

Complexity in ISFA (in-service fluid analysis): Part XXXI

Holistic condition monitoring in the 21st Century: Part III

LAST COLUMN I INDICATED SOME OF THE HURDLES involved in implementing holistic condition monitoring (CM). Two of them are particularly important to consider and understand:

1. **Data proliferation issue:** There will be a mountain of data types with the advent of holistic CM and the varied techniques and disciplines utilized. Powerful intelligent agents (IAs) will be needed.
 - **Meaning:** Manual evaluation would be almost impossible and add unnecessary risk of missing subtle patterns.
2. **Timing issue:** Combining episodic (sensor) data with bench testing (static) data necessitates assessing the indications provided by sensors where the data are always in real time, but the last bench testing occurred prior to the most current sensors.
 - **Meaning:** The further in the past that the last bench tests (consisting of data not available via sensors) are, the more risky conclusions can be.

Data proliferation can be daunting, but it need not be

suffocating or overwhelming. Simple, available calculations and/or determinations to using the data effectively, while minimizing the amount actually gathered for evaluation (and not necessarily permanently stored once information is extracted), include:

- **Mean:** Knowing the average value sets a reference basis.
- **Data bandwidth:** Excursions, both high and low, are of keen interest because they can be, and often are, evidence of potentially traumatic events. At the very least they announce a change in environmental or operating conditions. These moments are where sensors provide their payoffs.
 - *Excursion duration* is key.
 - *Repeating patterns* are key and may be indicative of harmless operational variance (e.g., duty cycles) rather than trauma.
 - *Feedback* (from work order-generated diagnostics) is vital to identifying and differentiating actual trauma from routine (expected) operational variance. Since good, consistent feedback reporting has never been a hallmark of CM, at least for ISFA, the sensor era has a chance to help mitigate that neglect. This isn't simply

Sensor/Sampling Interplay	JAN			FEB				MAR	
SCENARIOS	Week	Week	Week	Week	Week	Week	Week	Week	Week
Highest Sampling Risk	Best case for a sensor: Sensor gives significant warning signs shortly after most recent sample; sampling program is out of phase								
Dynamic Measure SENSOR >	Sensor	Sensor	Sensor	Sensor	Sensor				
Static Measure SAMPLE >	Sample Due	Extra Sample?	?	?	Sample Due				Sample Due
Machine Condition >	Good?	Repairable?	Too late?	Failed?	Failed				
Example Scenario	A diesel engine develops a coolant leak within hours after last sample was taken; sensor responds strongly to a glycol/water presence								
Post Mortem	While oil analysis was necessary to corroborate the sensor warning, there is little chance the engine would have survived a regular sample interval								
Simultaneous Timing	Sensor gives significant warning signs shortly before next sample is taken; both monitoring systems corroborate each other in real time								
Dynamic Measure SENSOR >	Sensor	Sensor	Sensor						
Static Measure SAMPLE >	Extra Sample?	Sample Due	Sample Vetting		Sample Due				Sample Due
Machine Condition >	Failing?	Urgent	Repairs made						
Example Scenario	As per the diesel engine above, the sensor 'spots' the coolant leak and an unscheduled sample verifies it; repairs are scheduled with a degree of safety								
Post Mortem	The problem is identified somewhat earlier than it would have been with no sensor readings available. There will be times when that extra time is essential								
Sensor In Front	Good sensor case: Sensor gives warning significantly before scheduled sample, triggering a corroborating sample; repair is 'timed' according to problem type								
Dynamic Measure SENSOR >	Sensor	Sensor	Sensor						
Static Measure SAMPLE >	Sample xtra	Sample xtra	Sample Due		Sample Due				Sample Due
Machine Condition >	Failing?	Repairable	Failed?						
Example Scenario	Coolant leak is signalled and corroborated via sensor and sample, respectively, but with sufficient warning time comfort to choose the most efficient action								
Post Mortem	Extra time to react is ALWAYS a benefit but coolant leaks, like abrasives, can quickly cause significant damage, underscoring the benefit of earliest warning								
Sensor Lags or Defaults	Sensor not of warning help: Barring malfunction, sensor may lack sufficient sensitivity, or is not the appropriate sensor for the problem type								
Dynamic Measure SENSOR >	Sensor	Sensor	Sensor	Sensor	Sensor	Sensor	Sensor	Sensor	
Static Measure SAMPLE >	Sample Due				Sample Due	Sample Vetting		Sample Due	
Machine Condition >	Good	Good	Good	Good	Repairable	Repairs made	Residuals	Good	
Example Scenario	A wear problem from abrasives may be occurring, but no wear debris sensor is in use (a standard dielectric sensor will not demonstrate sufficient sensitivity)								
Post Mortem	A single sensor will not have the versatility of a full oil analysis; a suite of sensors is better, but quite expensive, and may still miss some possibilities								

Figure 1

a statement about historical negligence—*maintenance systems cannot be left wanting for validation in today's monetized world. This is the adjudicating information that justifies CM by providing a credible path to a true proposed ROI as derived from one's CM program.* CMMS systems can readily demand and track such feedback.

- **Applying the IA:** This is part of 21st Century CM. There are far too many pieces of information for a human to quickly and most advantageously link together—this is the domain of software. As I've stated earlier, a few qualified IAs exist and, of course, can always be improved (or more written, as particular purposes arise) to accomplish the critical task of evaluation, the end product of CM—what to do and why.

The *timing issue*, that of resolving the effect of old data from static lab testing versus real time data, is tricky but can be logically addressed.

Figure 1 was presented a few years ago to suggest at least four possibilities that will routinely present themselves. There are a few more, along with nuances, to be sure, but developing an approach to each scenario is the key. Once feedback is available (and if it's not, consider a different pro-

cession hereafter rather than stubbornly hope for it as I do), adjustments ranging for tweaking to restructuring the logic can be accomplished. *There is no secret to doing this—it requires domain expertise in the logical mix, i.e., in the software code, and is also teachable with useful feedback.*

As an aside, sensor proliferation will shift the application of domain expertise where it, perhaps, ultimately belongs—to those who know the machinery best because they see it daily. It is not going to be feasible for bench evaluators and diagnosticians to learn all the nuances that sensors will begin to expose, thus presenting new avenues to deeper diagnostics.

Next column I will suggest some ways in which the IA can approach the contribution of sensors in the context of ongoing fluid analysis bench testing, expanding on the example above.



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