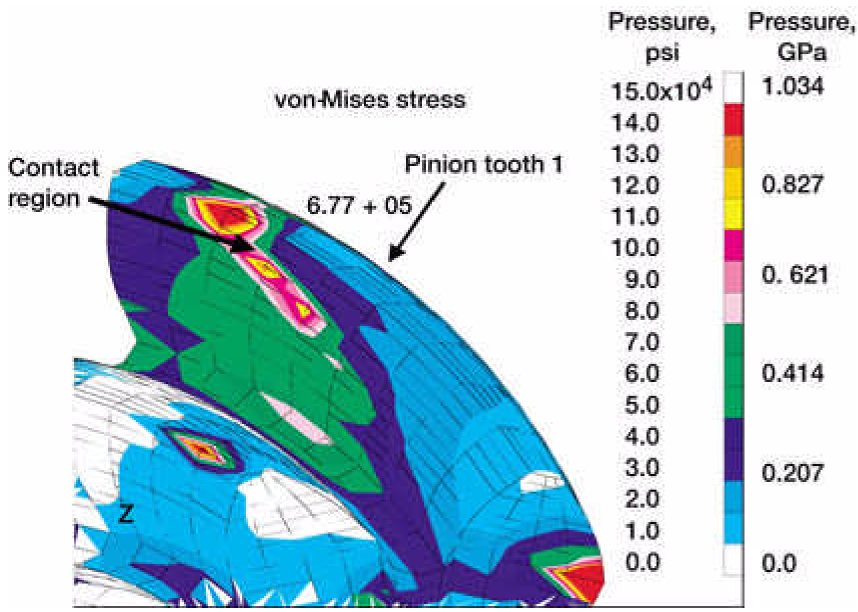
Experimental and Analytical Determinations of Spiral Bevel Gear-Tooth Bending Stress Compared

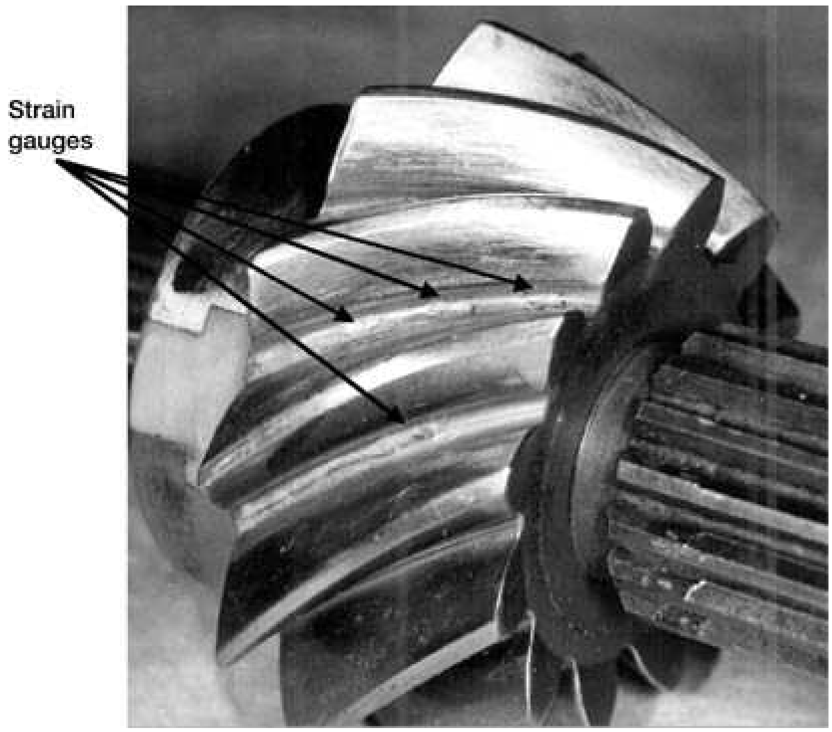
Spiral bevel gears are currently used in all main-rotor drive systems for rotorcraft produced in the United States. Applications such as these need spiral bevel gears to turn the corner from the horizontal gas turbine engine to the vertical rotor shaft. These gears must typically operate at extremely high rotational speeds and carry high power levels. With these difficult operating conditions, an improved analytical capability is paramount to increasing aircraft safety and reliability. Also, literature on the analysis and testing of spiral bevel gears has been very sparse in comparison to that for parallel axis gears. This is due to the complex geometry of this type of gear and to the specialized test equipment necessary to test these components.



