

THE POWER OF REMOTE MONITORING

M. Theodore Gresh, Flexware Inc., USA, explores the factors that go into implementing an effective condition monitoring maintenance programme.

A common refrain of late has been “Well, we’ll just have to do it remotely.” Seeing a doctor remotely, working remotely, having meetings remotely, training remotely, and monitoring of equipment remotely has been around for some time now, but the COVID-19 virus has forced many people into doing things remotely with some reluctance. 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 monitoring equipment remotely. It brings things together quickly and easily at the touch of a finger, saving everyone time and money.

Condition monitoring is the process of monitoring, trending, and forecasting the condition of machinery such

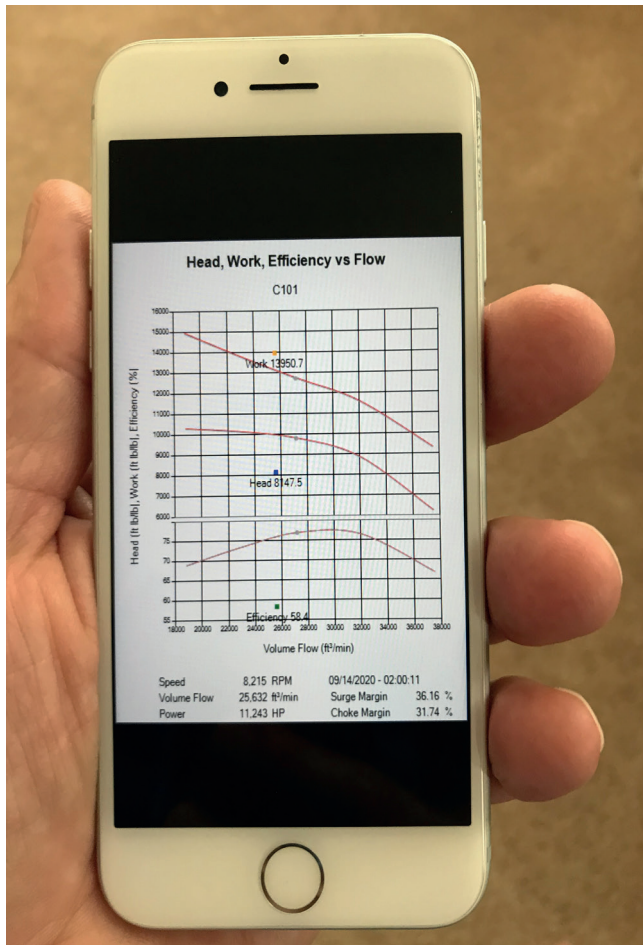


Figure 1. In addition to knowing where the compressor is operating on the curve, knowing the surge margin, margin to choke, and work input can be very helpful. Work input is a good indicator of the quality of the data being measured.

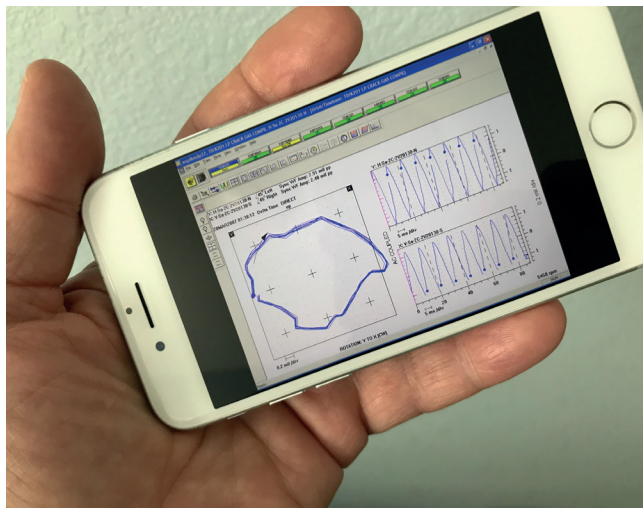


Figure 2. Tying vibration with aerodynamic performance can be very helpful in detecting the root cause of the vibration. For example, higher than normal synchronous vibration in conjunction with poor aerodynamic efficiency can mean a dirty or fouled compressor, and all that is needed is on-line washing to correct the situation.

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

While a good, effective maintenance programme is not free, and the cost of maintaining that programme 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 programme with real benefits. Instant feedback on information with minimal intervention is key. Basing a maintenance programme on equipment condition rather than operating time will go a long way towards saving money.

Monitoring equipment remotely has brought the details of equipment health to our fingertips in such a way that the operators and 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.

Knowing how the equipment is running is just as important as knowing plant profits on a real-time basis. Online monitoring of performance (Figure 1) and mechanical parameters (Figure 2) of critical turbomachinery equipment adds value by generating instant awareness of when something goes wrong or is starting to go wrong, and the trending and forecasting (Figure 3) 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 well, then there is no need to spend time and money opening it up and inspecting and replacing all the wearing parts.

