A VIBRATION PROBLEM

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1.0 Introduction

Nova Gas Transmission has an installed fleet of 31 pipeline compressors running on magnetic bearings. The total experience in excess of 1 million running hours was accumulated over the past 10 years of operation. The intent of this paper is to present a very brief introduction to magnetic bearings, and to show two test cases in which the bearings were used to determine the cause of machine vibrations and prevent impending failures.

2.0 Brief Review of Magnetic Bearing Technology

The development of magnetic bearings involved several areas of knowledge including: Mechanical engineering design, magnetics, electronics, controls, and rotordynamics. It wasn't until these subject areas were well developed that magnetic bearings could come to maturity.

The magnetic bearing system consists of the bearing actuators (magnets), feedback sensors, and the control system.

The actuators can be either electromagnets (active) or permanent magnets in combination with electromagnets. All of the bearings used in the Nova system are of the active kind. The bearings can provide stiffness and damping tailored to the requirements of the mechanical design. Most systems will have the actuators located at 45 degrees with the vertical axis, sharing the weight for horizontal rotors. Since they can be imbedded in the process fluid, the possible arrangements of the bearings is limited only by the imagination.

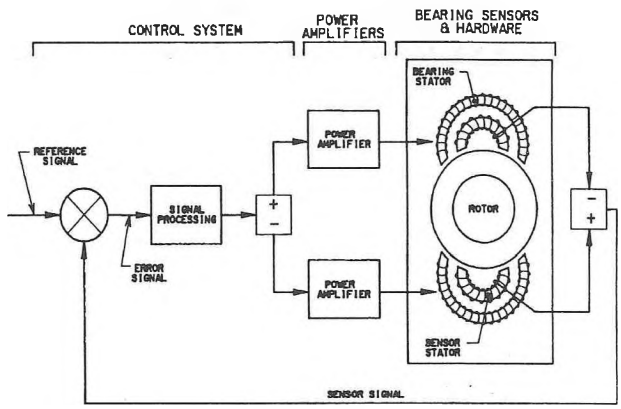
Auxiliary bearings or bushings are necessary to support the rotor when at rest or in case of extreme loads.

The sensors are used to provide position feedback to the control system (and sometimes velocity and force). Sensorless bearings are also being studied. There are generally 5 axis of control, 4 radial and 1 axial. These can be independent or not according to the control scheme.

The controller has to provide stability to the dynamic system which consists of the rotor and bearings over a wide frequency range. This range is typically dictated by the rotating speed of the machine and its rotordynamic characteristics. Digital controllers are used in most installations nowadays.

The rotor center running position can be prescribed and precisely controlled.

The vibrations transmitted to the surroundings can be minimized. Alternately vibrations transmitted to the rotor can be reduced.



3.0 Advantages of magnetic bearings

Immersion in the fluid.
Minimal consumption of energy.
Tailoring of the rotordynamics.
High speed operation. High DN numbers.
High temperature operation.
Vibration suppression. Shock resistance.
Reduced friction losses. 1-2% efficiency increase.
Ability to do field balance at speed. Modal balance.
Diagnosis of process conditions. Can determine the forces from impeller and fluid interaction.
Low maintenance requirements.
Reduce forces transmitted to structures with the use of ABS or optimized feed forward controls.(Autobalance mode of control)
Prediction of running shaft distortion.

4.0 A Vibration Problem

One of our large compressors was exhibiting a high vibration which started at a certain rpm and went up very quickly to the point of shut down. This happened after a new wheel had been installed in this machine.

We suspected something changing in the dynamic system, and decided to implement the auto balance mode of control to see if the change was happening in the rotor. Our suspicions were confirmed, the vibration persisted in spite of the shaft being suspended in zero stiffness bearings (at running speed). We suggested that the wheel was coming loose on the shaft when the centrifugal force due to rotation exceeded the preload given by the interference fit. This was confirmed upon disassembly.

5.0 Another Vibration Problem

One other compressor showed step increases in vibration at running speed. After the second time this happened, we decided to open the unit and inspect. The compressor wheel had two pieces of vanes broken off. Other five vanes were found cracked. The diagnostic capability of the bearing prevented a much more costly incident.

6.0 Conclusions

Magnetic bearings are a mature technology which can greatly enhance the capabilities of rotating equipment in general. For the past year and a half, the reliability of the units in the Nova pipeline system has been around 99.98% which compares favorably with oil bearing technology.