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Pedestal bearings — The rotordynamics challenges

It is the middle of the night and once again the phone rings at your home. Before you answer it, you know what it is about. You are the maintenance manager at a major ethylene plant and before you left work today vibration levels started to climb on the pedestal bearing on the turbine compressor train. It happens several times a year, and no one really knows why. You have brought in the original equipment manufacturer (OEM) and all sorts of consultants to study the problem because this has shut the plant down at least three times in your tenure as maintenance manager. The "phenomenon" theories are free flowing and you have listened to opinions how operations are setting up a transient affecting the balance of the plant.

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So you head out to the plant and once again it is shut down due to high vibration in this bearing. Having coffee at midnight with one of the 35-year operators who has lived with this equipment brought great insight. He told you that the problem did not start until the train was sped up by 300 rpm to increase production. He also told you the problem occurs with weather changes. It just so happened a "Blue Northerner" came though the previous afternoon and the temperatures dropped 30 F.

Now it just so happens that the structure is elevated and the turbine compressor train is on the second floor. In the mean time you have to start the plant back up and you do what you always do to get it to run — you change the oil temperature to stabilize the bearing. As the night wears on you look at the rotordynamics reports from the past few years. All of the work indicates a stiffness in the pedestal bearing but none show where it comes from. The next day you investigate and discover that the stiffness does not include the elevated structure or consider the ambient thermal growth of the structure. At this point it has all come together for you.

Sometimes a turbine train will consist of a turbine and compressors all in one unit. A pedestal bearing is installed in some cases. Rotordynamics studies are conducted to ensure the unit will operate as intended. However, many boundary conditions are assumed for the studies that may not always be valid. For example, the structural stiffness of pedestal bearings. Two problems exist with pedestal bearings regardless of the specific bearing design itself — the stiffness can affect the critical speeds calculated and the pedestal itself can experience vibration problems as well.

One important parameter in the rotordynamics study is the stiffness of the pedestal in all-principal directions. Of course the bearing damping coefficients and bearing type are important as well. The stiffness of the pedestal bearing is not always easy to obtain. Sometimes the support structure should be figured into the ball game as well. The structural stiffness can be calculated using a finite element tool. A structural dyanmics model can be developed to determine the dynamic response of the support structure.

The boundary conditions can be derived from the finite element model and incorporated into a rotordynamics model. If problems exist, the pedestal model can be revised as required to obtain the desired response.

Pedestal bearings are a major player in many turbine compressor and turbine generator trains. A suggested procedure for tackling the issue is as follows:

1. If the unit is existing, perform a field study to determine natural frequencies of the structure.
2. Create a base rotordynamics model of the train.
3. Perform a sensitivity study on the stiffness of the pedestal bearing.
4. Develop a finite element model of the equipment's support structure.
5. Incorporate the stiffness into the rotordynamics model. This should include any temperature effects.
6. Develop a detailed rotordynamics evaluation including the support structure.
7. Look at changes in bearing design and structure that can detune the system away from detrimental criticals.

Every situation is unique to itself and each application should be reviewed by a professional engineer who is competent in rotordynamics.

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