

INSTABILITY IN HYDRAULIC MACHINES DEMONSTRATION RIG

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In fluid-flow machines, the working fluid involved in rotative motion due to shaft rotation significantly modifies the rotor synchronous response. This can result in the rotor maintaining the high vibration amplitude that occurs at resonance over an extended rotative speed range. The phase changes in this range are typically very small. The fluid may also create rotor instability, i.e., subsynchronous self-excited vibrations, when the rotative speed is sufficiently high. This rotor instability is often rub-related and increases with higher rotor unbalance. (Opposite to other types of instability such as oil whirl/whip, internal friction, etc.)

OBJECTIVE

The rotor rig demonstrates typical dynamic behavior of hydraulic machines. At lower speeds the effect of amplitude/phase mentioned above is noticeable; at higher speeds the subsynchronous instability occurs.

ROTOR RIG

The rig consists of a vertical single disk rotor and supported in one rigid and one 10-segment rubber-lined, water-lubricated bearing (Fig. 1 and 2).

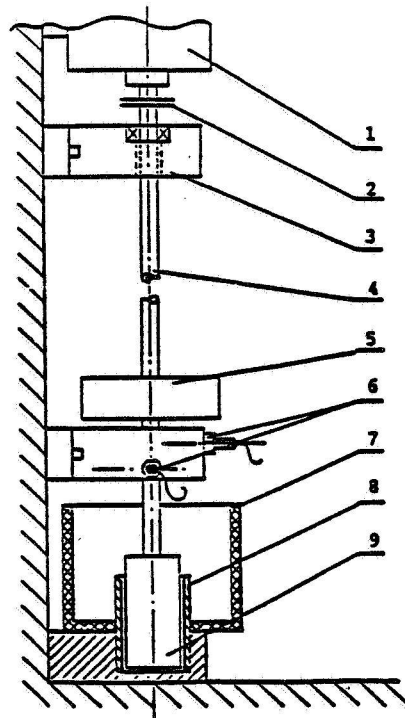
INSTRUMENTATION

Two pairs of x-y eddy current proximity probes and one Keyphasor® probe connected to the oscilloscope allow monitoring rotor vibrations at the water bearing and next to the disk. The rotative speed may be varied from 0 to 12,000 rpm.

RESULTS

The results are presented in a form of cascade spectrum, orbit, as well as Bodé & polar plots of the synchronous (1x) response (Figures 3, 4 and 5).

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1. MOTOR
2. COUPLING
3. RIGID BEARING HOUSING
4. SHAFT
5. DISK
6. PROXIMITY PROBES
7. WATER CONTAINER
8. 3/4" DIAMETER RUBBER-LINED BEARING
9. SHAFT JOURNAL

Figure 1. - Vertical rotor rig supported by rubber-lined, water-lubricated bearing.

