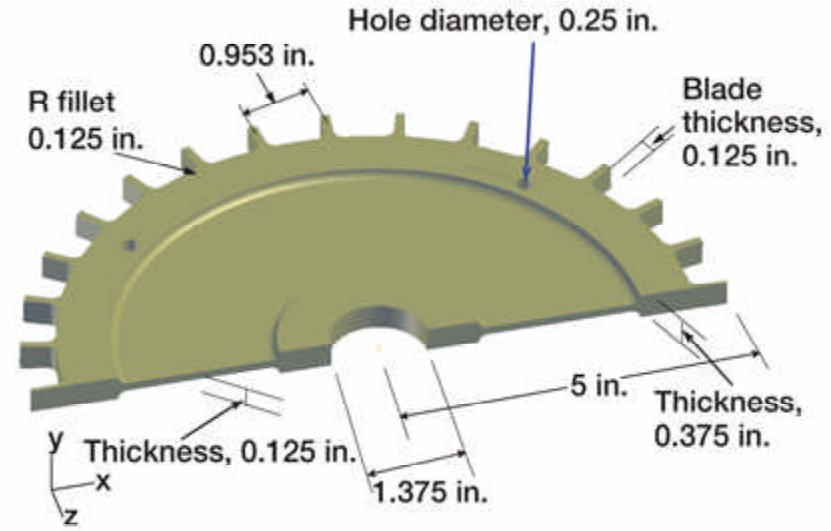
Applicability of a Crack-Detection System for Use in Rotor Disk Spin Test Experiments Being Evaluated

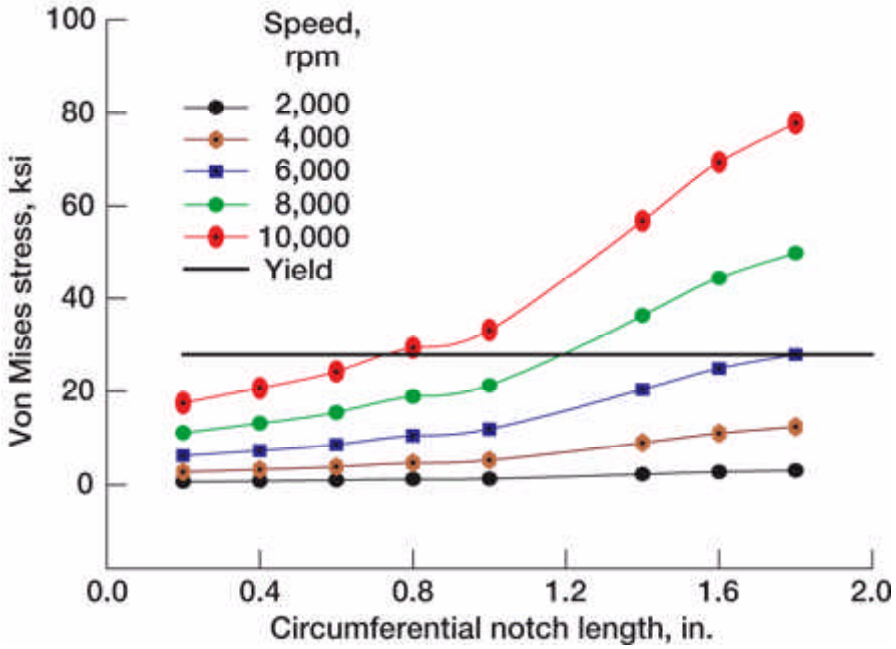
Engine makers and aviation safety government institutions continue to have a strong interest in monitoring the health of rotating components in aircraft engines to improve safety and to lower maintenance costs. To prevent catastrophic failure (burst) of the engine, they use nondestructive evaluation (NDE) and major overhauls for periodic inspections to discover any cracks that might have formed. The lowest cost fluorescent penetrant inspection NDE technique can fail to disclose cracks that are tightly closed during rest or that are below the surface. The NDE eddy current system is more effective at detecting both crack types, but it requires careful setup and operation and only a small portion of the disk can be practically inspected. So that sensor systems can sustain normal function in a severe environment, health-monitoring systems require the sensor system to transmit a signal if a crack detected in the component is above a predetermined length (but below the length that would lead to failure) and lastly to act neutrally upon the overall performance of the engine system and not interfere with engine maintenance operations. Therefore, more reliable diagnostic tools and high-level techniques for detecting damage and monitoring the health of rotating components are very essential in maintaining engine safety and reliability and in assessing life.



