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**Performance Optimization Tips: A Symptoms Approach to
Identifying Efficiency Improvement Opportunities**

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Previous *Energy Matters* articles (1, 2) broached the subject of the need to focus efforts for both reliability and energy purposes on those systems with the greatest potential for improvement or savings opportunities. As an example, the fact that a relatively small percentage of the motor population was responsible for most of the energy consumption in U.S. industry implied the need to focus system- (not component-) level evaluations on large equipment that runs a lot.

But in many industrial facilities, many big pieces of equipment run most of the time. In this article, we'll focus on pumping systems, and use a different approach—the presence of certain symptoms—to further prescreen opportunities for savings.

The goal of prescreening is to identify and prioritize the systems where we're most likely to find significant opportunities for improvement or savings. Although the symptoms we will discuss are specific to pumping systems, analogous conditions exist in other fluid handling systems, such as fan systems.

Pumping systems share a number of common features with people, and readers might find it helpful to consider them in an analogous sense. For example, both people and pumping systems:

- Are composed of a variety of components
- Require external sources of energy and energy conversion devices to keep them going
- Have a device that keeps fluid moving, but at a rate and pressure controlled by other components and factors.

It also turns out that symptoms, both in people and in pumping systems, can be helpful indicators of health.

Symptoms in People

While we are encouraged, particularly as we get older, to get periodic checkups of one form or another, we still rely on symptoms to serve as primary indicators of physical and mental health.

In some cases, the symptoms are acute and obvious. I recently conducted an un-planned verification of several laws of physics; in particular, the relationship between potential and kinetic energy.

A 4-inch-diameter poplar limb which I had just cut hit the ground and in a combative demonstration of its resilience, sprung and knocked out from beneath me the unsecured



ladder upon which I was perched. Up until this arboreal rebellion, I was about 20 feet off the ground, chainsaw in hand.

Recognizing that this situation was in reality a once-in-a-lifetime experimental opportunity (of the variety that often culminates a lifetime), I quickly ensured that a major source of external thermodynamic and kinetic energy (the chainsaw) would not confuse the experimental results (I tossed it off to the side). Even though this was an unplanned test, I was able to quickly develop an experimental hypothesis (that it was going to hurt when I hit the ground). That my hypothesis was accurate was borne out in short order by a sequence of verbal emissions and mechanical gesticulations, which were validated by an independent observer (my wife and erstwhile ladder anchor).

Now, before you call me stupid, just how many physics experiments have you conceived, performed, analyzed, and had independently verified in 1.1 seconds?

On the other hand, some symptoms are chronic in nature. Headaches, sinus congestion, and sore joints are things some of us regularly tolerate, but persistent nagging may ultimately spur a visit to the doctor.

The existence of symptoms isn't proof-positive that we have a serious health problem. Even my experimental fall only resulted in a couple of cracked ribs and a few bruises to body and ego (although my wife did suggest that there was ample evidence of pre-existing brain damage). Likewise, plugged sinuses can be extremely annoying, but we can learn to live with them. But overall, the presence of certain physical symptoms suggest the possibility that something is wrong, and the more symptoms that are present, the greater the likelihood that it is serious. It might finally be noted that some of our symptoms are quite obvious to ourselves and others, while other symptoms are more subtle and require greater attention to detect. And of course, in some cases, a serious condition can exist even though there are no apparent symptoms.

Symptoms in Pumping Systems

Pumping systems that are ill—in the sense they are wasting energy—often have their own symptoms; as with people, some are acute and obvious, while others more closely fit the chronic category. The patterns or symptoms discussed below have been found useful in the prescreening process. The existence of one of these symptoms doesn't guarantee a significant savings opportunity, just that it is more likely; and the more symptoms that are present, the greater the likelihood.

Throttled valves. Valves that are consistently throttled to control flow rate, pressure, level, temperature, or some other parameter in the system provide direct evidence that fluid energy is being dissipated. Significant losses from throttling are common in process industries such as petrochemicals and paper, although I've observed heavily throttled valves even in raw water pumping applications.

Open bypass lines. Open bypass or recirculation lines are sometimes used for control purposes. In a few cases, a combination of concurrent throttling and bypass flow control is found. Needless to say, opportunities to achieve energy reductions in those situations are usually excellent.



Multiple parallel pumps with the same number of pumps always operating.

Multiple pumps are used in parallel to provide redundancy and/or to provide flexibility in responding to changing load conditions. If two pumps are installed for redundancy, but both normally operate, there is a strong likelihood that the pumps were not well-sized or that they have degraded. Alternatively, if multiple pumps were installed to provide flexibility in operations, but the same number always run, it is worth asking whether the expected variability in demand really doesn't exist, or if the number of pumps needed for the maximum load condition are continuously run as a matter of course.

Continuous pump operation in a batch environment. Pumps that run continuously when the fundamental nature of the system requirement is of a batch nature may simply be left running even when they aren't needed. One example of this would be a pump that runs 24 hours a day even though the load that requires the pump is only present during one or two shifts.

Frequent cycling of pumps in a continuous process. Some pumps cycle on and off, typically to maintain level or inventory. If pumps in such service cycle frequently so that they only run a relatively small amount (for example 40% of the time), there are likely to be energy and demand cost savings opportunities, not to mention the likelihood of improving pump, motor, and motor starter life.

As pumps depart from their design or best efficiency point, both static and dynamic loads associated with unstable flow conditions increase. Reduced seal, wear ring, or bearing life can be a result. While other factors, such as poor alignment, a generally harsh environment, or mechanical imbalance can also affect these elements, at least an increased likelihood exists that off-design operation is a factor.

Systems that have undergone a change in function or demand. Although this is not a symptom, per se, it is always useful to consider the history behind the system. In cases where system requirements increase with time, pumps are normally upsized to meet the growing demand. On the other hand, if requirements drop, the pump that was presumably properly sized will now be oversized.

The existence of one or more of the symptoms outlined above suggest that a system is more likely to have savings opportunities than one with none of the symptoms. However, systems with none of these symptoms can still be sick. I have run across systems with savings potential of 40% or more even when none of these symptoms was present. But since all of us have a finite amount of time, and hopefully our time is worth something to someone, it is incumbent upon us to use it wisely. I've personally found the symptom-based prescreening to be very helpful, and hope you might find it beneficial as well.

Diagnosis and Prescription

When the symptoms of health problems or energy opportunities appear to warrant it, measurements and analyses are often performed to establish the magnitude of the problem. If the magnitude is significant enough, the evaluation of possible treatments may be pursued.

But it is important to recognize that there is no panacea in either the human or the energy system domains. The best treatment for an ailment in humans may depend on multiple factors such as age, other health problems, and our ability to pay the costs.



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Likewise, external factors such as the electric rate structure, implementation costs of alternatives, current and anticipated company financial health must be considered.

So how do we quantify the potential savings opportunities in systems that appear to be worth exploring? And even more fundamentally, what do we do with all the systems that don't fit our prescreening criteria—either because they're small, don't operate a lot, or don't exhibit any of these symptoms?

We'll try to address those questions in future articles.

References

1. RCM—Gateway to a World Class Maintenance Program, Anthony M. (Mac) Smith, *Energy Matters*, January/February, 2000.
2. Performance Optimization Tips—The Vital Few, Don Casada, *Energy Matters*, September/October, 2000.