Energy efficiency

Refurbishment is vital to efficiency

Efficiency testing is key towards lowering pump energy consumption, improving operational performance, and further significant benefits. In this article we report on a large-scale water pump testing programme which supports the case for routine testing and pump refurbishment.

The in situ operation of pumps is affected by a variety of factors and to varying degrees depending on the unique circumstances of each pump and its installation. It is both reasonable and intuitive to expect that a pump’s hydraulic performance and energy efficiency characteristics will degrade over time. Given the importance of pumps in the service they deliver, as well as the current and anticipated future cost of electricity, it is also reasonable that these characteristics should be observed so as to identify trends and opportunities for improvement to restore performance levels.

There are two generally accepted methods for conducting pump tests: (i) the conventional method; and (ii) the thermodynamic method. Both methods require direct power and pressure measurements. The conventional method relies upon flow measurements in order to indirectly calculate efficiency. The thermodynamic method relies on accurate temperature measurements of the pumped fluid immediately upstream and downstream of the pump in order to directly calculate efficiency (via thermal losses and the properties of the fluid). Both methods have been successfully applied and, depending on the specific field installations of pumps and associated piping works, the conditions may favour either, both, or possibly neither, of the methods.

Field installations are typically unique and often challenging to test, particularly in relation to factory conditions. The availability of exposed piping, the piping configuration itself, differences between actual demand/system conditions and predicted demands used for initial design purposes, amongst other matters, contribute to these challenges. Commissioning performance testing of pumps, while conducted, is generally not a typical standard practice in the North American water and wastewater industry. The result is that utilities assume that the installed pumps perform exactly as their factory tests suggest, both initially as well as over often long periods of time once in operation. Accordingly, any deficiencies in the piping and appurtenances upstream and downstream of the pump may not be discovered and may be erroneously ascribed to the pump well after installation.

A typical case in point is where the piping immediately upstream of the pump results in low pressures causing cavitation which, in turn, damages the pump’s components...
and negatively alters its performance. In this example, the cause is the suction piping characteristics, although it may erroneously cast a negative light on the pump itself. Commissioning testing can be used to prove the pump’s performance and identify any problems in the system in which the pump is connected that may give rise to concerns.

In 2011 and 2012, over 150 water pumps were tested across Ontario, Canada’s most populous province. The pumps’ motors ranged in size from 30hp to 4,000hp, and the pumps ranged in age from one year to 61 years old. The different testing methods were employed in the following proportion: (i) thermodynamic method only – 90%; (ii) conventional method only – 10%; both methods – 8%. Some of the results of the testing programme include:

- Average pump efficiency: 73.7%
- Average water-to-water efficiency: 69.4%
- Average efficiency loss at Best Efficiency Point (BEP): 9.3%

These efficiencies are considerably lower than what pumps are typically able to operate at when new. In addition to the loss in efficiency between the originally manufactured BEP and that tested (9.3%, as noted above), there is often further inefficiency due to where the pump is operated on its curve. Accounting for operational inefficiencies, the loss of 9.3% increases significantly to an overall efficiency gap of 12.7% based on the pumps tested.

This information, in and of itself, can be quite useful in developing business cases in support of refurbishment or other improvements to the pump and/or the operating protocols controlling it. Still, an estimate of the potential efficiency recovery from refurbishment or some other intervention is needed to strengthen the case. As part of the testing programme, two pumps that had been in operation for 34 years each were tested before and after a refurbishment exercise. The results showed that 65% and 71% of the efficiency lost from original manufacture was recovered through the refurbishment. While these results are insufficient from a statistical perspective to be extrapolated in a general sense, they do provide an indication of the potential that refurbishment can offer.

The testing results were used in conjunction with an economic model to provide utilities with guidance on testing frequency (see Figure above). While this guideline is specific to the Canadian context in terms of electricity pricing and typical water distribution system characteristics, it does provide some useful insight of a generalized nature. For instance, the value of pump testing and refurbishment increases with the pump’s output for which the motor size (hp or kW) can be used as a suitable proxy and also with the pump’s utilisation, both of which are intuitive. Larger pumps that are used more often will offer higher potential savings as efficiency degradation occurs, on average. Accordingly, it is more valuable to test such pumps more frequently for purposes of early detection of efficiency concerns and to observe performance trends.

In fact, a case can be made for the continuous monitoring of those pumps which fall in the indicated region of the testing frequency guideline presented in the Figure left. Fixed monitoring units can be implemented for permanent or quasi-permanent installations for continuous monitoring, with or without real-time data transmission. In addition to the large pumps, an argument can be made for using such fixed units for any pumps which are considered critical from an operational perspective. The testing frequency guideline considers electricity pricing alone, but important additional considerations include the value of providing continuous, reliable service, preventative maintenance practices, or damages resulting from failures in service delivery, as examples.

Water systems are complex and pumping is often central to the functioning of these systems. The hydraulic performance and energy efficiency of pumps are therefore important to providing the service demanded from them in a financially and environmentally responsible manner. Routine testing, the frequency of which can be prioritised based on pump energy consumption and importance to system operation, is a key component to making intelligent decisions regarding interventions to improve pump behaviour, as well as informing asset and operational management practices. The financial and other benefits of such testing and any improvements often outweigh their costs by quite some margin; the opportunities for positive return on investment can be guided by the testing frequency guideline shown above and other findings from the testing programme conducted in Ontario, Canada. Moreover, the testing results can be extended well beyond the pumps themselves and are useful for hydraulic and energy optimisations that often yield significantly larger savings or improvement potential through consideration of the larger system in which the individual pumps operate.

Additional information is available at the contact details below.

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