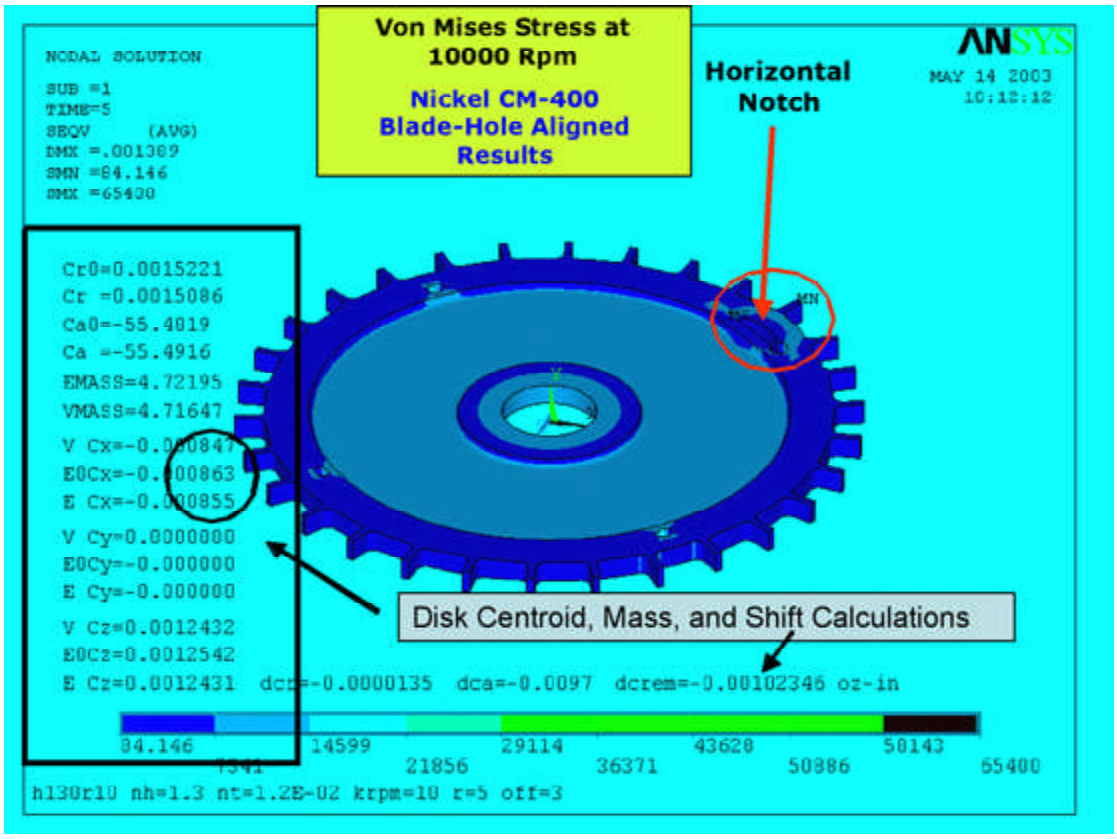
Flat disk geometry and dimensions.

These concerns are high priorities in the NASA Aviation Safety Program, whose intention is to develop and demonstrate technologies that will help reduce the aviation fatal accident rate by a factor of 5 by the year 2007. This ambitious program is a partnership that includes NASA, the Federal Aviation Administration, the aviation industry, and the

Department of Defense (ref. 1). The program's objectives are twofold: (1) to develop and demonstrate technologies that will reduce aircraft accident rates and (2) to develop technologies that will reduce aviation injuries and fatalities when accidents do occur. As a result and in support of the latter aim, the NDE Group at the NASA Glenn Research Center is actively involved in developing combined experimental and analytical health-monitoring technologies to detect rotor damage prior to any catastrophic events (ref. 2). This work is focused on presenting finite element results of a 25.4-cm- (10-in.-) diameter flat turbinelike disk used to evaluate crack-detection techniques. The preceding illustration shows the geometry. The solutions are focused on finding the changes in maximum radial deflections and changes in the center of mass as a function of the rotational speed and crack characteristics (crack size and location) to make detection feasible in the subscale flat test disk. The study is motivated by data showing that cracks as small as 1.27 mm (0.05 in.) have been detected in jet engine rotors tested in spin pits (Drumm, M.J.: Personal communication, 1998.) by monitoring the radial vibration amplitude and phase and detecting changes in the center of mass associated with a minute unbalance of the distorted strain field of a developing crack (ref. 3). The current analytical work is seeking an optimized disk design that can be tested to evaluate the functionality of the health monitoring and its applicability in the spin test facility. Data pertaining to the results obtained are shown in the following figures, where the maximum stress (ref. 4) due to the applied rotational speed and the notch size are shown.



Von Mises stress as a function of crack or notch size.



Von Mises stress contour plot at 10,000 rpm for a 1.3-in.-long notch located in the rim region of the disk.

References

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