Brüel & Kjær Vibro

Application Note

Detecting, diagnosing and correcting for compressor surge at a petrochemical plant

Vibration analysis is a valuable tool for fault diagnosis and root cause analysis. This case story demonstrates how a newly purchased Vibroport 41 was used to analyze structural resonance and surge vibrations that previously had resulted in frequent impeller cracks and premature bearing failure of the compressor. The underlying cause of the surge and its remedy is also analyzed.

Olefin, polyolefin petrochemical plant

The Tabriz Petrochemical Company (TPC), commissioned in 1997, produces almost 450,000 tons of olefin, polyolefin and other chemical products each year in the Islamic Republic of Iran. Using naphtha and LPG from the nearby Tabriz Oil Refinery, a wide range of raw material products are made for use in domestic downstream plants, such as styrene, polyethylene (linear low density and high density), propylene, ethylene as well as other petrochemical products. Polystyrene (general purpose, high-impact and expandable grades) is the primary export product. This ISO 14001 certified plant is one of nine petrochemical plants in Iran under the state-owned National Petrochemical Company (NPC).

Fig. 1 Air compressor for the polyethylene line

Compressor maintenance history

The separation and drying unit of the HDPE polyethylene line uses a single air blower (centrifugal compressor) in the final degasser vessel for separating the dry polyethylene powder from the nitrogen and heptane gases that are part of the slurry leaving the polymerization reactor. It uses inlet guide vanes to adjust the airflow.

Type	Single-stage centrifugal, backward curved blades
Speed	2970 rpm (49.6 Hz)
Flow	21 000 m^3/hr
Diff. Pressure	0.182 bar

Table 1 Compressor specifications

Prior to vibration monitoring, this compressor had to be inspected and serviced every month because of the following recurring problems:

- Prematurely failing bearings
- Cracks on the impeller welding joints

It is a critical non-spared machine so all downtime results in lost production. Despite the monthly liquid penetrant testing, a piece of the impeller detached itself one day and destroyed the impeller and bearing housing, which also seriously damaged the compressor case and motor. This resulted in six days downtime.

Fault diagnosis

It was at this time the Vibroport 41 vibration analyzer was purchased and played an important role in finding the root cause of the problem. Unusually high radial vibrations in the upper frequency range plus high axial vibrations were detected using this instrument. These vibrations coupled with the abnormal noise of the compressor plus the high bearing temperatures gave an indication of compressor surge. The excessive vibrations caused by this flow disturbance also excited resonant frequencies of structural components and ultimately led to excessive loading and fatigue on the impeller and bearings.

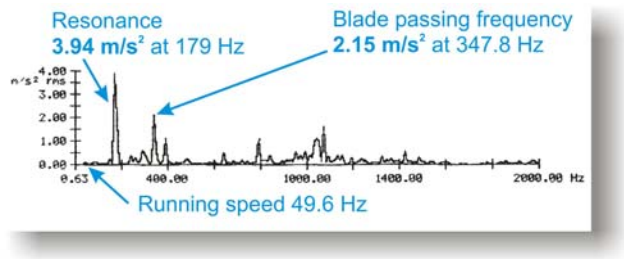

Fig. 2 Radial vibration spectrum from motor foundation showing an asynchronous peak that is presumably caused by a natural frequency excited by surge.

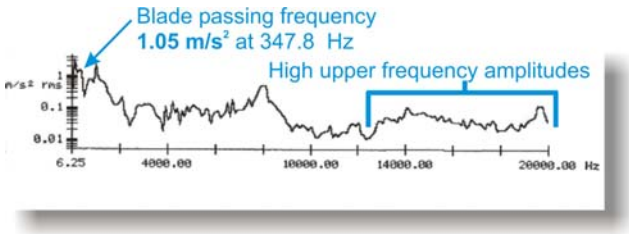

Fig. 3 Compressor bearing radial vibration spectrum showing upper frequency vibration caused by surge.

Conclusion: Root cause analysis and re-design of the compressor

It was later determined that the cause of the surge was due to the fact that the compressor was over-designed for the application. The inlet guide vanes were normally open only 20% in order to avoid too much airflow into the process. This adversely affected the performance of the compressor and caused it to surge, which in return caused the impeller cracks and premature failure of the bearings.

There were three methods for resolving the problem:

- Make a suction bypass line
- Reduce the running speed
- Reduce the impeller diameter

The most cost-effective solution was decided to reduce the impeller diameter from 118 cm to 109 cm, as determined by thermodynamic calculations. This solved the problem! As seen in Figures 4 and 5, this reduced the resonances and vibrations caused by the surge.

Three years after the impeller redesign, the compressor has been performing flawlessly.

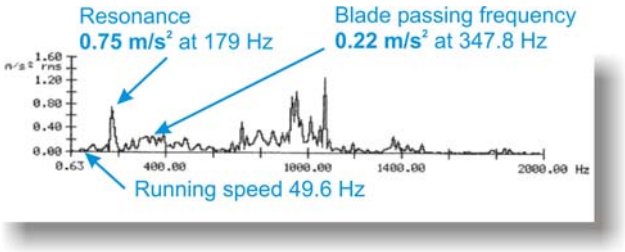

Fig. 4 After repair: Radial vibration spectrum from motor foundation showing the non-synchronous natural frequency peak and blade passing frequency have reduced or vanished in relation to Fig. 2.

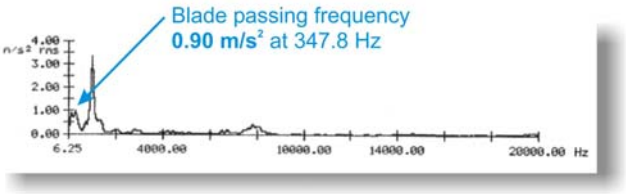

Fig. 5 After repair: Compressor bearing radial vibration spectrum showing upper frequency amplitudes reduced in relation to Fig. 3.

Acknowledgements

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