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OPTIMIZING THE STRENGTH OF HELICAL GEAR USING DESIGN OF EXPERIMENT TECHNIQUE

Engineering

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ABSTRACT

Gears play an important role in power transmission in different mechanical systems. The load carrying ability of the gears is determined by its beam strength and wear strength. In this paper beam strength of the helical gear is studied considering its module, number of teeth and helix angle as the design parameters. An attempt has been made to achieve the optimum result in the experimental study by employing Design of Experiment with full factorial design. The ANOVA analysis was used to obtain optimum parameters and optimum parameters are module 7mm,no. of teeth 26 and helix angle 20° to achieve maximum beam strength.

I. INTRODUCTION

Gears are toothed wheels which are used to transmit power from one shaft to another by successive engagement of teeth with zero slip. In helical gears teeth are in the form of helix on the pitch cylinder and are used to connect two parallel shafts. Unlike the spur gears where also the teeth are cut parallel to the shafts and the contact between the meshing teeth occurs along the entire face width of the tooth, here in helical gear the contact between the meshing teeth begins with a point on the leading edge of the tooth and gradually extends along the diagonal line across the tooth. Thus there is a gradual pick up of the load by the tooth resulting in smooth engagement and quiet operation.

There are two basic modes of gear failure:

(i)Breakage of gear tooth due dynamic and static loads : To prevent this failure the various gear design parameters such as module, face width etc are so selected that the beam strength of the gear tooth is more than the static and dynamic loads.

(ii)Surface destruction: The surface failure of the material may take place due to the presence of some foreign particles like dirt, metallic debris etc in the lubricant or due to corrosion or pitting of the tooth surface.If the contact stresses between the two meshing teeth exceed the surface endurance strength of the material the failure of the gear tooth occurs due to wear.

The various design parameters of the gear should be selected to transmit high power without undergoing any of the above said failures. But the gear load capacity may be limited by tooth strength. With the development of gear heat treatment technology, such as carburizing, high-frequency hardening and nitriding technology, the tooth contact strength has been significantly improved. In this study the beam strength of the helical gear tooth is considered as the objective function which is to be maximized considering module, number of teeth and helix angle as the various design parameters.

The beam strength of the gear tooth is given by Lewis equation which is: $W_s=\sigma_o*C_v*b*m_n*y$

where ,σ_o=allowable stress ,C_v=velocity factor, b=face width, m_n= normal module, m_n=m cosΦ, m=module,Φ=helix angle, y=tooth form factor based on formative number of teeth.

Fig.1.1 Helical Gear

II. METHODOLOGY

Design of experiments (DOE) method are among the most effective and useful statistical quality control technique to investigate the individual and interaction effects of the process parameters. DOE methods can be an important part of system optimization, yielding definitive system design or redesign recommendations. These methods also involve the activity experimental planning, conducting experiments, and fitting models to the outputs. An essential ingredient in applying DOE methods is the use of experimental design can have a large influence on the accuracy and the construction cost of the approximations. Several experimental design techniques have been used to aid in the selection of appropriate points. Experimental design strategy, using Taguchi orthogonal arrays concept is used in the paper.

The following L-9 orthogonal array was applied:

Table 1.1 L-9 Array

Module (mm)	Helix angle	No.of teeth	Strength
5	20	20	13467
5	30	24	13844
5	35	26	13624
6	20	24	20410
6	30	26	20225
6	35	20	18857
7	20	26	28428
7	30	20	26090
7	35	24	26425

III. RESULTS & DISCUSSION

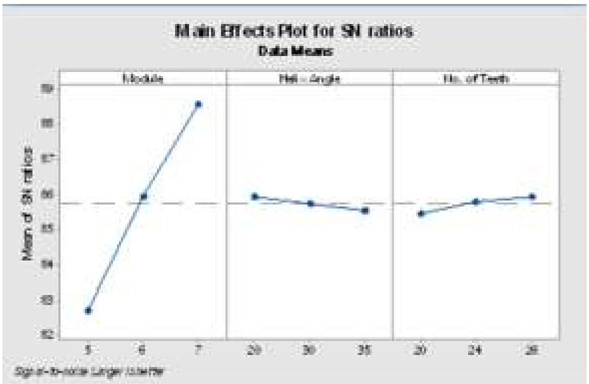


Figure 1.2 Main effects plot for S/N Ratio

The above SN ratio graph was made using 3 variables i.e. module, number of teeth and helix angle. As observed from graph, it is clear that at 7 mm of module, 26 number of teeth and 20° helix angle gives the best output in terms of beam strength of gear teeth will be maximum.

ANOVA Test results for strength of gear

Table 1.2 General linear Model (ANOVA) for strength of gear

Analysis of Variance for SN ratios

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Module	2	52.6602	52.6602	26.3301	4140.93	0.000
Helix Angle	2	0.2488	0.2488	0.1244	19.56	0.049
No. of Teeth	2	0.3740	0.3740	0.1870	29.41	0.033
Residual Error	2	0.0127	0.0127	0.0064		
Total	8	53.2957				

S = 0.07974 R-Sq = 100.0% R-Sq(adj) = 99.9%

Table 1.3 Percentage contribution of design parameters

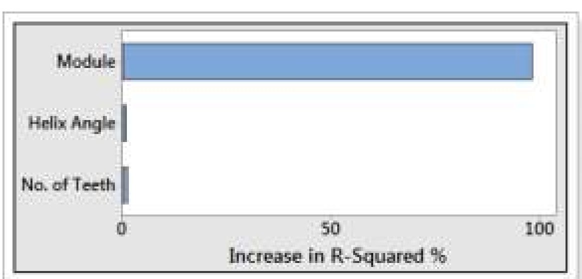
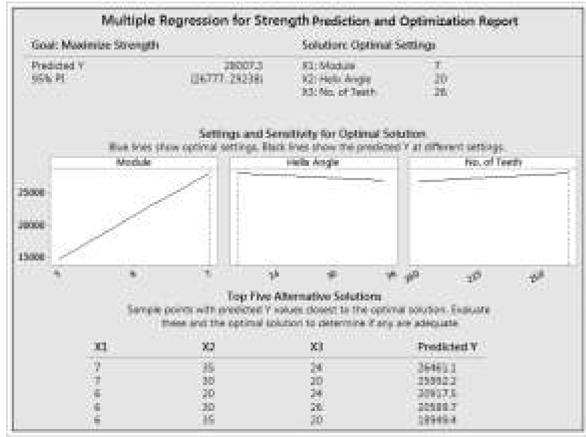


Table 1.4 Optimization Report



IV CONCLUSION

The optimized value of strength of gear teeth comes out to be at 7 mm module,26 number of teeth and helix angle 20° as shown in Fig1.2 and the optimized value is 28007.3 at 95% confidence level. Further from Table 1.2 it is evident that maximum contribution towards achieving the optimized output is of module which is 98.8 %..The contribution of number of teeth and helix angle is insignificant as compared to module. The application of Taguchi L9 array provides the optimized result with 95 percent confidence level and by using only 9 input values rather than conducting 27 experiments. Hence this technique of optimizing is accurate, fast and reliable and can be carried out conveniently with less effort and resources.

V FUTURE SCOPE

In the present study beam strength of helical gear is optimized with design variables as module, no. of teeth and helix angle. Further the study can be extended to include face width as design variable. The optimized parameter in future study can be wear strength of helical gear taking into account three set of input variables out of module,no of teeth ,face width and helix angle.

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