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Early, Automatic, Online Detection

Successful avoidance of major secondary damages using proximity measurements to detect a partially fractured piston rod

BY DR. UWE LADWIG

Introduction

In December 2007, the online monitoring system at the Yara Brunsbüttel (Germany) urea plant site avoided compressor damage by detecting a cracked piston rod at the first stage. Prior to a complete rod failure, the machine automatically stopped, avoiding costly consequential damages.

Application

The urea plant operates, besides others, two Thomassen reciprocating compressors in carbon dioxide (CO_2) service. Since October 2001, both compressors have been equipped with a Prognost-NT online condition monitoring system. In recent years, several machinery failures have been detected by the system, such as rider ring wear, loosened components and valve problems. The machines are four-throw, double-acting, four-stage horizontal compressors and have been in operation since 1997.

The Prognost monitoring system continuously monitors all safety and performance-relevant parameters on the compressors. Vibration and displacement sensors, as well as pressure probes, produce the signals needed for gapless and meaningful safety protection and condition monitoring. Additionally, all relevant process data from the distributed control system (DCS) are integrated, monitored and trended. Yara decided to have an automatic shutdown in case a dangerous machine status occurred. Based on crank angle-related rod-position analyses, Prognost shuts down the machine. The system calculates the peak-to-peak value of the segmented piston-rod position (runout) signal, providing additional

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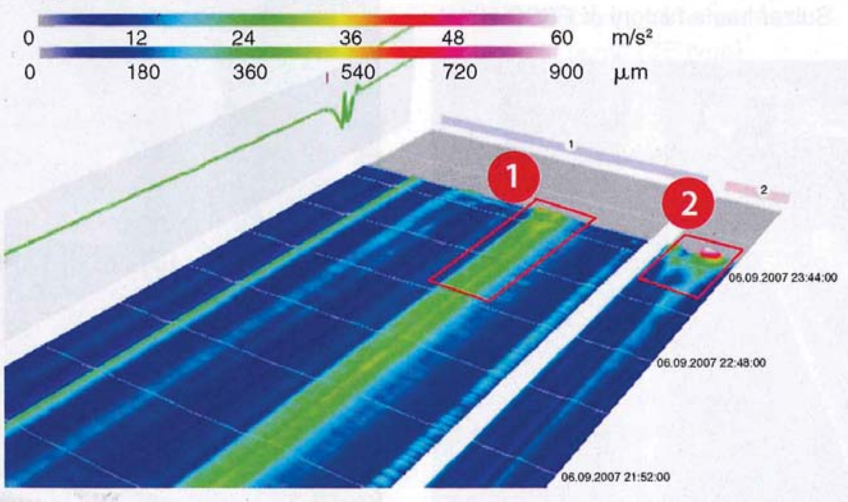
Thomassen reciprocating compressor.

Early indications of the compressor overload



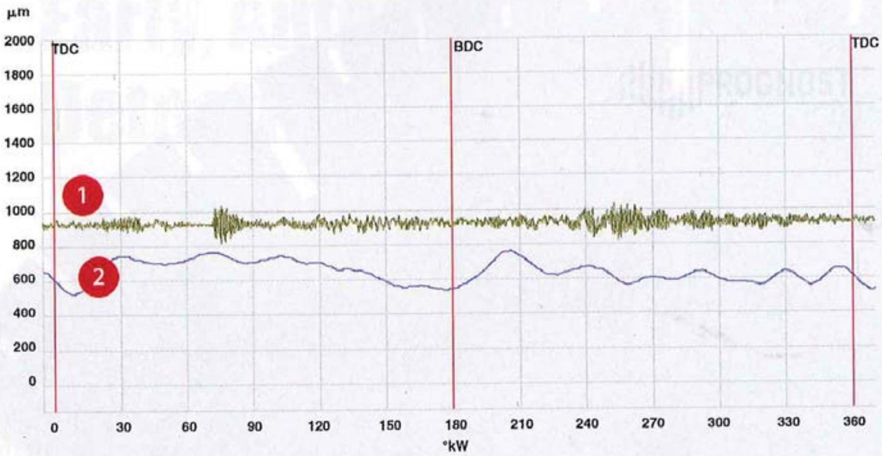
Waterfall (3-D) plot of average minute per revolution values over two hours of machine operation. The left side (1) displays the crosshead vibration values; the right side (2) shows the piston-rod position analysis values. Whereas the vibration reading is within the normal range and shows no early indication, the dynamic piston-rod position continuously issued alarms for more than 30 minutes and finally triggered the automatic shutdown.

information regarding the condition of motion works components.

