HELICAL GEAR DESIGN TO OVERCOME STUCKING AND SCUFFING

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ABSTRACT

Scuffing is one of the most common surface failure modes observed at lubricated, loaded contacts experiencing excessive relative sliding. The machine containing old gear having stucking and scuffing problem was checked for vibration analysis. Machine is among heavy duty application, these machines are operated at very high speed. In this work, analysis of high speed helical gear used in machine has been carried out. The new gear and pinion pair is designed with Gleason software of gear design consisting highest technology in gear design. Finally the result obtained by FEM analysis of old gear and new Manufacturing gear and pinion pair is again checked using a FEM and the result are compared to check the correctness. A conclusion has been arrived on the new design manufacturing gear is best suited for the machine based on the result. Basically the project involves the design and analysis of helical gear in industrial application. It is proposed to focus on reduction of vibration and better performance.

INTRODUCTION

The development of gear technology for making various types of gears gives the ability to transmit motion and power between rotating shafts regardless of whether they rotate about parallel axes, non-parallel axes, or intersecting axes. In comparison with other power transmission systems, gear systems can be used with high reliability to transmit high power with generally low space requirements. Helical gears resulted from development of spur gears to improve their performance. Spur gears transmit motion and power between parallel shafts through teeth that run parallel to the gear axes across the face width. The gear is described as helical when the teeth are not parallel to the axis but are twisted at an angle with the gear axis.

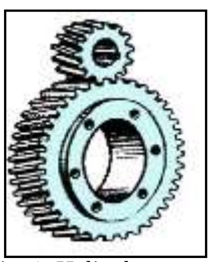


Fig. 1. Helical gear pair

In a pair of mating helical gears the helix angle must have the same value. In addition, they must have opposite helix hand. A typical helical gear pair is illustrated in Figure 1. Scuffing is often seen near the tips and roots of the teeth as shown in Figure 1.2. In general those areas of the teeth have the worst combination of high sliding velocities and load conditions.

Fig.2- Scuffing on tip of gear tooth

The occurrence of scuffing may be promoted by any factor leading to overloading under high slide to roll ratio or the failure of the oil film separating the tooth surfaces. These effects may be the result of various causes, such as insufficient tip relief modification, thermal effects and the consequences of pitting of the teeth. Tooth surfaces need to be protected from this sort of failure and this can be achieved to a large extent by using special additives to improve lubricant properties under severe conditions of high pressure and temperature (EP additives).

PROBLEM STATEMENT-

1) Scuffing and pitting phenomenon in helical gear of press machine which causes improper elasto hydrodynamics.
2) Vibration and noise in gearing system.

LITERATURE SURVEY

Tejas K. Patil and V. G. Bhamre [1] had reviewed the work on Design and analysis of helical gear using ANSYS, FEM & AGMA standards, which provides information of surface strength and tooth root strength of helical gear in static condition. By analytical methods, the calculated bending stresses and contact stresses have errors. The error percentage is 1 % in contact stresses & 6 % in bending stresses respect to ANSYS. Parametric study is done by varying the geometry of the teeth.
Sathyanarayana Achari, R. P. Chaitanya and Srinivas Prabhu [2] had done the investigation on comparison of bending stress and contact stress of helical gear as calculated by AGMA standards and FEA. To estimate the bending stress at the tooth root Lewis beam strength method was applied.
Govind T Sarkar, Yogesh L Yenarkar and Dipak V. Bhope [3] had done the work on stress analysis of helical gear. The involute profile of helical gear has been modeled and the simulation is carried out for the bending and contact stresses by finite element method and result obtained in analysis were compared with AGMA standard. It can be concluded that the helix angle is critical for contact stress as increasing helix angle increases contact stresses because it increases length of contact in the area.
S. Jyothirmai, R. Ramesh, T. Swarnalatha and D. Renuka [4] had done the investigation on a finite element approach to bending, contact and fatigue stress distribution in helical gear system. The objective of their work is to conduct a comparative study on helical gear design and its performance based on various performance metrics through finite element as well as analytical approaches.

