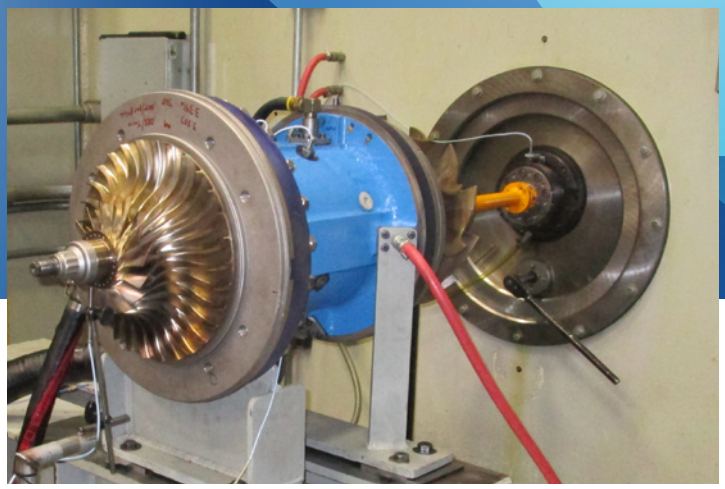


- Predict vibrational response
- Qualify rotor modifications

Rotordynamic analysis

Sulzer is your global partner with reliable and sustainable solutions for your key operations. We offer repair and maintenance services for turbines, compressors, pumps, generators and motors. We also offer OEM and aftermarket parts. With one of the largest service networks in the industry, we are close to our customers with over 180 production facilities and service centers worldwide. Our cutting-edge engineering services provide unique and innovative solutions customized to your equipment needs.

The customer has been operating this nitric acid plant for over 25 years with a NOx module that typically runs at 14,700 rpm, with a MCOS of 15,750 rpm. The rotor consists of a single stage open compressor wheel driven by a single stage open expander wheel. Both impellers are mounted at opposite ends of the same shaft. The rotor is supported by two tilt pad radial bearings and a double acting thrust bearing located between the impellers. Due to this double overhung configuration, and the high operating speed, this rotor is susceptible to a variety of deflection modes due to the interaction of centrifugal and gyroscopic forces.

Historically, this unit has been field balanced and that required a plant startup to achieve normal operating speed on the NOx unit. Obviously, the equipment was subjected to multiple thermal cycles and the field balancing often consumed four or five days. In addition to the lost production time and expense, this unit was difficult to build in the shop due to unequal weight distribution between ends of the rotor. This made shop assembly more difficult since the rotor would pivot down towards the heavy expander wheel.

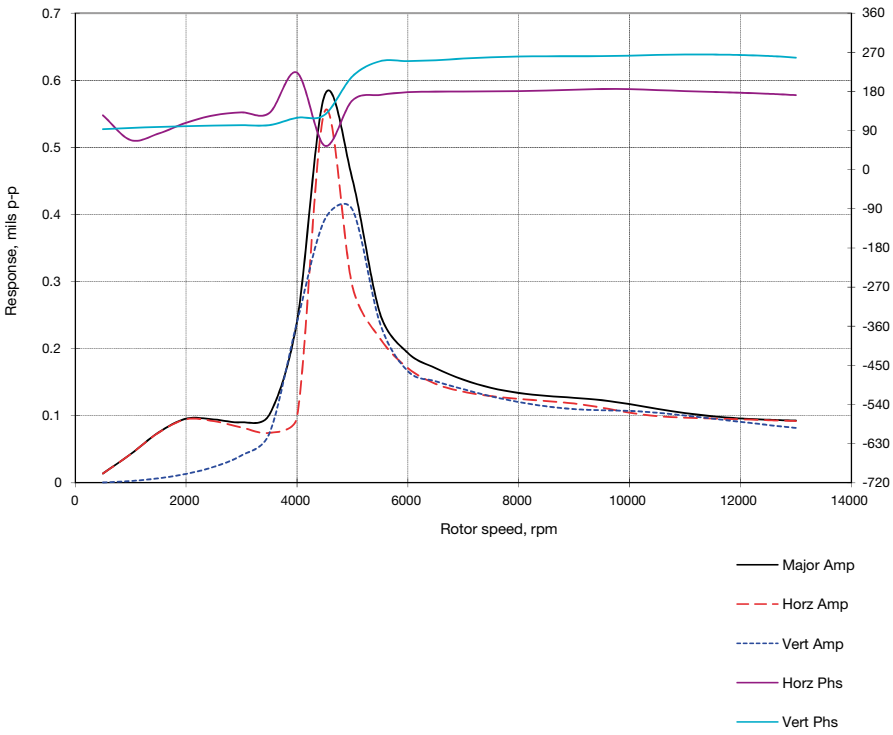
In order to correct these deficiencies, Sulzer developed a detailed model and conducted a Rotordynamic Analysis (RDA) with the following primary objectives:

- Increasing load on the compressor end bearing
- Improving overall system stability
- Improved balancing procedures

The RDA study revealed that enlargement of the midspan shaft diameter and reduction of the expander impeller weight provided a positive downward load on the compressor end journal bearing. These two mechanical changes improved rotor stability and reduced the amplification factor at the major rotor resonance speed of nominally 6,200 rpm. In addition, the NOx unit was balanced as a complete machine in the Sulzer at-Speed bunker as shown in the adjacent photograph. The setup included two additional vertical proximity probes on the overhung wheels. These external probes supplemented the information from the X-Y probes mounted adjacent to each bearing.

This balance configuration allowed easy access to the NOx balance planes for balancing at rated speed. This bunker arrangement virtually eliminated any requirement for field trim balancing, with substantial cost reductions for the customer.

NOX module rotor, initial model, sta. no. 33: expander end bearing



Sulzer provides cutting-edge services and solutions for rotating equipment dedicated to improving customers' processes and business performances. When pumps, turbines, compressors, generators and motors are essential to operations, customers need a service partner they can trust. With our technically advanced and innovative solutions, we give our customers the assurance they need to focus on their operations.

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Engineering Services capabilities/service offering:

- Alignment tracking
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- Technical upgrades (blade design improvements)
- Root cause failure analysis
- Rotordynamic analysis
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