# Experimental Study of a High-Speed Rotor Supported by Aerodynamic Bearings Under Base Excitation

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**Abstract.**

This paper presents an experimental investigation of the dynamic response of a high-speed rotor system supported by aerodynamic tilting pad journal bearings subjected to base excitation. The study focuses on the influence of various operating conditions, including different rotational speeds and base excitation frequencies, on the dynamic response of the system. The base excitation was applied using a controlled shaker excitation, and the system response was measured using non-contact displacement sensors. The results highlight critical speed dependencies, amplitude variations, and damping characteristics under different conditions. These findings provide insight into the dynamic performance of rotor systems operating in low-viscosity environments and serve as a basis for future model validation and optimization.

## Introduction

With increasing demands on the performance of rotor systems, research into rotors operating with bearings utilising low-viscosity media has gained momentum. These systems are particularly promising for space applications. A fundamental requirement for the design of an optimal rotor system is a thorough understanding of its dynamic behaviour, including the identification of critical speeds and associated vibration characteristics. This is typically achieved by numerical modelling (e.g., finite element method) combined with experimental analysis during rotor operation [1,2]. However, what is less frequently addressed - particularly in the context of rotors operating in low viscosity environments - is their response to base excitation, even though such conditions are common in real-world scenarios [3,4]. This paper presents an experimental investigation of the dynamic response of a high-speed rotor system supported by tilting pad journal bearings subjected to base excitation. The results include a comparative analysis of different operating conditions, highlighting their influence on the dynamic response of the system.

## Experimental Setup

The experiment was carried out using a custom-built test rig designed to evaluate the dynamic properties of bearings under base excitation. The system consisted of a rotor and two bearing housings, one of which incorporated both radial and axial aerodynamic bearings, and a drive unit. The drive system was coupled via a magnetic connection to prevent additional vibration from the motor. The rotor dimensions were 20 mm in diameter and 220 mm in length. The system was instrumented with non-contact displacement sensors (Micro-Epsilon EU1) for measuring rotor motion in both horizontal and vertical directions, an optical sensor for monitoring rotational speed, and a three-axis accelerometer mounted on the casing to record acceleration. The whole system was mounted on an RMS 1507 shaker, as illustrated in Figure 1. Sensor data were collected using a DAQ system

## Measurement Procedure

The rotor was driven on speeds of 30,000 rpm, 50,000 rpm, and 80,000 rpm. Base excitation was applied using sinusoidal frequency sweeps from 30 Hz to 1500 Hz, with a constant acceleration amplitude of 5 $m/s^2$. Additionally, a random vibration test with a normalized excitation spectrum was performed to assess the broadband dynamic response of the system. Throughout the tests, rotor displacement and excitation frequency were continuously recorded.

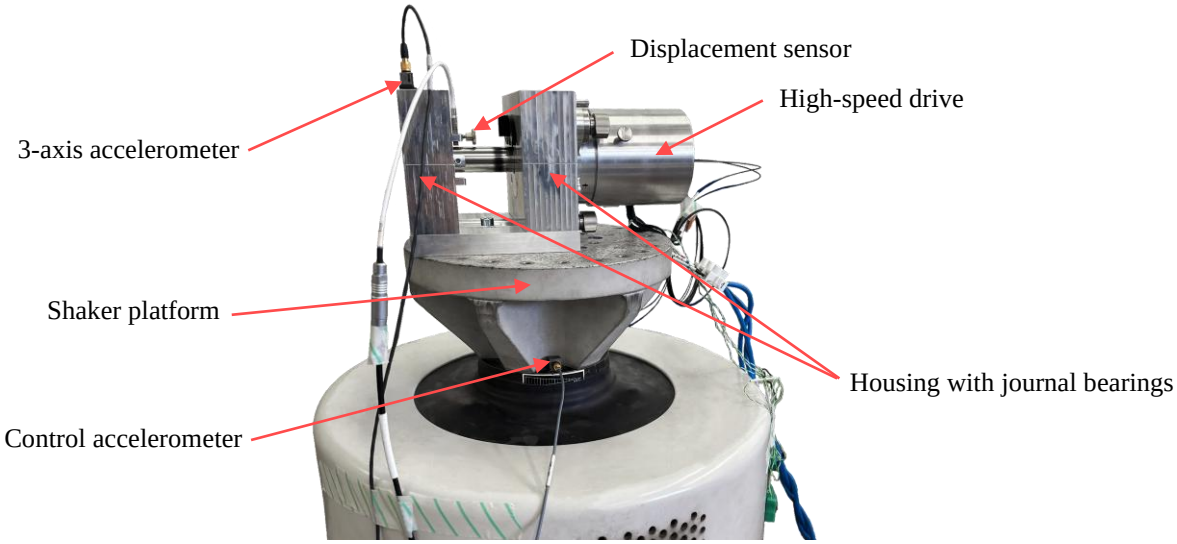


**Figure 1: Experimental set-up: Rotor and housing assembly mounted on the shaker platform.**

## Results and Discussion

The experimental data shows how the rotor system responds to different speeds and base excitation frequencies. Changes in damping and resonance behaviour were observed over the test conditions. Figure 2 shows the spectrogram at 30,000 rpm. The excitation sweep appears as a rising line with a significant influence at lower excitation frequencies where the system is more sensitive to base excitation. At higher excitation frequencies, the absence of significant artefacts indicates high mechanical stability. These results confirm that both speed and excitation frequency influence the dynamic behaviour of the system. Due to the complexity of the results, a more detailed analysis will be given during the presentation.

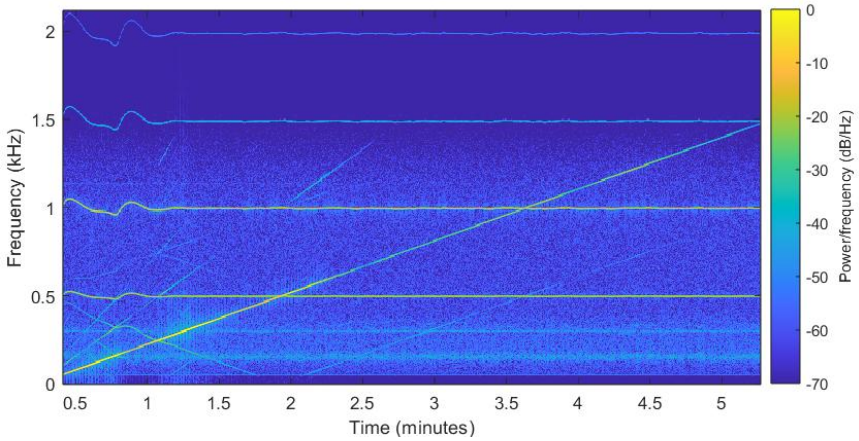


**Figure 2: Dynamic response to base excitation - spectrogram of horizontal displacement at 30 000 rpm.**

## Conclusion

The primary objective of this study was to investigate the influence of base excitation on the dynamic response of a high-speed rotor system supported by aerodynamic bearings. The experimental data provide valuable input for future research and numerical modelling, particularly in applications with bearings utilising low-viscosity mediums. Although the results of the random vibration test are not discussed in detail here, they are consistent with the general expectation that this type of excitation imposes the highest dynamic loads. The results obtained will help to develop and refine future experiments and computational models.

## References

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