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Continuous Performance Monitoring

Why "continuous" monitoring of Turbomachinery performance? Why not just a spot check occasionally? Why not wait until there is a problem? Why check it at all? This article will offer some reasons to continuously monitor compressor and turbine performance and present some case studies in support of continuous performance monitoring.

Sometimes things go bump in the night. Having continuous performance monitoring will provide the data you need to confirm the root cause of a problem instantly saving costly troubleshooting time and minimizing downtime and production loss. Weather it's a vibration issue, high bearing temperatures or compressor efficiency, you want to have the information immediately, not wait to send out your crew of experts or hire someone to assess the situation. Knowing instantly offers time to correct the situation before it gets too serious or it may simply confirm what you suspect but can't prove. The instant feedback of compressor and turbine performance allows operators to make process adjustments with consideration for the turbomachinery or proceed with on line washing or schedule a shutdown for the appropriate maintenance.

Keeping a plant operating at it's peak efficiency is crucial to success. It is that little bit of extra performance that is the cream, the profits that make the difference between surviving and thriving in a competitive world.

While the cost of maintaining a good condition based maintenance program does cut into the bottom line, the added revenue from operating at peak performance and minimizing unplaned outages far offsets the cost. Of course, the key is to have a low cost program with real benefits like instant feedback of operating information weather sitting in your office or while you are out at the ball game and checking your phone. Getting to the problem quickly cuts losses and adds to the bottom line.

Case Study#1: Synthetic Natural Gas Compressor, Figures 1 through 3. Note fouling on the impellers in Figure #1. Similar fouling was found on the stationary components. Overnight a large amount of rust peeled off the inlet piping and was ingested causing this fouling and sudden drop in compressor efficiency. Having continuous monitoring made it quick & easy to confirm the root cause of the problem and provide the evidence needed to open the compressor in question, saving a lot of time and money.

Figure #1. Fouling on impellers. Overnight a large amount of rust peeled off the inlet piping and was ingested causing this fouling and sudden drop in compressor efficiency.

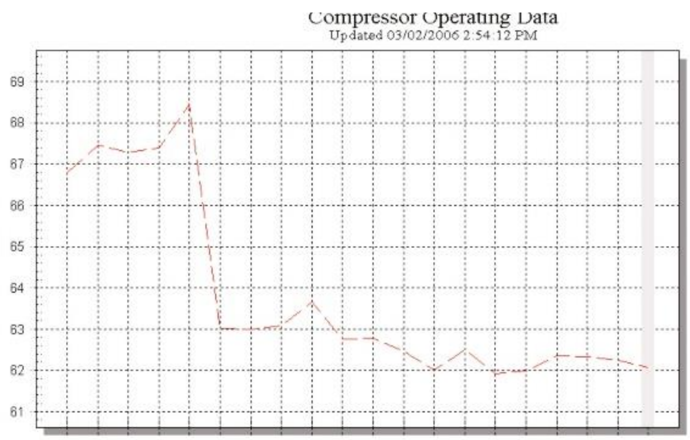

Figure #2. Plot of compressor efficiency vs. time. Note the sudden drop in efficiency. Having continuous monitoring made it quick & easy to confirm the root cause of the problem and provide the evidence needed to open the compressor in question, saving a lot of time and money

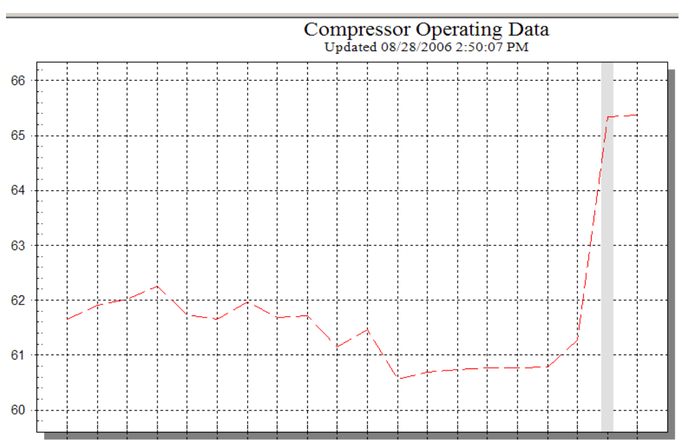

Figure #3. Plot of compressor efficiency vs. time showing the start up after opening the compressor and cleaning the internals. After disassembling the compressor, cleaning it up and installing a new rotor, it is easy to see by the performance that the problem was properly addressed.