RESEARCH GAP:

In the literature nobody has special study on stucking and scuffing phenomenon for helical gear pair of press machine.

HELICAL GEARS:

A Helical gear has teeth in the form of helix around the gear. Two such gears may be used to connect two parallel shafts in place of spur gears. The helixes may be right handed on one gear and left handed on the other. The pitch surfaces are cylindrical as in spur gearing, but the teeth instead of being parallel to theaxis, wind around the cylinders helically like screw threads. The teeth of helical gears with parallel axis have line contacts as in spur gearing. This provides gradual engagement and continuous contact of the engaging teeth. Hence helical gears give smooth drive with high efficiency of transmission. Helical gearshave an involute profile similar to spur gears. The contact between meshing teeth of helical gears begins with a point on the leading edge of the tooth and gradually extends along the diagonal line across the tooth.When helical gears mesh, there is a gradual application of load. Thus, helical gears have smooth engagement and quiet operation.

Proportion of Helical Gears:

American Gear Manufacturing Association (AGMA) Recommendations:

Table 1- Proportion of Helical Gears

Pressure angle in the plane of rotation	$\propto = 15°$ to $25°$
Helix angle,	$\beta = 20 - 45°$
Addendum	0.8 m (maximum)
Dedendum	1.0 m
Minimum total depth	1.8 m (maximum)
Minimum clearance	0.2 m
Thickness of tooth	1.5708 m

Dimensions of Helical Gear:

(No.M Trail 5 Cut)

All Dimensions Are Metric Unless Otherwise Specified Released By - RSB

Table 1. - Dimension of helical gear

	PINION	GEAR
Number Of Teeth	14	80
Module		2.587
Face Width	78.55	79.21
Pressure Angle - Pin Concave	20D 0M	
Pressure Angle - Pin Convex	20D 0M	
Shaft Angle	90D 0M	
Transverse Contact Ratio		1.117
Face Contact Ratio		2.151
Modified Contact Ratio		2.424
Outer Cone Distance		105.05
Mean Cone Distance		93.94
Pitch Diameter	36.22	206.95
Circular Pitch	8.13	
Working Depth	4.48	
Whole Depth	4.91	4.96
Clearance	0.43	0.49
Addendum	3.12	1.36
Dedendum	1.80	3.60
Outside Diameter	42.36	207.42
Theoretical Cutter Radius	5.740”	
Cutter Radius	2.500”	
Calc. Gear Finish. Pt. Width		0.060”
Gear Finishing Point Width		0.060”
Roughing Point Width	0.025”	0.050”
Outer Slot Width	0.024”	0.060”
Mean Slot Width.	0.049”	0.060”
Inner Slot Width	0.064”	0.060”
Finishing Cutter Blade Point	0.020”	0.040”
Stock Allowance	0.000”	0.010”

Max. Radius - Cutter Blades	0.010”	0.039”
Max. Radius - Mutilation	0.019”	0.050”
Max. Radius - Interference	0.016”	0.044”
Cutter Edge Radius	0.010”	0.035”
Calc. Cutter Number	5	10
Max. No. Of Blades In Cutter		12.980
Cutter Blades Required	STD DEPTH	STD DEPTH

Model of helical gear pair:
Introducing a new Model of any gear is the primary procedure to design of gear from given dimensions and analysis of gear pair.

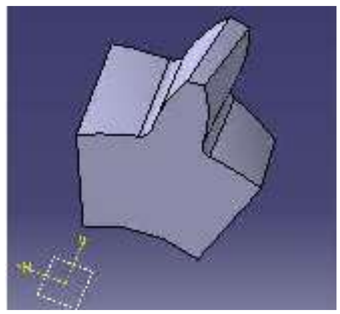



Figure 3. Model of Single helical pinion tooth profile *Figure 4. Model of Helical Gear tooth Profile*

Figure 3. and 4. shows the model of helical pinion tooth profile and helical gear tooth profile. When the helical gear design, firstly create the model and before analyses the model in FEM.

