Remotely

"Well, we'll just have to do it remotely." How many times have you heard this recently? While seeing your Doctor remotely, working remotely, having meetings remotely, having training remotely, and monitoring of equipment remotely has been around for some time now, the COVID 19 virus has thrown many of us into doing things remotely kicking and screaming. The virus has ramped up the trend of doing things remotely that otherwise may have taken years to transition to. But there can be a lot of advantages to doing equipment monitoring remotely. It brings things together quickly and easily. At the touch of a finger! Saving us all time and money.

Figure 1. Monitoring equipment remotely can be very beneficial by providing the user with instant asset information consolidated at his fingertips.

Condition monitoring is the process of monitoring, trending and forecasting the condition of machinery such that maintenance can be scheduled before a developing situation becomes serious or a failure occurs allowing time to schedule maintenance.

Continuous online monitoring of Turbomachinery, trending and forecasting of those trends is crucial to plant operation and maintenance and is a key part of a thorough machine reliability program. Integrating machine real-time aerodynamic performance along with mechanical parameters like vibration data, thrust position, journal and thrust bearing temperatures and oil condition, makes for an all-encompassing condition based maintenance program resulting in better maintenance and reliability decisions.

While a good effective maintenance program is not free, and the cost of maintaining that program cuts into the bottom line, the added revenue from high onstream factors more than offsets this cost. The goal is to have a low-cost program with real benefits. Instant feedback on information with minimal intervention is key. Basing a maintenance program on equipment condition rather than operating time will go a long way toward saving money.

Monitoring equipment remotely has brought the details of equipment health to our fingertips in such a way that the operators & rotating equipment engineer can respond to maintenance scheduling decisions, process adjustments, upsets or emergencies instantly, no matter where they are. Making decisions with the condition monitoring system is much easier and much less time consuming to complete when all the information is consolidated in one place at your finger tips.

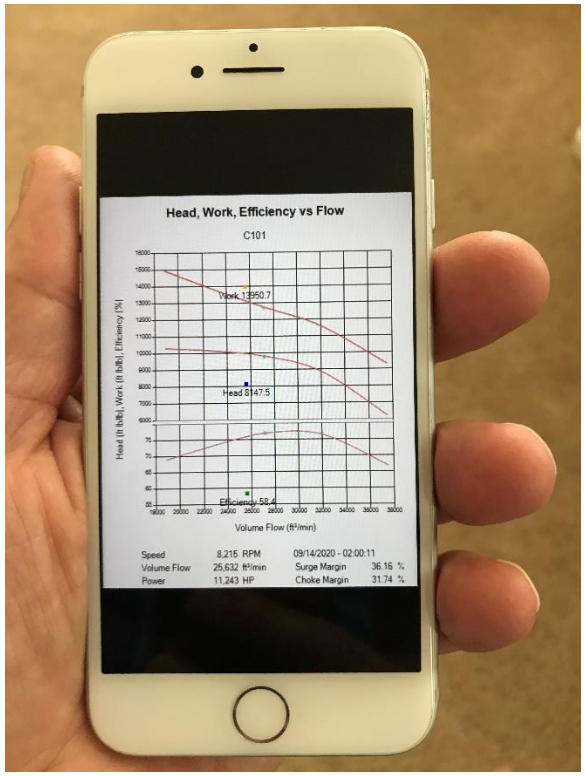

Figure 2. In addition to knowing where the compressor is operating on the curve, knowing the surge margin, margin to choke and work input can be very helpful. Work input is a good indicator of the quality of the data being measured.

Knowing how the equipment is running is just as important as knowing plant profits on a real time basis. Online monitoring of performance and mechanical parameters of critical turbomachinery equipment adds value by knowing instantly when something goes wrong or is starting to go wrong, and the trending and forecasting of the data provided helps scheduling maintenance and troubleshooting for the root cause. Getting to problems quickly cuts losses and adds to the bottom line. And, if the equipment is running fine, then why spend the time and money to open it up and inspect and replace all the wearing parts?

