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RAMPING UP MAGNETIC BEARING USE by Mike Swann

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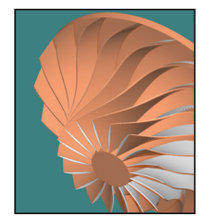


Designing for Manufacture

RAMPING UP MAGNETIC BEARING USE

REMOTE CONNECTIVITY WILL FACILITATE EASY INSTALLATION, TROUBLESHOOTING AND TUNING, THEREBY SAVING ASSOCIATED COSTS

MIKE SWANN
WAUKESHA MAGNETIC BEARINGS

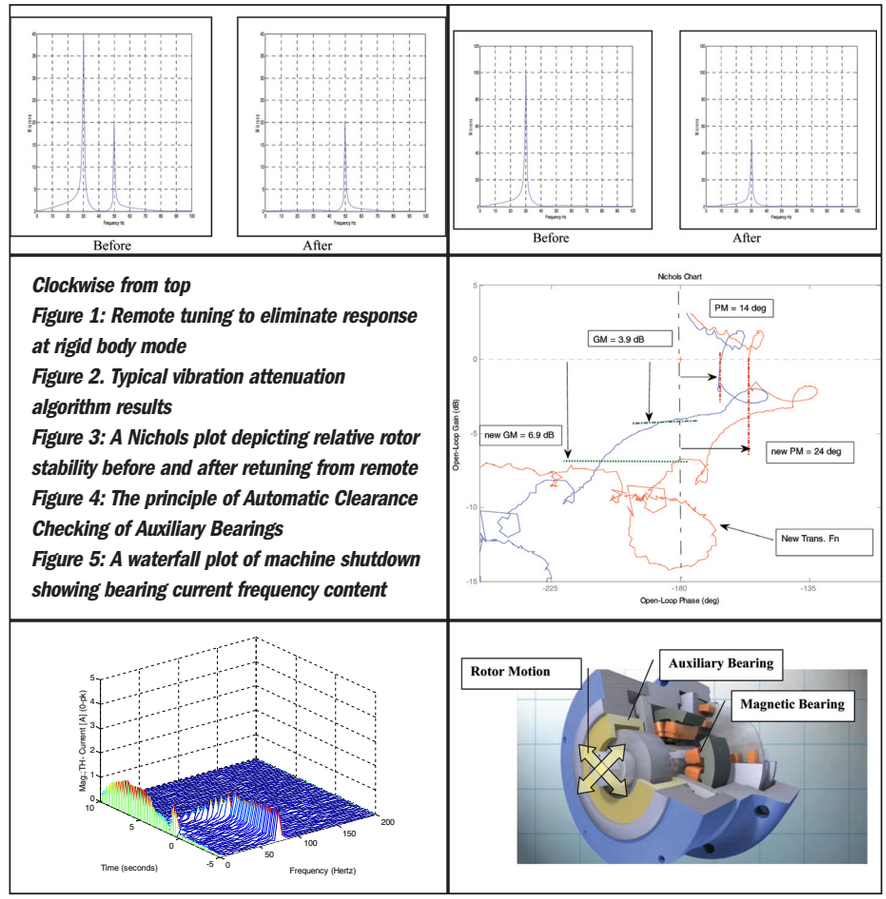
In the last issue (p. 30, Sept./Oct. 2009), we discussed the process of diffusion of magnetic bearings into the turbomachinery marketplace. And we noted how third generation technologies in magnetic bearings are helping to reduce their installed cost, increase energy efficiency and environmental friendliness, and improve reliability and availability. These benefits will be further enhanced by developments now on the horizon.

Remote control

The traditional method of installation and commissioning of magnetic bearings relies heavily on trained engineers onsite, both at the factory of the turbomachinery OEM, as well as the end-user field location. The same process is used during routine maintenance of the magnetic bearing system. Through enhancements in technology and remote connectivity, a new approach turns over most aspects of magnetic bearing commissioning and machine troubleshooting to the OEM and end-user, with specialist support coming primarily via remote condition monitoring.

To support this shift in approach, comprehensive training should be provided to assure all tasks are conducted reliably with confidence. This approach — originated by Waukesha — will reduce the need for onsite maintenance of the system, ultimately increasing machine reliability and availability.

The new paradigm described above is a fundamental change to the way magnetic bearing installations have been marketed over the last two decades. Not only does the traditional approach add to the operating expense of using magnetic bearings, it encumbers end-users with the logistical headaches of getting the supplier to the site in the time needed to support ongoing production needs.



Clockwise from top
Figure 1: Remote tuning to eliminate response at rigid body mode
Figure 2. Typical vibration attenuation algorithm results
Figure 3: A Nichols plot depicting relative rotor stability before and after retuning from remote
Figure 4: The principle of Automatic Clearance Checking of Auxiliary Bearings
Figure 5: A waterfall plot of machine shutdown showing bearing current frequency content

This approach leverages the inherent intelligence of magnetic bearing systems and the remote connectivity of third generation controls technology. The magnetic bearing system intelligence is used to commission machines and diagnose machine problems using a wealth of information not possible with mechanical bearings. Remote connectivity enables performance of these operations on-demand from a remote location with no site visits for "second-in-class" and subsequent machines.