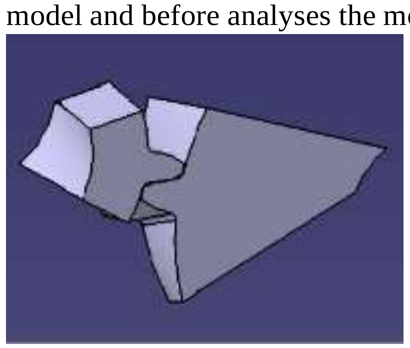


Figure 5. Model of Helical gear pair tooth profile

Figure 5. shows the model of helical gear pair tooth profile. It shows gear and pinion contact with each other and next FEM procedure is carried out.

Analysis of Gear:
Analysis of the characteristics of helical gear in a gearbox will be studied using linear Finite Element Method. Gear analysis was performed using analytical methods, which required a number of assumptions and simplifications. Bending stress analysis will be performed, while trying to design helical gear to resist bending failure of the teeth, as it affects transmission error. As computers have become more and more powerful, people have tended to use numerical approaches to develop theoretical models to predict the effect of whatever is studied. This has improved gear analysis and computer simulations.

Finite Element Method
The finite element method is numerical analysis technical of optioning approximate solution to a wide verity of engineering problems. because of its diversity and flexibility as an analysis tool , it is receiving

much attention in engineering school and industries in more and more engineering situation today , we find that it is necessary to obtain approximate solution to problems rather than exact close from solution it is not possible to obtain analytical mathematical solutions are many engineering's problems. An analytical solution is a mathematical expression that gives value of the desire unknown quantity any location in the body, as consequence it is valid for infinite number of location in the body. For problem involving complex material properties and boundary condition, the engineer resource to numerical method that provide approximate that eatable solution.

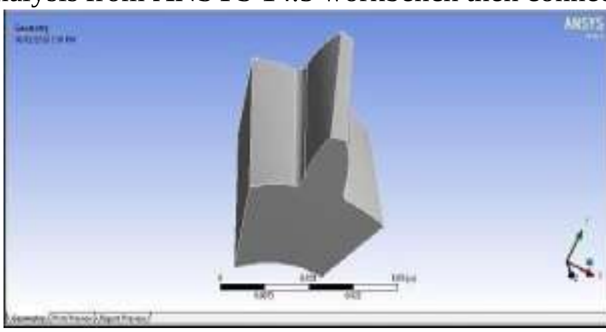
FEM PROCEDURE

Procedure of static analysis:

First of all, we have prepared assembly in Pro/E for helical gear and save as this part as IGES for Exporting into ANSYS work-bench Environment. Import IGES mode in ANSYS workbench simulation module. Apply material for spur gear (structural steel).

Geometry

For analysis of 3D model of helical gear tooth, imported the IGES file by selecting the static structural analysis from ANSYS 14.5 workbench then connected the geometry to analysis tab.



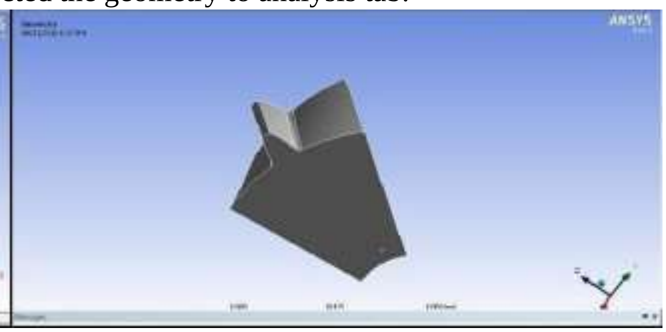


Figure 6. Geometry of Single tooth profile of helical pinion Figure 7. Geometry of Single tooth profile of helical gear

