TESORO

RECIPROCATING MACHINE FAULT AND CORRECTION REPORT 03/22/16

MACHINE DISCRIPTION:

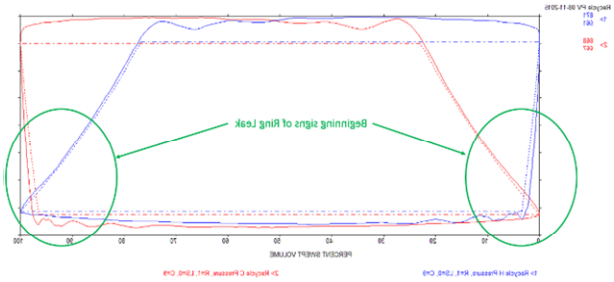
Machine : C2001B Hydrogen reciprocating compressor

BACKGROUND:

In late November 2015 Operations noted a reduction in capacity from the hydrogen compressor C2001B. With the excess capacity available from C2001A and B, there was not a reduction in unit production. However, the declining capacity of C2001B was a concern and corrective action needed to be taken. One option was to bring the machine down and visual inspect internal components to determine the issue. In order to avoid the lost production while down, a decision was made to perform a Windrock health and performance analysis on the unit during operation to identify the problem and minimize the downtime in repair.

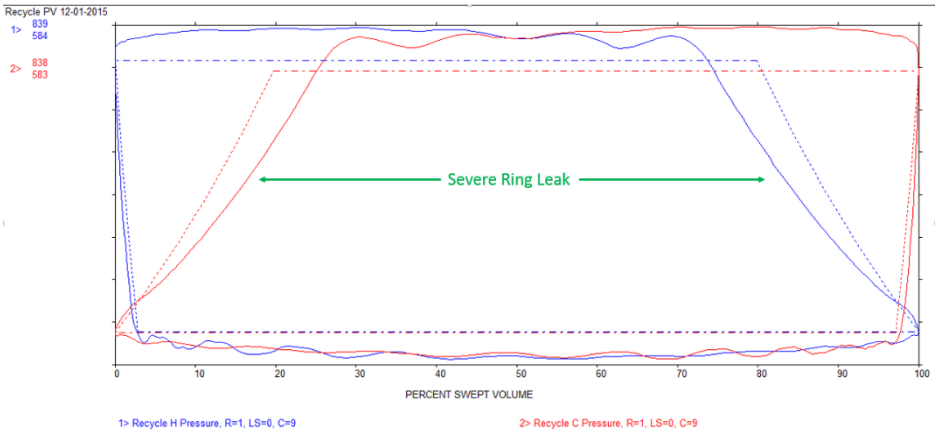
DIAGNOSTICS:

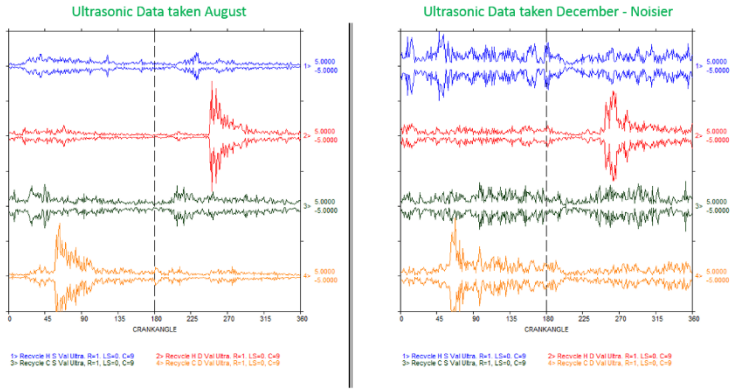
The Windrock portable analyzer was used to collect a full set of data on the unit, including crank-angle, in-cylinder pressure, valve ultrasonic and valve/cylinder/frame vibration. Total data collection time was approximately 45 minutes. Data was taken on the same machine a few months earlier in August 2015 and subsequent data was taken in March 2016, after the fixes had been implemented.



Looking at data that was taken in August, a slight ring leakage was detected. It was not enough for any action, but it was at the beginning stages of development. The lead is indicated by the slight deviation of the solid line (actual pressure) versus the dashed line, which is the theoretical (perfect cylinder data). Figure 1.

The data taken in November when capacity was limited shows that the ring leak has gotten much worse. Note the much larger difference between the solid and dashed lines. Figure 2.