Case study

A compressor user noted the steam turbine control valve to be fully open and that 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 thrust bearing temperature was high, and the axial position of the rotor was high. This information led to the conclusion that 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. This mechanical data (before data) confirmed the problem was more than fouling in the compressor and was

related to internal seal damage. The machine therefore required disassembly to remove the damaged seals and replace with new parts.

The balance piston damage was a result of surging during start-up 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. The differences in the various data for before and after the seal replacement should be noted. 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, raising 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.

Achieving accurate trend evaluation

Accurate trend analysis on compressors can be somewhat confusing as the operating point and even the gas analysis and other parameters, such as suction pressures 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 original equipment manufacturer (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 is then compared to this 'adjusted' prediction curve and the difference, such as delta efficiency, is plotted vs time (Figure 3). 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 shutdown.

In addition to monitoring the compressor performance and mechanical data, the process should be monitored as well. In the case of a compressor supplying air to a catalyst bed, over time the compressor performance decays due to dirt build-up, corrosion, increased internal recirculation from seal wear, etc. The performance curve generally shifts downwards and towards 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 (Figure 4).

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 somewhat.

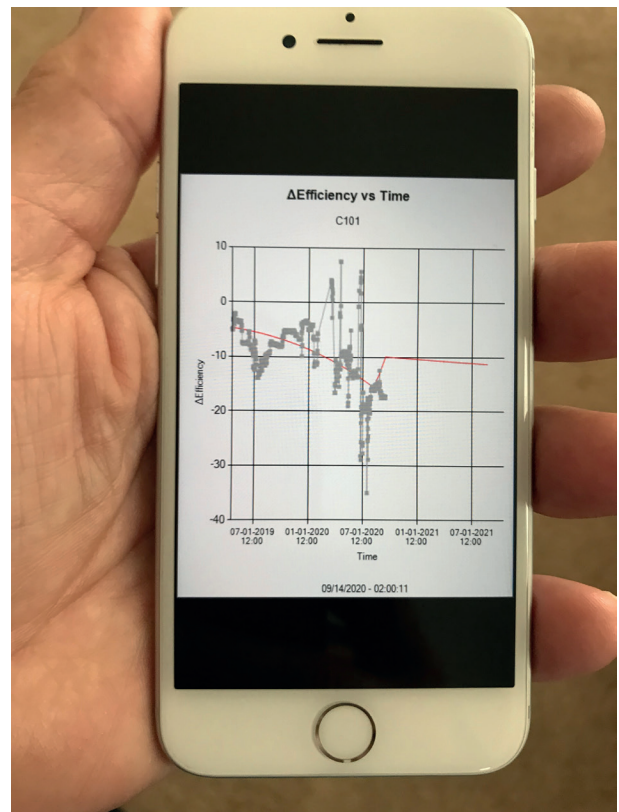


Figure 3. Turbomachinery health is best assessed by trending and forecasting and collectively assessing: delta efficiency (deviation from ideal), vibration, bearing temperatures, balance line delta P, seal operating data, and oil analysis.

Table 1. Compressor mechanical operating data before and after a balance piston seal replacement

	Unit	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	11 440	10 770
Thrust metal temperature	°F	240+	165

Any issues in trending and forecasting data can be minimised 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 analysed.

Conclusion

A quality condition monitoring maintenance programme considers mechanical parameters such as 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, minimising downtime and lost production.

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

By 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 minimising insurance premiums.

Having a remote, cloud-based system with trending and forecasting at one's fingertips makes the condition monitoring programme much easier and less time-consuming to manage. 

Bibliography

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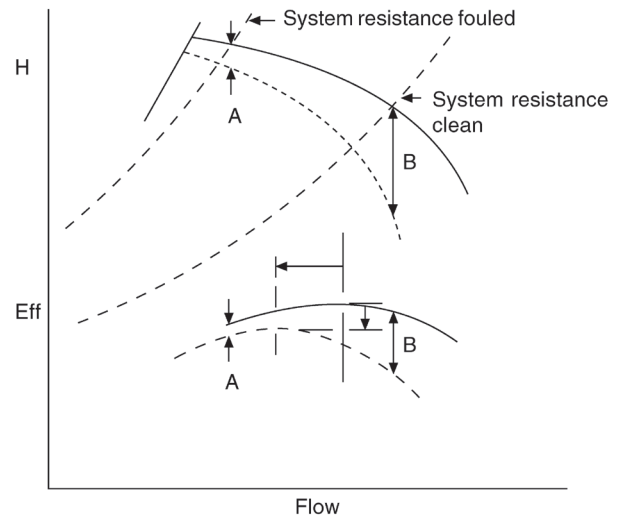


Figure 4. Effect of fouling on compressor performance curves and system resistance curves.