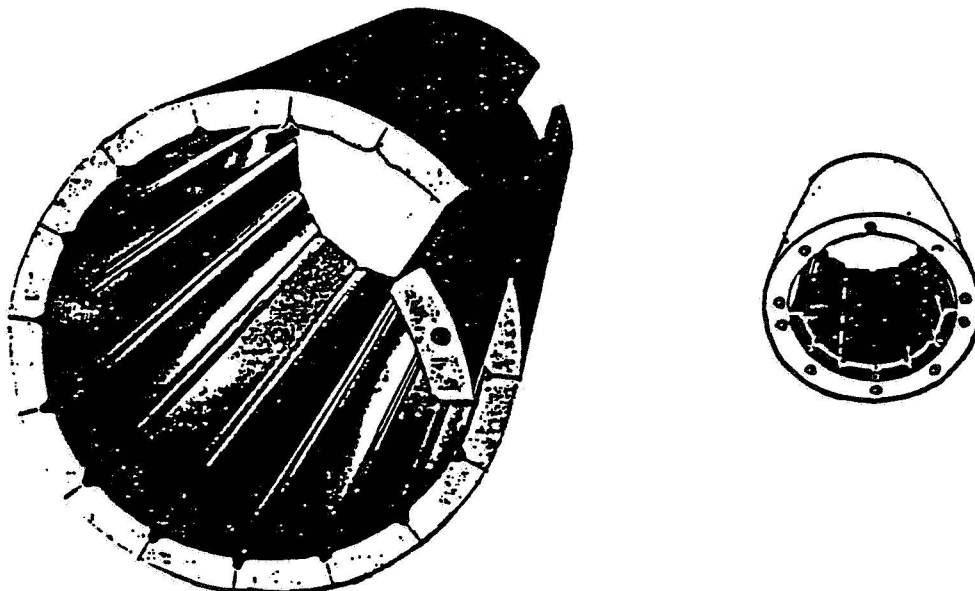


Figure 2. - Rubber-lined, water-lubricated bearing.

PLANT ID: R & D (621)
 TRAIN ID: VERT WATER WHIRL RIG
 MACHINE ID: M₁ SYNCHRONOUS
 PROBE ID: HORIZ-BRG(3) PROBE
 RUNUP
 RUN: 1
 DATE: 21 MAY 85
 TIME: 01:18

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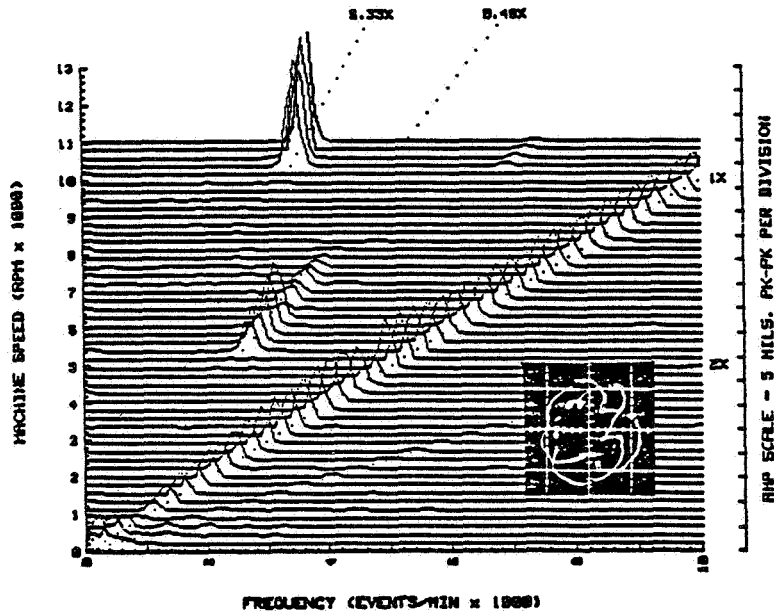


Figure 3. - Cascade spectrum of unbalanced rotor radial response and orbit at 10 500 rpm.

PLANT ID: R & D (621)
 TRAIN ID: VERT WATER WHIRL RIG
 MACHINE ID: M₁ SYNCHRONOUS
 PROBE ID: HORIZ-BRG(3) PROBE
 RUNUP
 RUN: 2
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 TIME: 01:53

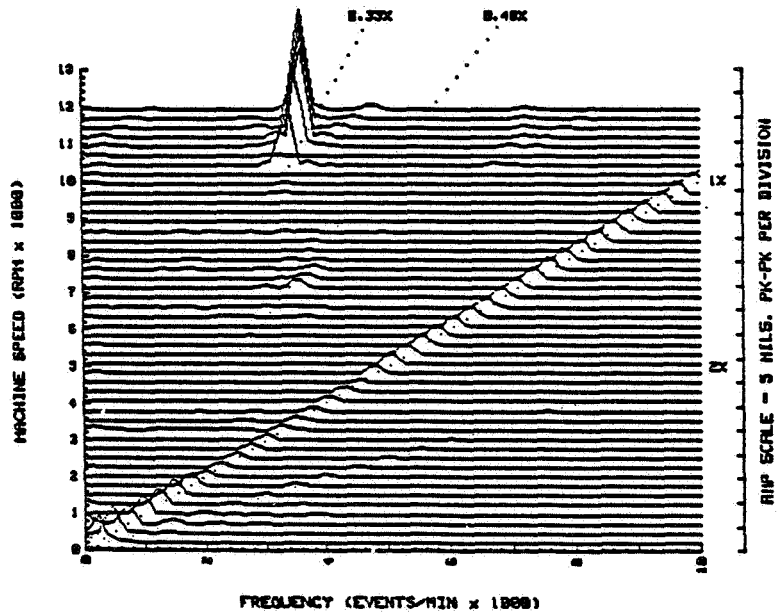


Figure 4. - Cascade spectrum at balanced rotor radial response.