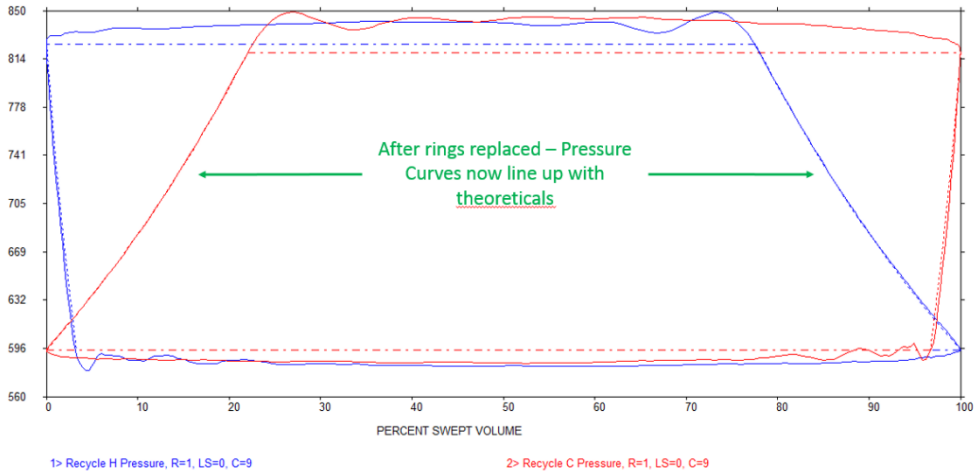


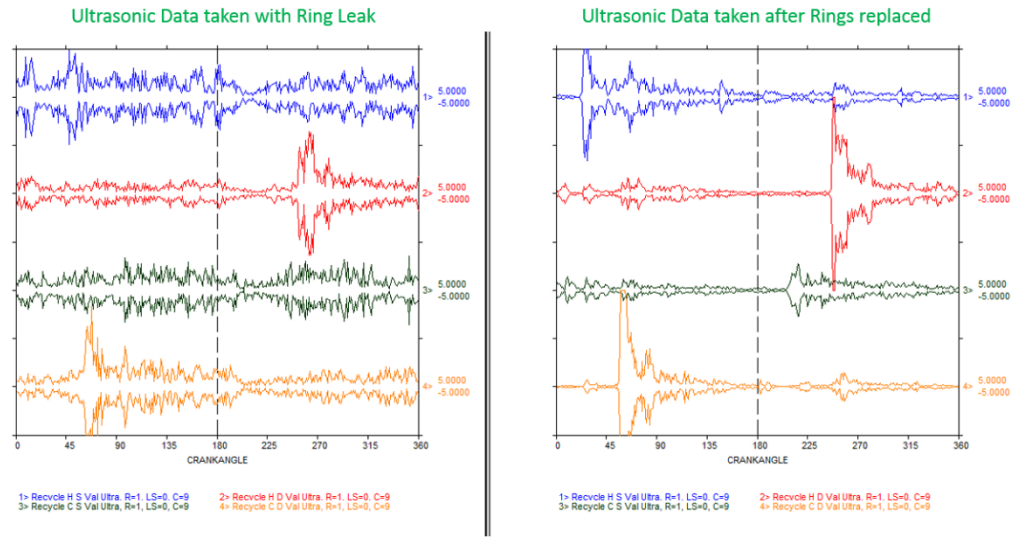


The leak was also verified while looking at the Ultrasonic data on each valves. From August to November noise levels due to the leak got worse (Figure 3)

CORRECTIVE ACTION:

Having pinpoint the issue, plans were made for the shutdown. During the shutdown, the rings were replace along with piston and rider bands. While the machine was down valves were also replaced. Total time for these repairs was 2 days. When the system was back running capacity had returned to normal. Data taken in March 2015 showed the compressor was operating properly and no significant leaks were detected. Figure 4 (Pressure) and 5 (Ultrasonic) show the before and after.





EXCESS POWER COMSUMPTION DUE TO FAULT

Recirculating gas cost $90.71 * 30 days = $2,449

This number is based on the driver cost being .07 $/hp-hr

COST AVOIDANCE

Lost production: Because the defect was known an estimated savings of 1 day downtime was realized due to the fact that visual inspection was not needed to determine the problem. Because the work could be planned and reserves could be created only ten percent of the DDU plant was down during the repairs meaning instead of 10,000 barrels a day, only 9,000 could be produced. At $37.00 a barrel a savings of $37,000 was incurred. (1000 barrel * 1 day * $37.00 a barrel). If this would have been an unplanned downtime cost could have been as much as $300,000 if the entire DDU plant was down.

NOTE: Wholesale price of Low-Sulfur Diesel is $1.20 per gallon and approximately 31 gallons to a barrel so wholesale cost per barrel is $37.20