Example of stress output produced by the model.

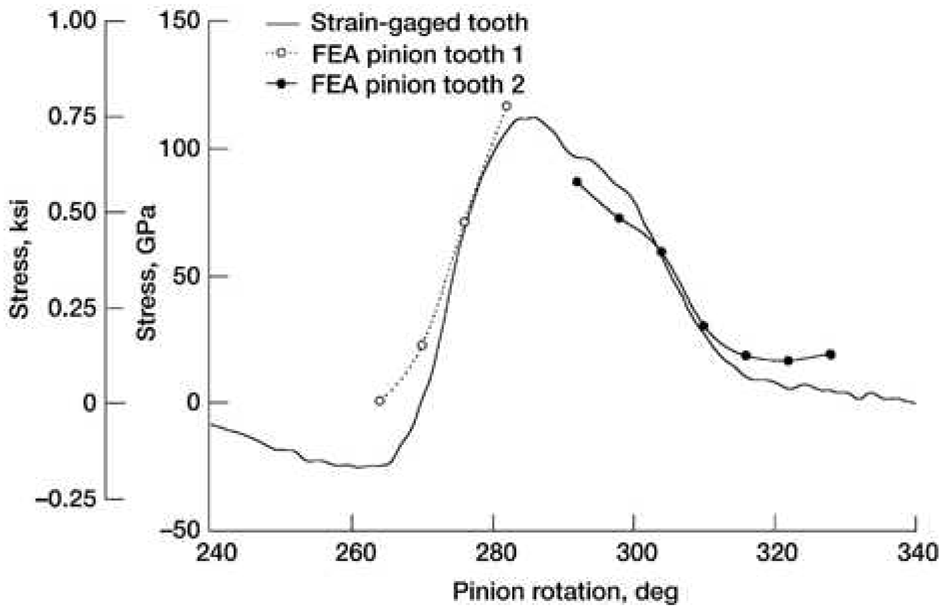
To develop an analytical model of spiral bevel gears, researchers use differential geometry methods to model the manufacturing kinematics. A three-dimensional spiral bevel gear modeling method was developed that uses finite elements for the structural analysis. This method was used to analyze the three-dimensional contact pattern between the test pinion and gear used in the Spiral Bevel Gear Test Facility at the NASA Glenn Research Center at Lewis Field. Results of this analysis are illustrated in the preceding figure. The development of the analytical method was a joint endeavor between NASA Glenn, the U.S. Army Research Laboratory, and the University of North Dakota.

To validate the predictions made by the newly developed numerical method, experimental tests were conducted on Glenn’s Spiral Bevel Gear Test Facility. The following figure shows the instrumented spiral bevel pinion that was used in the test. The instrumented spiral bevel gears were tested from static to high rotational speeds (14,400 rpm) at various levels of load (up to 539 kW (720 hp)).



Instrumented spiral bevel pinion used in the tests.

Results from the experiments were compared with those produced analytically by the newly developed model. As seen in the final figure, the experimental and analytical results are in good agreement with each other. In addition, both sets of results indicate that the peak gear-tooth bending stresses occur in the fillet radius near the midface of the tooth.



Comparison of experimental and analytical stresses at the pinion midface at 14,400 rpm and 539 kW (720 hp).

Find out more about this research http://www.grc.nasa.gov/WWW/5900/5950/.

Bibliography

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