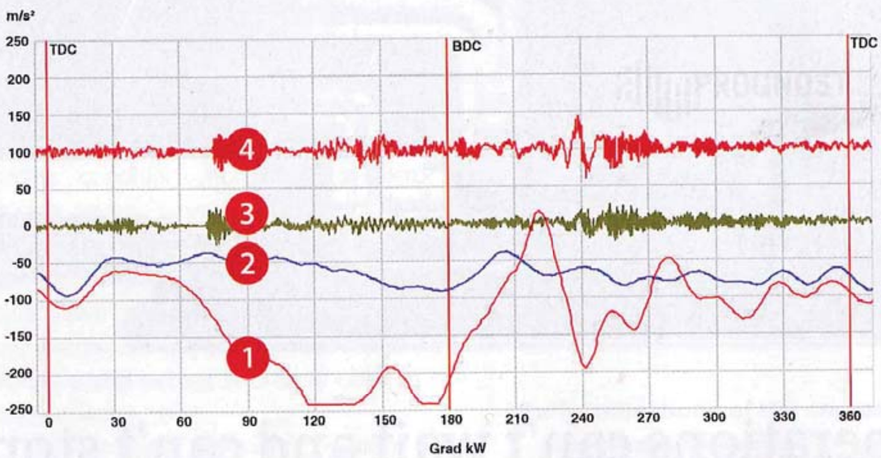
Sequence of events

"After six years' experience with this machine monitoring system, Yara was confident that the compressor would be safely tripped in time if the overloading caused bigger mechanical problems," said Yara Maintenance Manager Dr. Uwe Ladwig. "The compressor was intentionally operated beyond design limits. We simulated for a short time a capacity increase to identify potential bottlenecks in the downstream urea plant in advance of the installation of an additional compressor."

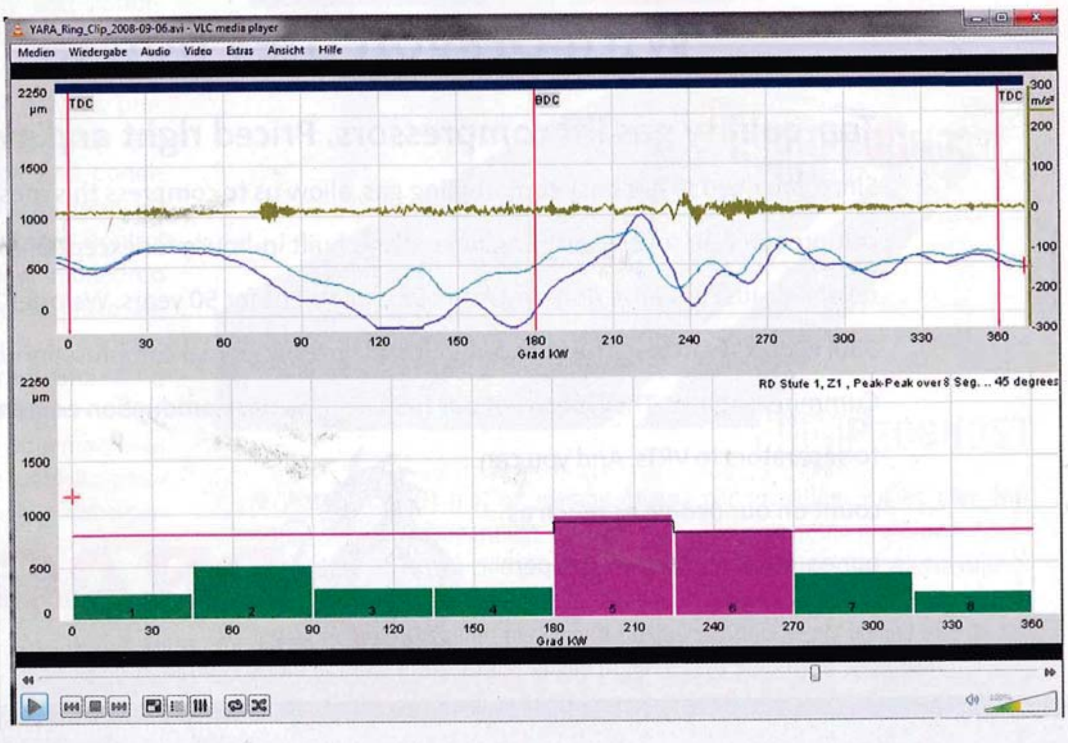
Yara increased the suction pressure to increase the volume of compressed



■ Online signals of the crosshead slide vibration (1) and the dynamic piston-rod position (2) with normal readings in "good condition" and regular machine operation.



■ Composition of online signals to display the developments. "1" is the dynamic piston-rod position at the moment of the trip alarm; the blue line (2) is the same signal in good condition. The two readings above are crosshead acceleration signals: in good condition (3) and at the moment of alarm (4). Whereas the vibration shows no deviation between "good" and "bad" machine condition, the piston rod has massive movements that leads to the tripped alarm.



■ Screenshot from the ring buffer in the moment of the shutdown. The segmented piston-rod analyses initiated a series of alarms for several minutes prior the trip. The Prognost ring buffer enables users to perform root cause analyses based on uncompressed data — here used in audio video interleave format in a freeware media player.

The piston rod with a 75% circumferential crack.

gas per cycle; discharge pressure as well as running speed remained. The screenshots and data are extracted from the ring buffer data that the Prognost system automatically saved. This allowed a subsequent root cause analysis to be performed by the author.

Findings

"When the machine stopped, we found a partially cracked piston rod on the first stage," Ladwig said after the stress test. "Thanks to the — as expected — timely trip, we were able to repair and restart within 24 hours."

Displacement sensor to measure the dynamic piston-rod position (runout) on the first stage.

Today it is possible to shut down reciprocating compressors before a piston rod fails completely. The dynamic piston-rod position is the determining parameter to detect loose connections within the drive of the piston or cracks within piston rods at an early stage. Automated online machine monitoring, including safety shutdown functions, lead to lower costs of production and higher plant efficiency.

About Yara

Yara converts energy, natural minerals and nitrogen from the air into essential products for farmers and industrial customers. The main application is fertilizers, while industrial uses and environmental solutions are also important growth segments. The Yara Brunsbüttel site has two production units, an ammonia plant and a urea plant. CT2