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Performance Optimization Tips: Understanding the Changing Needs of Your Systems

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Note: This article, focusing on understanding the changing picture of system operations, is the second of a series dealing with potential pitfalls in field measurements of motor systems. The first appeared in the November 1998 issue of Turning Point.

Wherever you're reading this, take a look at the electrically-operated equipment around you. How many of those devices are currently operating? How many are constant loads? Here in my home office, I see a clock, portable heater, desoldering iron, oscilloscope, test loop pump, the computer on which these words are being composed, and probably 20 other devices, including the lights that let me see all this stuff. Some are presently energized and run about 99.9% of the time (the clock); others aren't, and operate less than 0.1% of the time (the desoldering iron). Although the patterns are certainly different than residential, industrial systems likewise see varying loads.

A cornerstone of any process or system optimization effort involves developing a thorough understanding of how demand varies with time and creating a system that can respond both efficiently and effectively. We wouldn't expect grocery stores to set cash register clerk schedules based on the checkout queue at 7 a.m. on Sunday (although experience at times suggests that could be the case). Likewise, a single snapshot in time of an energy consuming system usually won't suffice in optimizing its operation.

Figure 1 is an example of a load profile for a pumping system. Although the flow requirements vary by more than a factor of five, it can readily be seen that nearly 90% of the time, the flow requirements are between 0.5 to 1.5 thousand gpm. Clearly, any energy optimization process would primarily consider this load range. The information conveyed in Fig. 1 can be arranged in any number of fashions; the key point is to clearly reveal the distribution of load conditions.

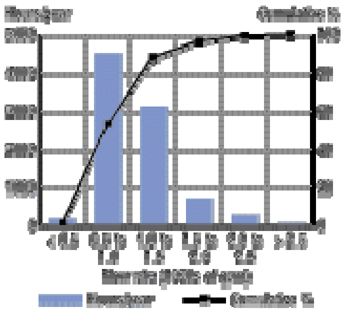

Figure 1. Annual flow rate requirements distribution.

How does one develop such a profile? A permanent monitoring and logging program could provide the requisite data, and may be both feasible and desirable for large (hundreds of hp) systems, but it is often not practical for small and intermediate size systems. Are there alternative methods that can be used to establish a reasonably accurate profile for small and intermediate size systems without the expense and complication of a comprehensive monitoring and automated data logging program? The answer, in many cases, is yes. Let's use a chilled water system (Fig. 2) to illustrate. Assume that our present focus is on the tower water pumping portion of the system (which removes heat from the chillers), and that there is no existing electronic data logging for the system.

A good first step in any situation is to apply a little common sense (an increasingly less common commodity), and consider whether the processes supported by the system are, in fact, likely to change with time[1]. In this case, it is reasonable to expect that the loads on the chilled water system would vary significantly with the time of year and to a lesser extent, the time of day and week; therefore, variation in tower water pump operation would be expected. To understand pump operational efficiencies, the numbers of pumps running, flow rate, head, and motor input power across the course of the year are needed. Existing pressure and flow instrumentation, supplemented by motor power or current monitors could be used in conjunction with a temporarily installed electronic data logging system to accumulate data over the course of several months. Should we set up the system and let it start acquiring data for us? Maybe, but consider some alternative courses of action first:

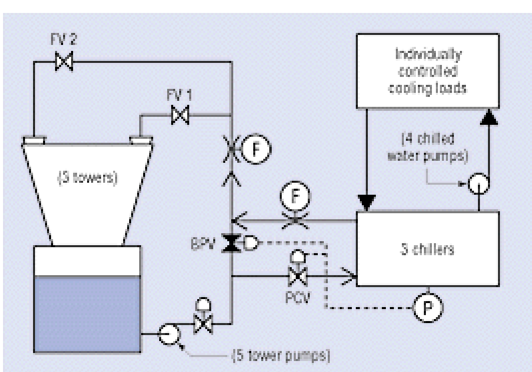

Figure 2. Chilled water system with heat rejected to a tower water system.

1. Interview operators. Or more precisely, shoot the bull with them. Get to know what drives them and makes their life difficult. Most operators are quite willing to share their opinions about the "idiot that designed this system," and what they have to do to make it work. Let operators know why you're asking, and make it clear that you're looking to them for advice. If you can help address their problems in conjunction with any energy-saving action, your chance for success will be greatly improved.

Any energy reduction action that makes life more difficult for operators may very well, over the long haul, result in greater energy consumption, since the operator's principal focus is to keep things running; and energy costs are usually well down on the priority list. On the other hand, any action that makes their life easier will encourage a relationship that can help in identifying other energy-saving opportunities.

Operators can help develop estimates that, although less precise than logs, can often provide a fairly accurate picture of operational patterns. More importantly, operator "interviews" can shed a great deal of light on reasons for the existing conditions that careful data logging would entirely miss. For example, an operator might note that up until a couple of years ago, one pump in winter and two pumps in summer worked fine in removing heat from Chiller A. But recently, three pumps have been required during the summertime, and even with the additional pump running, chiller condenser pressure is 2 psig greater in the summer than it was previously. Information such as this should immediately raise a flag and spur questions about what has caused the degradation. Any number of factors could be involved, such as a malfunctioning bypass valve or condenser pressure control, pump degradation, or scale buildup on the condenser heat exchanger tubes, any of which is deleterious to energy-efficient operation.

On the other hand, if the operator states that the same number of pumps are run year-round, a different flag should be raised, since our common sense suggests that load variation would be expected to result in variation in supporting pump operation.

2. Find and review manual operator logs, if available. If logs don't include all the desired information, request that the operator logs be supplemented to include the missing parameters. This can be valuable in two senses-the needed data will be acquired and it will give you and the operators a chance to discuss why the information is important to system optimization.

3. Develop a separate manual log maintained by non-operations personnel on an energy reduction team[2]. An advantage to this is that it provides a mechanism to ensure that desk jockeys get out into the field. In many instances, simply being around operating equipment and the folks who operate it will help flag problem areas that are independent of the data being logged.

4. If initial review and discussions indicate that relatively narrow regions dominate the load profile (as in Fig. 1), concentrate more refined data collection efforts on those regions. It may be possible to get comprehensive, accurate data that represents 80-90% of the load duration with only two or three sets of test data instead of a much more massive accumulation via manual or electronic logs.

Things change. The establishment of a load vs. time profile is a critical part of the optimization effort. It is sometimes a tedious job, but it can often be simplified. Accurate data are, of course, important. But communications, particularly with operations staff, can significantly reduce the detailed monitoring effort needed to develop at least an approximate system profile. Equally importantly, these discussions can reveal opportunities that would have never been recognized with a more precise, objective, but silent electronic data log.

Comments/questions welcome by e-mail: a85@ornl.gov.

[1] Generally speaking, the proper sequence for optimizing any system is to start at the end goal of the system and work backwards. In this case, the tower water pumps should only be considered after addressing the loads, the chilled water, and the chillers.

[2] It should be clear from this article that the author believes that any energy reduction effort should include a strong operations presence, so it is not suggested that operators can be bypassed in the data collection process. Rather, this recommendation is based on the observation that engineer's computers produce much better results when the fingers pressing the keyboard and moving the mouse have dirt, grease, and burn marks on them.