Case study #2: Data scatter, Figure #4. Performance on a machine can be erratic due to process conditions or intermittent liquid ingestion. By conducting continuous monitoring, you can easily determine the true performance trend of a machine as well as forecast the performance for maintenance scheduling. Knowing the instantaneous performance can permit you to make the proper process changes on the fly to get that perfect process – compressor match. Having a live feedback of the machine performance permits the operators to make process changes with consideration of the compressor and turbine performance thus maximizing plant efficiency and production.

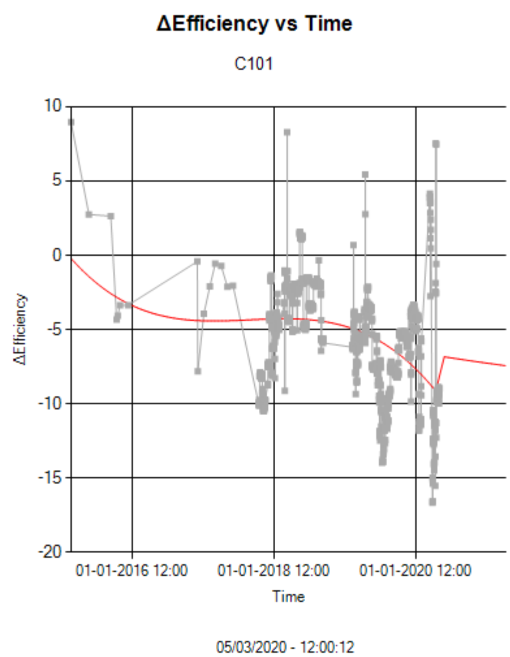

Figure #4. Data scatter. Erratic performance due to process conditions or intermittent liquid ingestion. Continuous monitoring clearly provides the true performance trend of a machine as well as forecasting the performance for maintenance scheduling

Case study #3: Compressor fouling, Figure #5. The gas in ethylene feed gas compressors tend to polyminerize as the pressure and temperature rise sticking to the walls of the diffusers and even to the impellers. Being able to monitor this continuously and forecast the performance allows for proper timing for washing the compressors and eventual disassembly to clean.

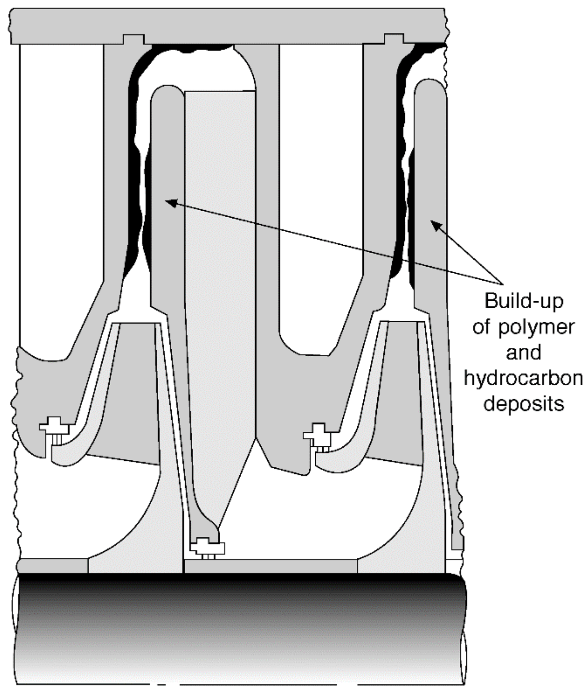

Figure #5. Fouling on an ethylene feed gas compressor.

