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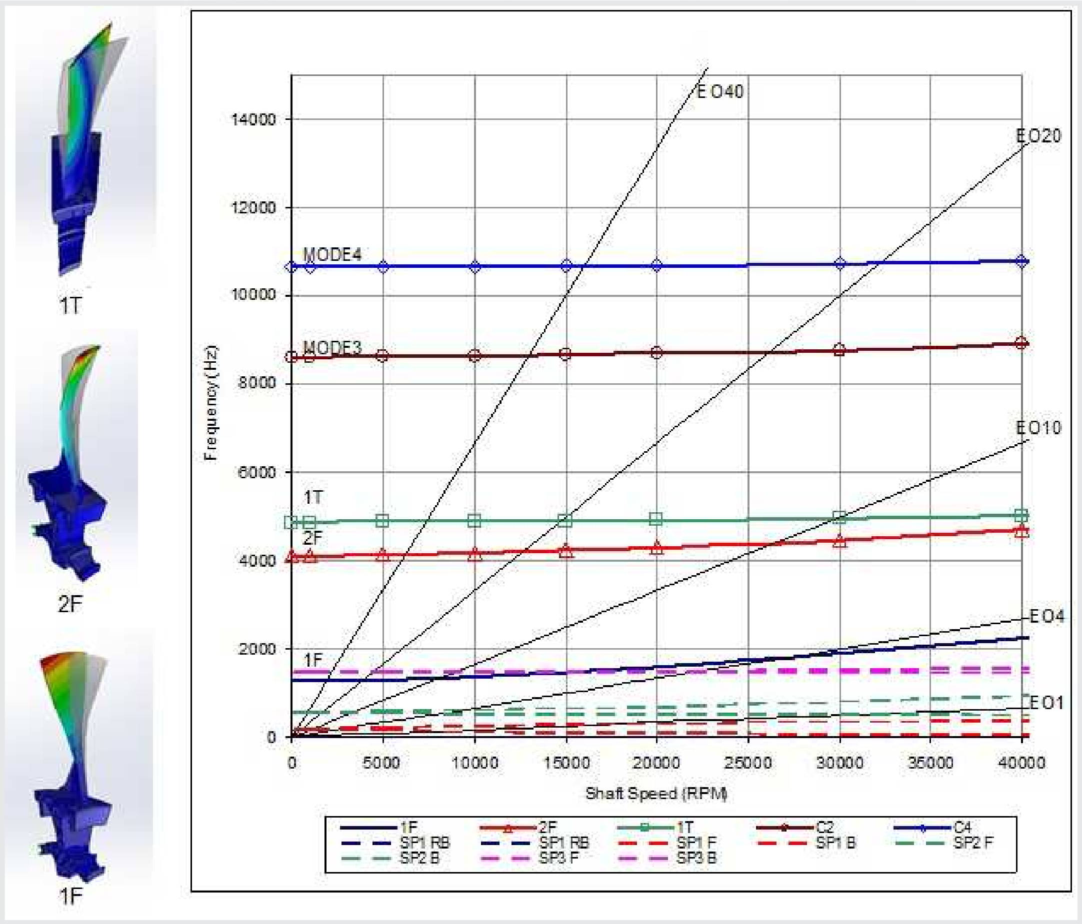
Test Devices by SCHENCK

# Turbine Blade Testing




To validate the line on the Goodman diagram, Test Devices conducts multiple tests of blades at various speeds and alternating stress amplitudes.

There are two types of stress happening to a turbine blade: an alternating, or vibration, stress and a centrifugal static stress. As blades rotate, they experience natural resonant frequencies at different rpms. While vibrating, the blade is also under a centrifugal load as if it is being pulled from root to tip. For a complete stress test, all stresses should be tested for simultaneously.

There have been attempts to pull on the end of a vibrating blade to test the interaction of both static and dynamic stresses which has proven unreliable due to failure of the blades at the tip before reaching adequate loading or cycles. Pulling on the blade also creates a constant stress from root to tip. Actual blades experience a stress gradient (high at the root and zero at the top) since one end of the blade is free. This fact also adds to experimental error.

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Other than using dynamic spin testing, the only alternative to test for both accurate static and dynamic stress is to run the blade in an actual jet engine. This is not only extremely expensive, but to test the part to the point of failure will ruin the engine. What we developed was a way to induce customer-spec fed vibrational modes and associated amplitudes in a spinning environment that require very tight speed control and adequate excitation force to produce the right test conditions for those blades.

The process basically imparts dynamic (vibrational) and static (centrifugal) stresses in jet turbine engine blades to validate the predicted blade life. The interaction between static and dynamic stresses is often depicted in a Goodman diagram, where the vertical axis represents dynamic stress and the horizontal axis represents static stress. The Goodman line typically intersects the vertical axis at $10^7$ reverse bending cycles (static stress=0) and the horizontal axis at the yield strength of the given material under test (dynamic stress=0). The area under the Goodman line represents safe life for the blade, and the area above the Goodman line represents potential failure.

Instrumentation typically includes a non-intrusive stress-measurement system (NSMS) and strain gauges. If the customer desires a heated test, thermocouples may also be involved. An NSMS plot of the excitation mode, stress amplitude, frequency, and rpm is generated. Some tests require exceptionally tight speed control (±0.25 rpm) to hold on resonance for 3-4 Hz wide and Q-factor (poorly damped) mode. Conditions inside the spin rig change during the test, which produces slight variations in the natural blade frequency(s). These variations require altering speed slightly during the test to stay on the resonance.

Test Devices's dynamic test method is well suited for blade crack growth studies. Understanding how a crack progresses, specifically the time it takes to reach a critical length, in a specific type of blade drives the frequency of the inspection intervals which drives the cost to maintain a particuar turbine engine.

Testing various blade damping methodologies and anti-wear coatings, such as anti-fretting coatings, are good applications for this test method as well. Also, testing to determine foreign-object damage (FOD), the effect on blade life and helping to design blades that are more FOD tolerant are continuing interest.