Benefits of using GE's Bently Nevada* 3500 Series Machinery Monitoring System

Paul Bäumler (BASF), Dr. Thomas Kafka (GE/Bently Nevada)

BASF, the world's largest chemical producer headquartered in Ludwigshafen, Germany, experienced an unexpected shutdown and high vibration alarm on a steam turbine train. Using GE's Bently Nevada 3500 Series Machinery Monitoring System, BASF was able to quickly diagnose the problem and restart the machine. No repair was required.

The BASF Group comprises subsidiaries and joint ventures in more than 80 countries and operates six integrated production sites and 390 other production sites in Europe, Asia, Australia, Americas and Africa. With customers in more than 200 countries, BASF supplies products to a wide variety of industries.

During routine operation at BASF's Ludwigshafen production site, a steam turbine experienced a sudden, unexpected shutdown while operating at full load. The onsite BASF operators were uncertain about what caused the shutdown and also were concerned that the machine had been damaged and was unable to be restarted.

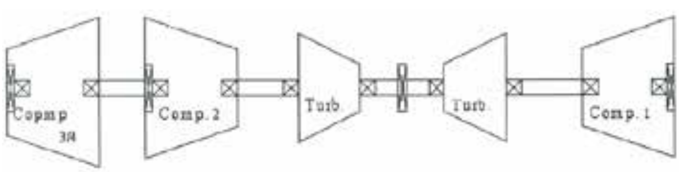

Figure 1: Turbine-driven compressor machine train

Figure 2: The steam turbine at BASF's Ludwigshafen, Germany site

Figure 3: The intermediate pressure compressor, which was driven by the steam turbine, at the site

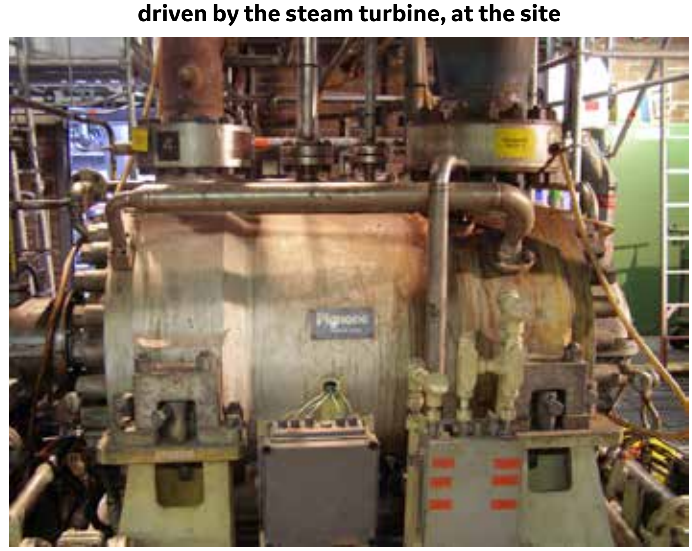

Figure 4: The high pressure compressor that is part of the machine train

A diagnostic and monitoring maintenance team started the failure analysis by checking the distributed control system (DCS) data. The only visible data showed a unit trip and high vibration alarm with no discernible cause. The turbine's operational speed and vibration levels associated with the event are shown in Figure 5.

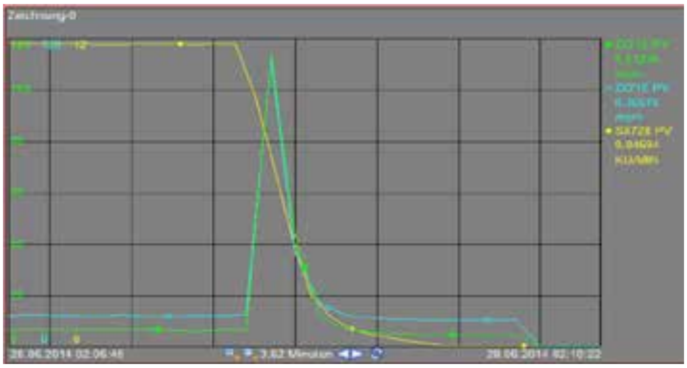

Figure 5: DCS reading of the event (yellow line indicates turbine operational speed, blue/green lines indicate vibration level in μm)

Based on the data provided by the DCS, the team was unable to determine if the machinery could be safely restarted.

The team needed a fast recording of all channels simultaneously, with high resolution, to define the cause of the shutdown. This is the type of data typically provided when GE's 3500 Series Machinery Monitoring System is used in conjunction with System 1* condition monitoring software.

While System 1 software was not connected to the 3500 system in this situation, the flight recorder functionality was activated. This functionality uses the built-in memory of the 3500/22 transient data interface (TDI) card to record data in an offline mode based on events. When this function is enabled, the 3500 system records and stores data associated with a shutdown. Using a converter tool developed by GE's Bently Nevada team, this data can be transferred into a System 1 archive, enabling the user to make a full diagnostic evaluation of the event.

Figure 6: Rotational speed trends during the event

An examination of the rotational speed trends (shown in Figure 6), revealed that machine speed decreased from 12,000 rpm to 0 rpm within three seconds, and then increased to 7,000 rpm three seconds later.

Based on the trend diagram during shutdown (shown in Figure 7), the major component of the vibration was not 1X related and the high vibration only occurred after the machine trip.