Case study #4. Impeller failures, figures # 6 & 7. It is well a documented fact that not only is surging a compressor an issue, but also operating in choke, especially when the possibility of liquid ingestion is involved. Refrigeration compressors are susceptible to ingesting liquids during choke condition as the demister pads in the knockout drums will be overloaded and some mist will carry though which will intensify the pressure gradients acting on the impellers and eventually cause a fatigue failure of the impeller. This propane compressor impeller failed after only 40 hours of operation. As part of the root cause analysis, it was demonstrated the compressor was operating in deep choke and most likely had liquid entrained in the gas. Having instant feedback on where the machine is running on the curve will allow the operators to avoid this dangerous operating condition.

Figure #6. Impeller failure due to operation in choke with liquid ingestion.

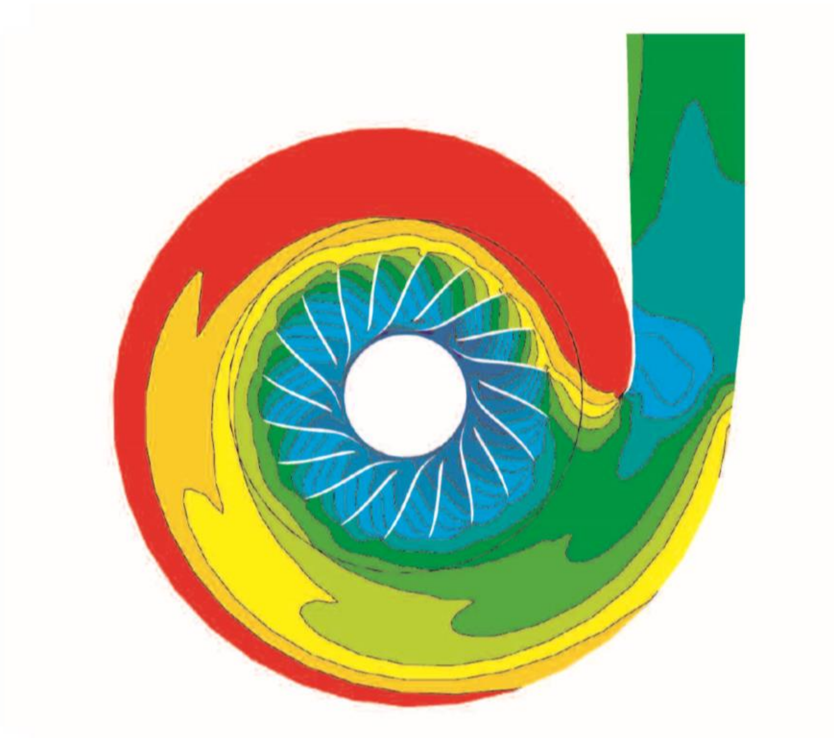

Figure #7. Nonuniform pressure field due to volute cut off. This pressure gradient is highest during choke conditions and high mole weight gases combined with even very small amounts of liquid can excite all impeller frequencies and eventually cause a fatigue failure.

Case study #5. Impeller failure due to operation in insipient surge, Figure #8. This 60" diameter impeller failed after extended operation in incipient surge. Flow separation at the impeller blade leading edges caused the blades to flutter, leading to the fatigue failure of one of the blades causing a catastrophic failure of the compressor. Continuous monitoring of the compressor would have allowed the operators to be aware of this dangerous operating condition and prevented this failure.

Figure #8. Impeller failure due to operation in insipient surge.

Conclusion

By integrating machine real time performance monitoring along with mechanical parameters like vibration data, bearing temperatures, seal data and oil condition, better informed decisions can be made regarding machine maintenance.

Online continuous performance monitoring should be a key part of every plant's machine reliability program. Key benefits include:

1. Knowing the equipment performance trend and forecasting along with the mechanical data like bearing temperatures and vibration provides the data to confidently extend or pull up planned maintenance outages.
2. Trending and forecasting of machine performance allows review of operating points that may have subsequently affected the machine condition.
3. The effects of process changes can be evaluated immediately.
4. Knowing the machine performance immediately significantly aids the process of troubleshooting a machine problem and minimizing downtime/loss production.
5. Performance monitoring provides valuable information when justifying an extended time between overhauls to an insurance company as well as minimizing insurance premiums.
6. Being able to check the machine performance from your smart phone allows you to tend to personal matters like attend your child's ball game, yet also quickly respond to critical plant matters when necessary.

M. Theodore Gresh
29-May-20

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