The intelligence of magnetic bearing systems stems partially from rotor position and vibration information used to control the rotor with electromagnetic forces. This information is available for display and monitoring from remote locations, but such information has been available in turbomachinery for many years with standard vibration-based conditioning monitoring systems, giving rise to what is known as "vibration signature analysis."

What makes the magnetic bearing

A new approach to magnetic bearings

The 38th Turbomachinery Symposium in Houston (Sept. 14 - 17) provided an occasion for Waukesha Magnetic Bearings (WMB) to announce a shift in market approach and introduce its full range of new digital controllers featuring the remote connectivity essential to this shift in approach. Waukesha engineers demonstrated the remote connectivity of a magnetic bearing controller from the company's booth at the symposium by connecting to a high-speed test rig in the WMB facility in Worthing, UK. This connection was employed to demonstrate remote tuning (an explicit part of the commissioning process for each machine) of the magnetic bearings along with the implementation of advanced software features, such as rotor vibration attenuation and automatic clearance checking of the auxiliary bearings.

With more than twenty years of experience in magnetic bearing technology, Waukesha has focused its efforts on simplifying the installation and commissioning process of its products used in turbomachinery applications. "Waukesha has recently demonstrated an availability of 99.9% across its fleet of magnetic bearing equipped motor compressors," says Mike Swann, General Manager at WMB.

The traditional method of installation and commissioning relies heavily on trained engineers on-site, both at the OEM factory as well as the end-user field location. This same process is used during routine maintenance of the magnetic bearing system. Through the enhancements in technology and remote connectivity, Waukesha's approach turns over most aspects of magnetic bearing commissioning and machine troubleshooting to the OEM and end user, with specialist support coming primarily via remote condition monitoring (see p. 32 for more on this approach).

The evolution of magnetic bearing technology has led to increased capabilities that permit end-users to not only derive the benefits of lower installed cost, increased energy efficiency, and environmental friendliness, but to also see significant enhancements in machine reliability and availability, adds Swann. "The latter benefits have already been demonstrated with available third generation technology and will be further enhanced with developments now on the horizon."

system different from rotors with mechanical bearings is that the magnetic bearing control system supplies information related to rotor forces, as well as fundamental information regarding the stability of the rotor-bearing system. The former is obtained via bearing currents or bearing magnetic flux measurements that may be viewed and analyzed remotely. The latter is enabled via the ability to remotely measure transfer functions of rotor displacement for force disturbances across a broad frequency band. This is performed by the internal spectrum analyzer, which adds a new dimension to the measurement capabilities of magnetic bearing systems.

The new ISO and pending API specifications on magnetic bearings recognize the significance of such transfer functions. The availability of spectral information from remote opens up an unexploited possibility in machinery health monitoring — that has not been available in the first two generations of magnetic bearing systems.

The third generation available from Waukesha allows for remote connection via TCP/IP to facilitate the measurements of vibration, bearing load, and rotor stability. Figure 1 shows elimination of the rotor response of a machine at the rigid body mode from remote. Figure 2 shows the before-and-after vibration response of a machine following remote implementation of a vibration attenuation algorithm.

These capabilities can be used for initial commissioning and subsequent troubleshooting. They can also be used to retune the machine after many years of operation where necessary.

For example, changing seal clearances may cause a change in cross-coupled seal forces that start to degrade the stability of the rotor. Figure 3 shows an example of a stability plot before and after retuning. Increasing seal clearances are a significant indicator of machine health, and may be measured by changes in the rotor "plant" equipped with magnetic bearings.

Taking transient overloads

Third generation technologies also provide the capability for using the auxiliary bearings to accommodate transient overloads of the magnetic bearings. This emulates the high load capacity of oil lubricated bearings while assuring rotor stability that can be seen and measured.

Moreover, the remote connectivity feature allows automatic clearance checking on demand (while non-rotating) to assure that the auxiliary bearing wear is below the threshold for ultimate replacement. This principle is illustrated in Figure 4.

It should be noted that only bushing-type auxiliary bearings allow this remote observability because wear is the only failure mode in this type of design. This capability completes the spectrum for present day condition monitoring of magnetic bearing systems.

Upcoming developments

In the not-too-distant-future, vibration spectra, force spectra, and rotor transfer functions will be used with expert systems to perform machine prognoses of problems before they occur. This will be followed by recommendations for corrective action that may then be implemented automatically by the magnetic bearing controller.

Reference spectra will first be captured for each bearing channel (five in most machines) at standstill and design speed. Measurements will also be obtained during startup and shutdown.

For example, a reference waterfall plot obtained from the controller is shown in Figure 5. To reduce the effect of noise, averages will form the reference for each channel. Changes in the reference spectra will be monitored closely on a regular basis and the software will decide when an adjustment or retuning is required.

Sensor validation will be employed to identify failed sensor hardware that would impair the capabilities of the diagnostic system. The software will also have the knowledge to know what changes are required and those actions will be taken and verified. TI

Author

Mike Swann is General Manager, Waukesha Magnetic Bearings based in Mystic, CT and Worthing, UK. He has been involved in the management of magnetic bearing projects for over twenty years.

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