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ANTI-SWIRLING DEMONSTRATION

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Fluid in bearings and seals, involved in motion due to shaft rotation and generating fluid dynamic forces, represents the well-recognized source of instability known as whirl and whip (Figure 1). It is characterized by shaft forward circular precession at subsynchronous frequency. Control of the flow pattern in the bearing/seal clearance may enhance the stability.

OBJECTIVE

The rotor system demonstrates the dynamic effect of perturbation of the flow pattern in a seal gap by blowing compressed air in the rotor tangential direction. This effect results in shifting the rotor threshold of stability to a higher value of rotative speed when the air jet direction opposes rotation, and to a lower value of rotative speed when the air jet direction coincides with rotation. This effect implies that an unstable rotor can be stabilized by blowing air in the direction opposite to rotation. This technique is known as anti-swirl (Figure 2).

ROTOR SYSTEM CONFIGURATION

The system consists of a slender shaft, rigidly supported, carrying a mid-span disk. The stator models a seal with 10 mils radial clearance and 5.4×10^{-3} clearance-to-radius ratio (Figure 3).

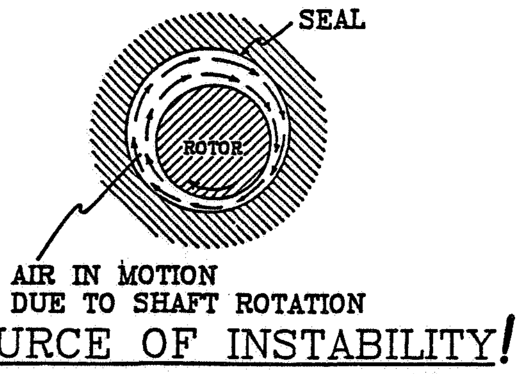
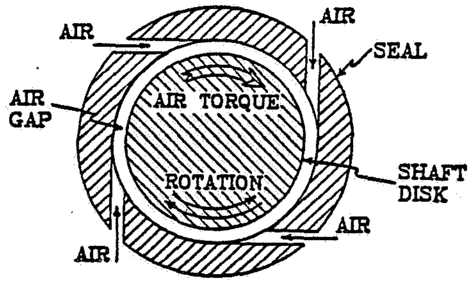


Figure 1. - Bearing/seal fluid-generated instability.



- AIR FLOW IN THE DIRECTION OF SHAFT ROTATION CAUSES DESTABILIZING EFFECT.
- AIR FLOW AGAINST THE DIRECTION OF SHAFT ROTATION CAUSES STABILIZING EFFECT (BREAKS THE ROTATION-INDUCED FLOW PATTERN).

Figure 2. - Anti-swirling technique (in setup, it is much easier to change rotation direction than to reverse air jets for demonstration of anti-swirling effect).

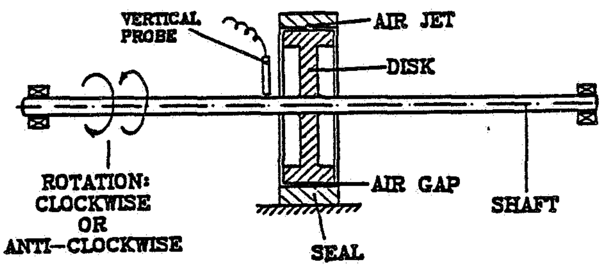


Figure 3. - Anti-swirling demonstration rig.

Four air jets with on/off valves are located tangentially to the disk (Figure 2). Rotative speed of the driving motor is variable in the range 0 to 12,000 rpm. The shaft can be rotated either clockwise or counterclockwise. The system is supplied with a speed controller and an air compressor.

INSTRUMENTATION

Two eddy current proximity probes mounted next to the disk allow monitoring of the rotor vertical and horizontal displacements. A Keyphasor probe gives phase and rotative speed measurements. Oscilloscope serves for continuous observation of the vibration pattern.

RESULTS

Results are given in the form of cascade spectra for several values of the supplied air pressure and both directions of rotation. The graphs indicate the different thresholds of stability.

