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Rotordynamics and the effects of structural dynamics

An order was placed for a gas turbine compressor train. A complete rotordynamics study was requested and received, which included the entire train. Support conditions were assumed and the response of the train was determined. A report documenting the study was developed indicating all the critical speeds and was submitted along with the order. The owner was happy; the study indicated there would be no operational problems. The unit was shipped to the plant site and installed. Off-line production testing looked good, and the unit and the plant were ready for start-up. The plant was started up, and guess what happened.

You guessed it — high vibration alarms were sounding. This made no sense because a complete rotordynamics study was conducted and everything should have been OK. Furthermore, after installation an off-line test was conducted, and the vibration levels at the jump shaft pedestal bearing were less than 0.15 mils. Now that the plant is in production, the compressor train is running with vibration levels around 3.5 mils and rising. What was the problem? Someone suggested that it must be alignment, and the plant manager approved shutting the plant down. The alignment was checked and was within specifications. Maybe the rotor needed balancing. To check this unit, it was false loaded on recycle and ran smoothly. The rotor was in balance.

It just so happens that the compressor train is on the third story of the plant structure. Two problems occurred in this situation. First, the structure was too flexible and changed the response of the train. The jump shaft within the rotor train experienced high vibrations. All kinds of issues were addressed to correct the problem. The bearing design was changed in the pedestal bearing, and other issues were evaluated such as oil type and oil temperature and viscosity. All of the attempts failed to resolve the problem. Second, the thermal growth caused by heat radiating to the structure false loaded one of the bearings.

To address the first problem, a structural dynamics model was developed and strategic supports were installed to de-couple the structure from the rotor criticals. To reduce the thermal growth issue, insulation was installed.

Another issue of concern was the main structure itself. The entire structure should be modeled to the "rigid" foundation. All primary and secondary members should be included. Mass elements should be included to represent the major parts of the rotating equipment. The "wildcard" in the system is how much of an affect the interconnecting piping will have on the structure. Large bore piping will play a significant role in the response. A separate structural dynamics analysis can be conducted to look at the ball game. Same bore piping with high flexibility may not have a remarkable contribution. The elevated structure should be treated as a separate structural dynamics problem. The response should be de-tuned from any defining force functions.

The final issue to review is the overall thermal growth of the structure. Major turbomachinery structures can be quite large. Differential thermal growth must be considered in the overall design and supporting. The same structural dynamics model can be used to model thermal growth effects.

A good approach to addressing rotordynamics interaction in structures is as follows:

1. For existing systems, perform a field study to evaluate the displacement and vibration. A shaker can be used to evaluate the natural frequencies of the structure or a "bump" check can be done.
2. Perform a lateral/torsional rotordynamics study of the train.
3. Evaluate the sensitivity of the system to the bearing stiffness.
4. Perform a structural dynamics analysis.
5. Iterate between the structural and rotordynamics models to determine the most accurate response.
6. Perform a structural dynamics model and make sure that any forcing functions from the turbomachinery do not couple with the structure leading to undesirable effects.
7. Conduct a detailed design review.

Remember, the work should be reviewed and approved by a professional engineer competent in rotordynamics.

For more information, visit www.knighthawk.com or call (281) 282-9200.

FEATURE

ExxonMobil Baton Rouge salutes community partners

ExxonMobil Baton Rouge, La., recently invited its community partners to the premiere of its commemorative documentary celebrating "A Century of Partnership." About 200 local nonprofit, governmental and educational leaders joined with ExxonMobil employees to celebrate the 100th anniversary of the company in Baton Rouge.

In a partnership with the Foundation for Historical Louisiana, the event was hosted at the Old Governor's Mansion, which was decorated with ExxonMobil displays depicting historical facts and volunteer outreach along with a collection of company memorabilia.

After visiting, guests were invited to view the 100th anniversary documentary, which includes first-hand accounts from many retirees, community members and employees. Refinery Manager Steve Blume reflected on the many partnerships between ExxonMobil and the community that have enhanced the quality of life in Baton Rouge.

For more information, visit www.exxonmobil.com or call (225) 977-7711.

Enjoying the event are, from left, Will Cirioli, Americas manufacturing director, ExxonMobil Chemical Corp.; Melvin "Kip" Holden, mayor-president, East Baton Rouge Parish, La.; Dan Schuessler, chemical sites manager, ExxonMobil Baton Rouge; and Steve Blume, refinery manager, ExxonMobil Baton Rouge.

Representing ExxonMobil at the event are, from left, Dave Dartez of the Baton Rouge Plastics Plant, Paul Guilfoyle of the Baton Rouge Polyolefins Plant, Steve Blume of the Baton Rouge Refinery, Dan Schuessler of the Baton Rouge Chemical Plant and Rich Mohring, global networking advisor.