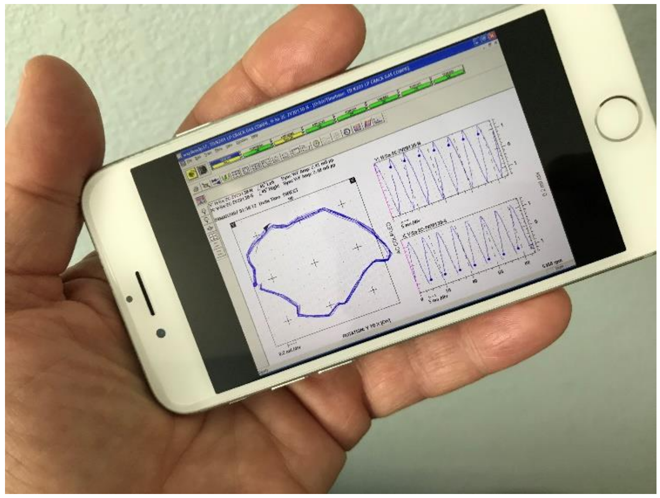

Figure 3. Tying vibration with aerodynamic performance can be very helpful in determining the root cause of the vibration. For example, higher than normal synchronous vibration in conjunction with poor aerodynamic efficiency can mean a dirty or fouled compressor and all that is needed is on line washing to correct the situation.

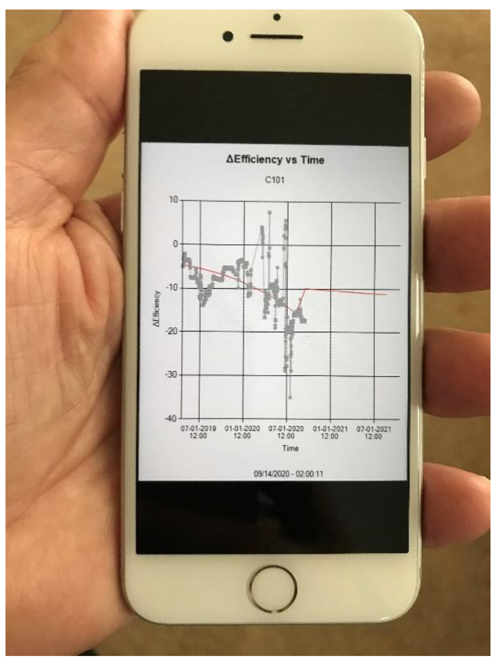

Figure 4. Turbomachinery health is best assessed by trending and forecasting and collectively assessing: delta efficiency (deviation from ideal), vibration, bearing temperatures, balance line delta P, seal operating data and oil analysis.

A compressor user noted the steam turbine control valve to be fully open and they were still having difficulties meeting discharge pressure requirements. A performance analysis showed the compressor head and efficiency to be well below normal expected values. Additionally, the speed was higher than normal, the thust bearing temperature was high and the axial position of the rotor was high. This information led to the conclusion the internal seals were damaged allowing for increased circulation and thrust. Table 1 shows the data before and after a balance piston seal replacement. This machine was in refrigeration service and was required to maintain a constant discharge pressure.

Table 1. Compressor mechanical operating data before and after a balance piston seal replacement. This machine was in refrigeration service and was required to maintain a constant discharge pressure. This mechanical data (before data) confirmed the problem was more than fouling in the compressor and was related to internal seal damage and the machine required disassembly to remove the damaged seals and replace with new parts.