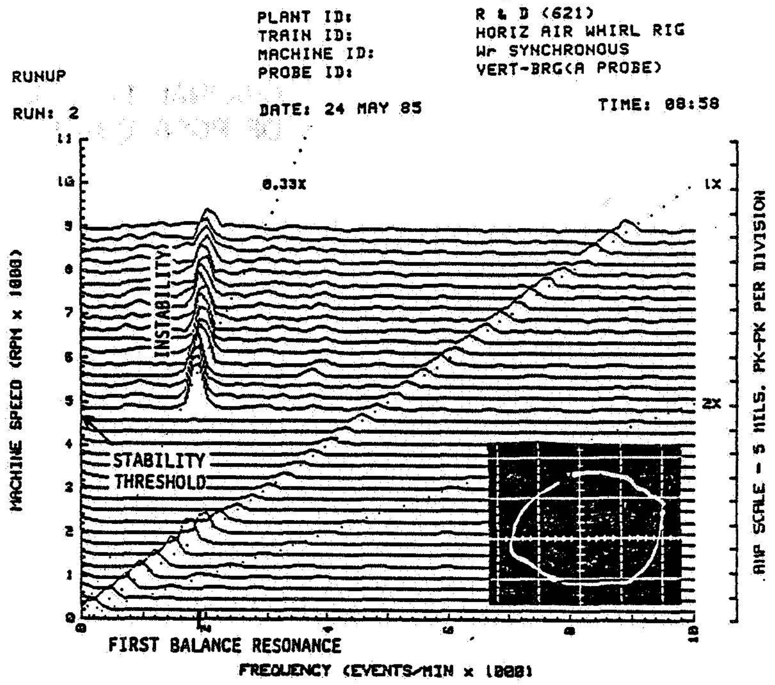


Figure 4. - Cascade spectrum of rotor original response and orbit at 6000 rpm. Threshold of stability, ~4800 rpm.

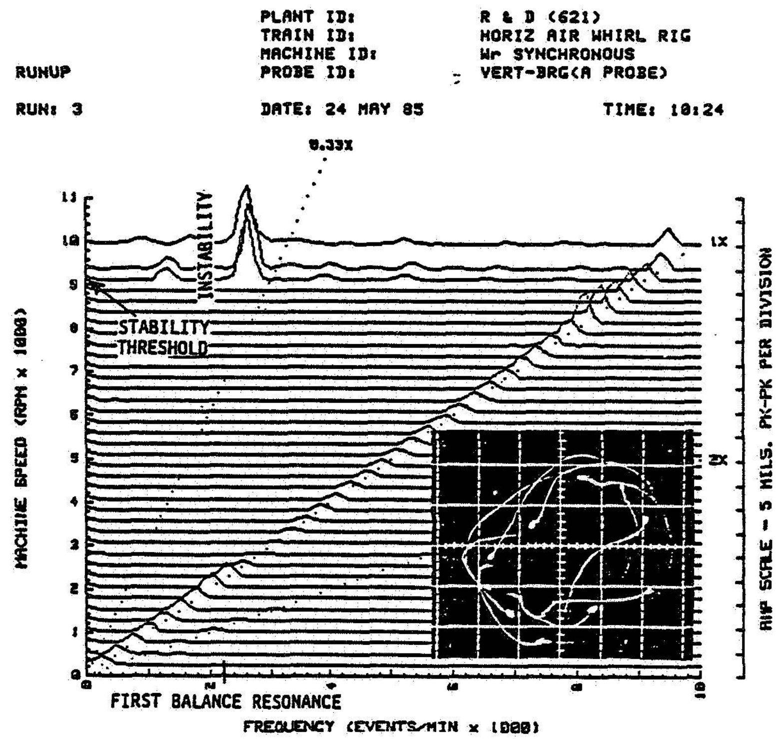


Figure 5. - Cascade spectrum of rotor response for 9-psi pressure (jets against rotation) and orbit at 9500 rpm. Threshold of stability, ~9100 rpm: anti-swirl effect.

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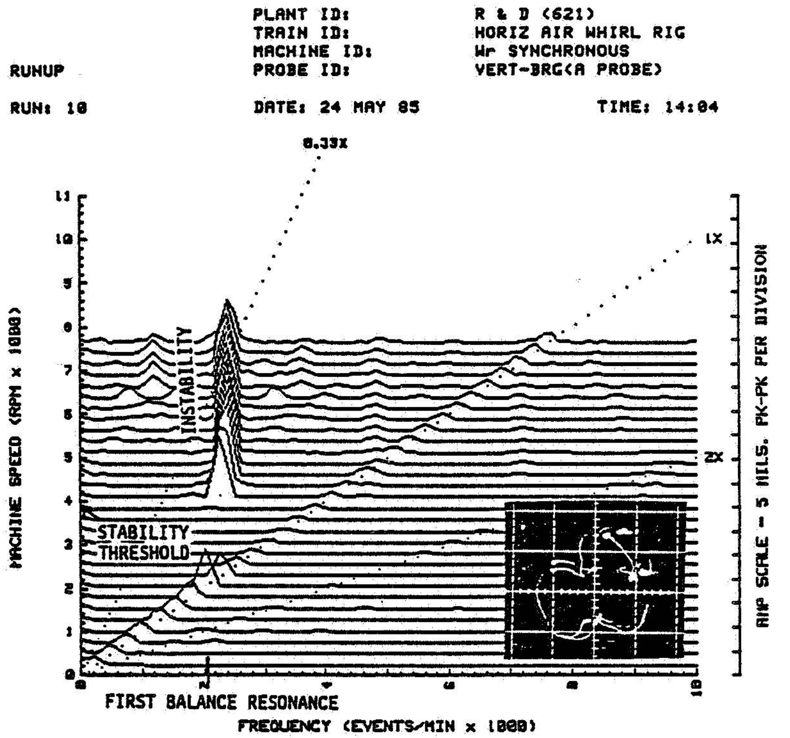

Figure 6. - Cascade spectrum of rotor response for 9-psi pressure (jets in direction of rotation) and orbit at 7500 rpm. Threshold of stability, ~4050 rpm.