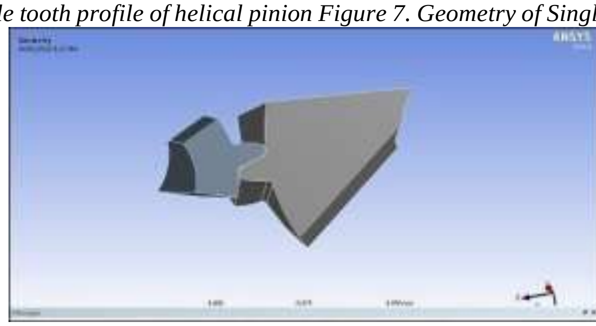
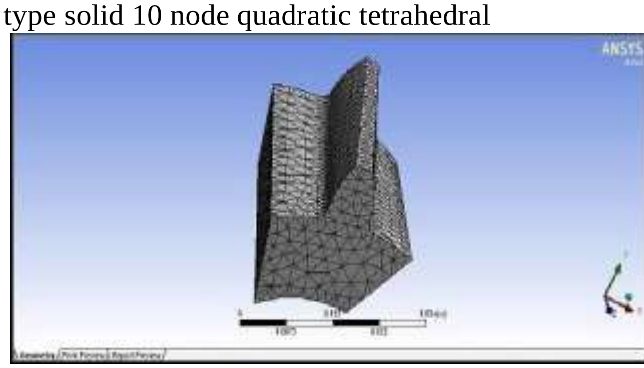


Figure 8. Geometry of Assembly of Single tooth profile of helical gear pair

Meshing of generated tooth profile:

3D tetrahedral mesh with element medium size is used for mesh generation of the gear models. Element type solid 10 node quadratic tetrahedral



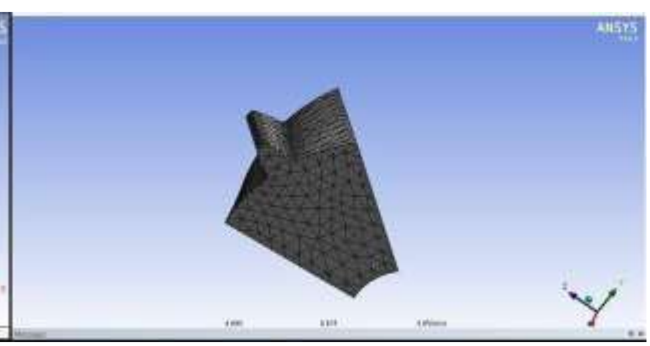


Figure 9. Meshing of Single tooth profile of helical pinion Figure 10. Meshing of Single tooth profile of helical gear

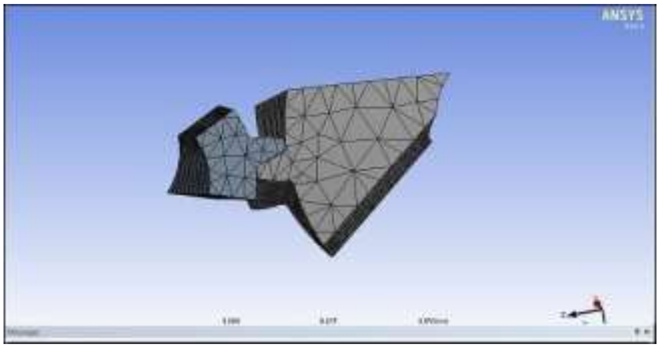


Figure 11. Meshing of Assembly of helical gear pair

Define boundary condition for analysis:

Boundary condition play the important role in finite element calculation here, I have taken both remote displacement for bearing supports are fixed.