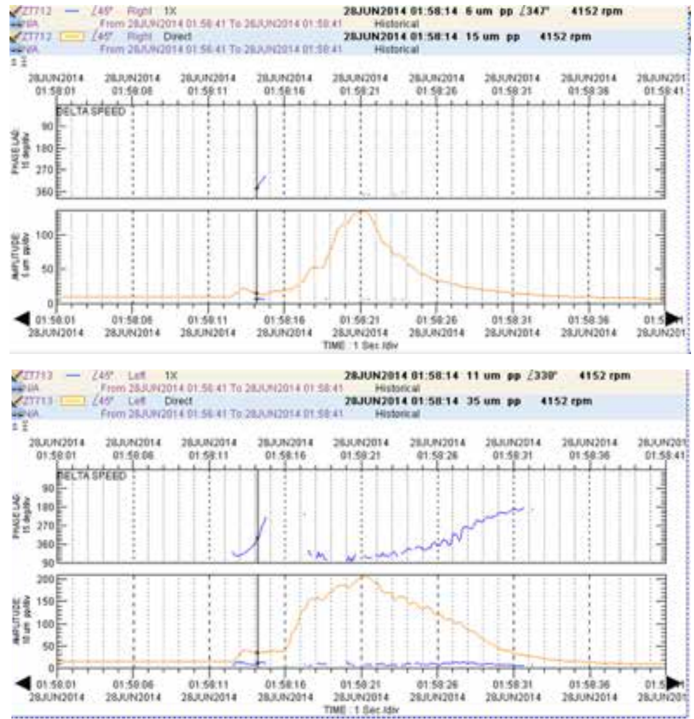

Figure 7: Trend plot during shutdown

The Keyphasor dots in the orbit plot (shown in Figure 8) recorded during the shutdown confirmed this finding.

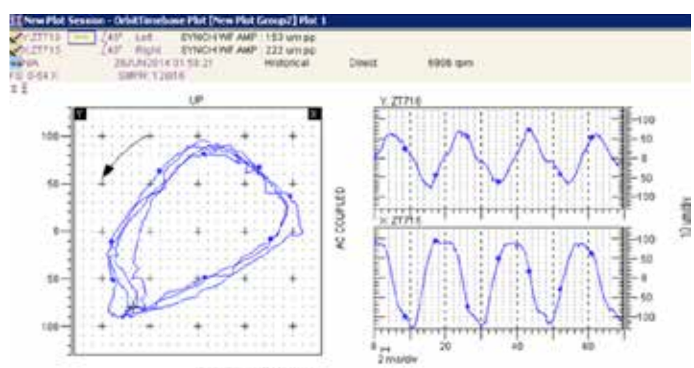

Figure 8: Orbit plot during shutdown

Closer inspection of the orbit plot indicated a negative rotation. In the recorded data, the rotation of the orbit plot changed during the shutdown event (see Figure 9).

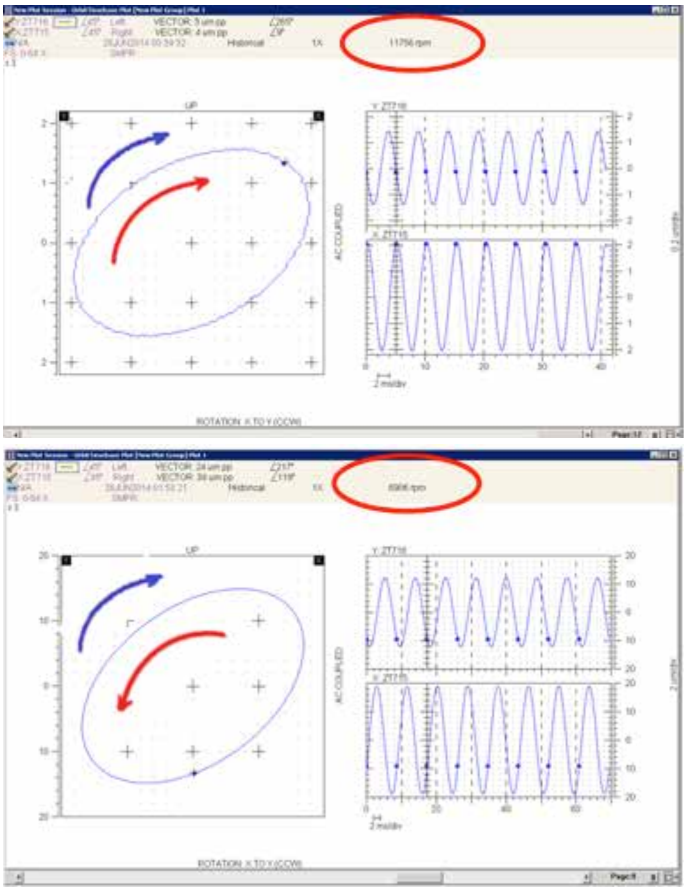

Figure 9: 1X- filtered orbit plot before and during the shutdown event

This data led the team to conclude that when the turbine slowed to 0 rpm, the machine restarted in reverse operation with the compressor driving the turbine. The reason for the reverse operation was high pressure in the pipeline between the compressor output and back-pressure valve. This pressure was high enough to drive the compressor and turbine train backward by a leaking back-pressure valve. As a result, during the reverse rotation the vibration level rose to high amplitude.

Based on the data, there was no evidence of machine damage due to vibrations during the event. The diagnostic and monitoring maintenance team recommended that the steam turbine be restarted without any further inspection requirements.

After restarting the machine, no additional changes in the vibration signature of the machine were observed.

The availability and quality of the data provided by 3500/22 TDI allowed BASF to limit required downtime to just eight hours and reduce the costs associated with the unplanned shutdown.

1631 Bently Parkway South
Minden, Nevada USA 89423

24/7 customer support +1 281 449 2000

geoilandgas.com

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