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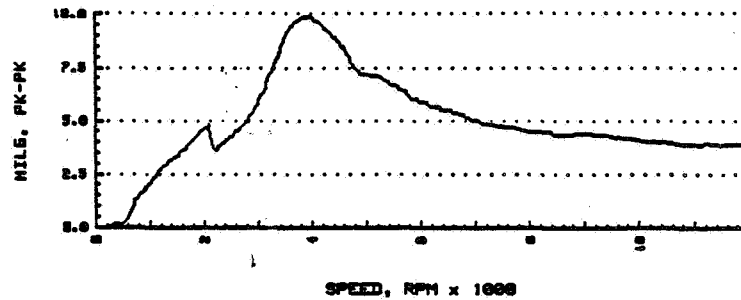
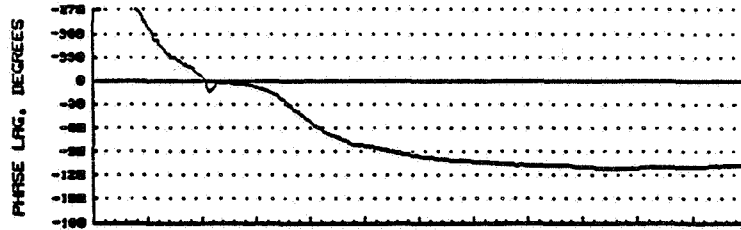
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TRAIN ID: VERT WATER WHIRL RIG
MACHINE ID: Vr SYNCHRONOUS
SOLID DATA: Comp VERT-BRG(A PROBE)

RUNUP

RUN: 3

DATE: 21 MAY 85

TIME: 02:19



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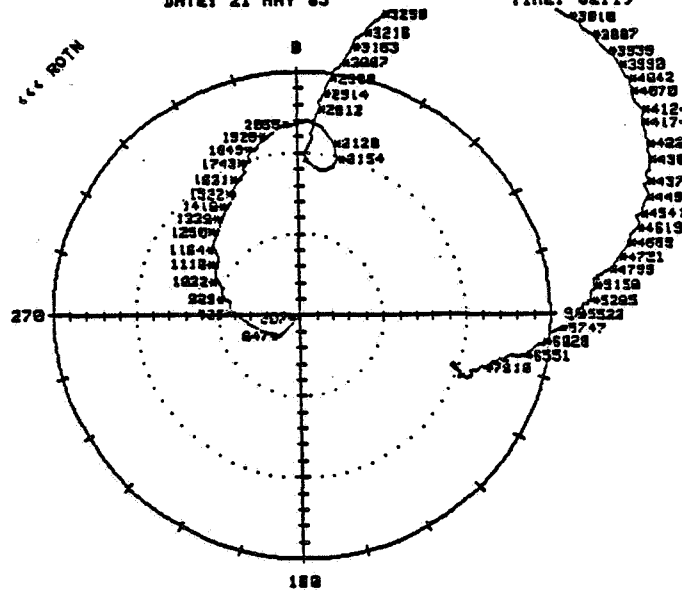
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MACHINE ID: Vr SYNCHRONOUS
SOLID DATA: Comp VERT-BRG(A PROBE)

RUNUP

RUN: 3

DATE: 21 MAY 85

TIME: 02:19



FULL SCALE AMP = 6 MILS, PK-PK AMP PER DIV = .4 MILS, PK-PK

Figure 5. - Bode and polar plots of rotor synchronous (1X) response. Graphs indicate existence of low-frequency structural resonance.