Parameter	Value
Tangential tooth load/ force	
Radial load/ force	
Axial load/ force	3487.41 N
Fixed Support	Bottom face of tooth for bending stress analysis and pinion tooth bottom face and gear tooth for contact stress analysis

Bending Stress for Helical pinion and gear tooth profile:

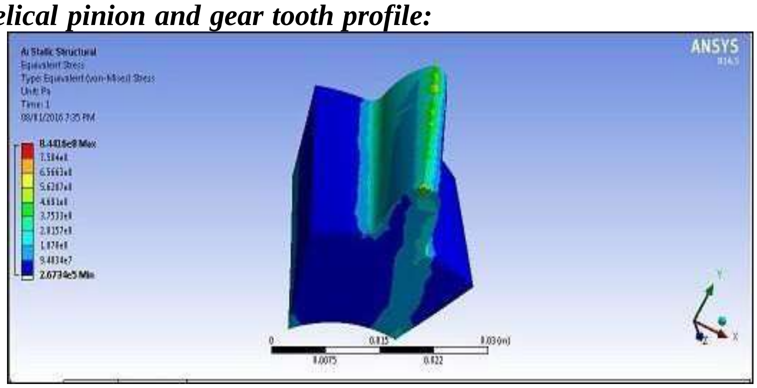


Figure 12.- Distribution of Equivalent von-mises stress along the pinion tooth profile

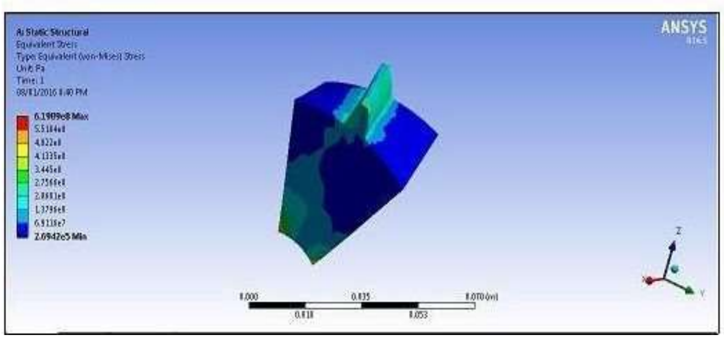


Figure 13.- Distribution of Equivalent Von-mises stress along the gear tooth profile

Figure shows Bending Stress for Helical pinion and gear tooth profile by using equivalent von-mises stress along the pinion tooth profile. It indicates 2.073e5 minimum stress to 8.4416e8 maximum stress bending stress. Figure shows Bending Stress for Helical pinion and gear tooth profile by using equivalent von-mises stress along the gear tooth profile.

Contact Stress of Helical gear pair of the teeth:

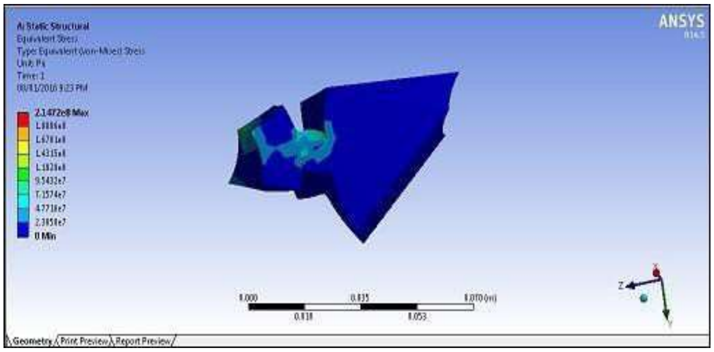


Figure 14.- Distribution of Equivalent Von-mises stress along the gear pair tooth profile

Figure 14. shows Contact Stress for Helical pinion and gear tooth profile by using equivalent von-mises stress along the pinion tooth profile.

CONCLUSION

From the design of new helical gear containing FEM analysis. FEM analysis observes the stucking and scuffing area about helical gear. From the result of bending stress of helical gear and contact stress of helical gear to overcome the stucking and scuffing area of helical gear.

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