Vs pressure angle on drive side gear tooth.

Data obtained from analytical calculation and software data are same which validate analytical solution. As the pressure angle on drive side increases, tip thickness reduces. Tip thickness decreases and tip becomes too sharp, more and more pointed.

From above data critical section thickness Vs pressure angle on drive side of asymmetric spur gear graph is developed to compare data obtained from analytical calculation and software data.

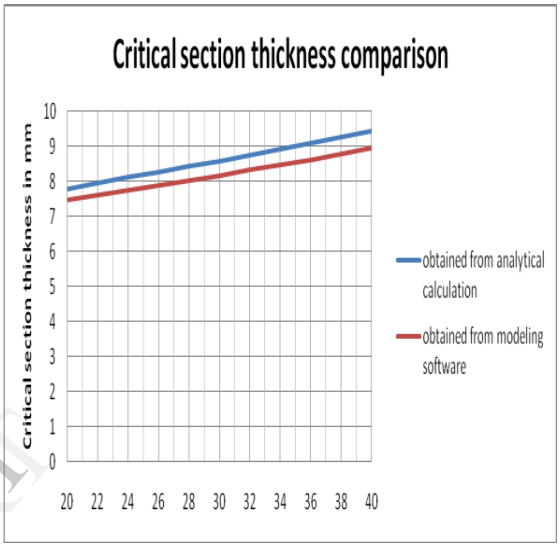

Fig. 3 Graph critical section thickness Vs pressure angle on drive side gear tooth.

Data obtained from analytical calculation and software data are same which validate analytical solution. Thickness of the critical section increases with increase in pressure angle, the bending stress reduces at critical section of asymmetric spur gear as critical section thickness increases. The gear becomes bigger and having more resistance to the load as critical section thickness increases.

5. Conclusion

Graphs are generate to compare result obtain from analytical calculation and modeling software for critical section thickness and tip thickness of asymmetric spur involute gear tooth. Data obtained from analytical calculation and software data are same which validate analytical solution for critical section thickness and tip thickness of asymmetric spur involute gear tooth.

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