		Before	**After**
Discharge Pressure	(PSIG)	410	410
Discharge Temperature	(°F)	142	116
Axial Position	(Mils)	24	19
Balance Line ΔP	(PSID)	4.7	1.5
Speed	(RPM)	11440	10770
Thrust Metal Temperature	(°F)	240+	165

The balance piston damage was a result of surging during startup and shutdown and vibration excursions through the first critical speed during these events. The interstage seals were also extensively damaged, which contributed to the poor compressor efficiency. Note the differences in the various data for before and after the seal replacement. The discharge temperature was high, since more work input was required to achieve the desired discharge pressure. In order to get the higher level of work input, the speed was increased, increasing power requirements and thus the wide open steam turbine control valve. The wiped seals not only caused increased inefficiencies, but also higher thrust loads. This showed up in the increased axial position, the high balance line delta P and the high thrust bearing temperature.

Accurate trend analysis on compressors can be somewhat confusing as the operating point and even the gas analysis and other parameters like suction pressors and temperature may be continuously changing. Since this alone will affect the efficiency of the compressor, how can the trend be evaluated?

One method that has been used with great success is to plot the deviation of a parameter (efficiency, head and work input) from the predicted value, usually the OEM performance curve.

Preferably, the predicted curve is adjusted according to established field data for the compressor. Adjustments must be made for changes in inlet conditions, gas analysis, pressure, temperature and speed. The operating data are then compared to this “adjusted” prediction curve and the difference, such as delta efficiency is plotted versus time. See Figure 4. Since performance degradation can be greater for off-design conditions, it is necessary to consider this effect when viewing the data. The actual operating range will determine the urgency of any maintenance shut down.

In addition to monitoring the compressor performance and mechanical data, monitor the process as well. Take the case of a compressor supplying air to a catalyst bed. Over time, the compressor performance decays due to dirt buildup, corrosion, increased internal recirculation from seal wear, etc., the performance curve generally shifts downward and toward reduced flow to the left.

Additionally, the process system may also be fouling, as with the system with a catalyst bed. This means a greater restriction for a given flow. So, while the compressor has less head capability, more head may be required by the system. See Figure 5.

The efficiency is reduced because of the increased frictional losses and/or increased internal recirculation, shifting the performance down and to the left. The increased system resistance also effectively reduces the capacity of the compressor, shifting the system resistance curves to the left. Even the shape of the curve will change some.

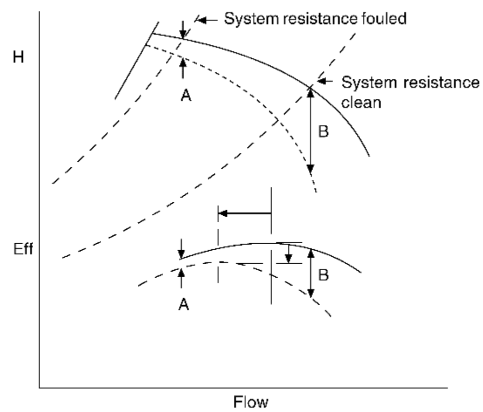

Figure 5. Effect of fouling on compressor performance curves and system resistance curves.

Any issues in trending and forecasting data can be minimized if a full range of continuous data is available over a long period of time. A plot of delta efficiency can provide a very clear trend. Plotting delta head will provide confirmation that the head is below prediction and plotting delta work input will confirm the accuracy of the data being analyzed.

Conclusion

Take a step back and look at the big picture. A quality condition monitoring maintenance program considers mechanical parameters like vibration, bearing temperatures, balance line delta P, thrust position, oil condition along with equipment efficiency, driver condition and process conditions.

Knowing the machine performance and mechanical data immediately significantly aids the process of diagnostics and troubleshooting a machine problem, minimizing downtime and lost production.

Long term trending and forecasting the machine data allows for better decision making regarding the timing for maintenance.

Knowing machine performance along with vibration, thrust, bearing temperatures and oil condition, scheduled maintenance and overhauls can be extended for well designed, maintained and operated equipment.

Monitoring equipment continuously provides valuable information when justifying an extended time between overhauls to an insurance company as well as minimizing insurance premiums.

Having a remote, cloud based system with trending and forecasting at your fingertips makes the condition monitoring program much easier and less time consuming to manage.

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