Canada takes a lead in benchmarking pump energy efficiency

A large-scale pump performance testing programme looking at over 150 pumps in Canada covered energy efficiency as well as the accuracy of both thermodynamic and conventional pump testing methods. **FABIAN PAPA** and **DJORDJE RADULJ** summarise the main findings from the programme with regards to improving pump efficiency and the potential for benchmarking.

In May 2013, the results of a large-scale pump performance and energy efficiency testing programme conducted in Canada were released. This programme involved testing of more than 150 water pumps across eight utilities in Ontario, Canada's most populous province, for the purposes of characterizing the actual in situ performance of these devices in order to help drive awareness and motivate energy conservation initiatives. The result is a well-documented reference that can be used by practitioners worldwide for comparative purposes, such as benchmarking, as well as to help improve general practices in this field.

Motivation

The linkages between water and energy are gaining increasing attention globally and, as both financial pressures and concerns over energy security increase, so does the need to thoroughly assess the use of energy and the cost associated with it. With this context in mind, the Ontario Power Authority (OPA), through its Conservation Fund, provided the primary financial support of the above-mentioned programme. OPA is an independent, government-owned corporation responsible for, among other things, assessment of the long-term adequacy of electrical resources in the province, forecasting future demand and the potential for conservation. This financial support encouraged the participation of several water utilities in a display of mutually beneficial cross-sectoral collaboration, the results of which are having long-lasting transformative effects on the province's water sector in addition to spillover benefits beyond the boundaries of the participating utilities and the province.

Traditional practices

Although it is both intuitive and understood that pumps deteriorate with time and usage, their performance is generally not measured or monitored. Operation and maintenance practices are often based on rules-of-thumb and qualitative field observations. Hydraulic models are frequently used to design new pumping systems, assess the operation of existing water systems, develop energy optimization strategies, etc. However, such models generally use original manufacturer specifications for hydraulic performance and energy consumption of pumps without proper consideration of their actual behaviour. As a result, many decisions are made without complete or accurate information and, accordingly, such decisions would be expected to be inferior to those that would be made with the best attainable information in hand.

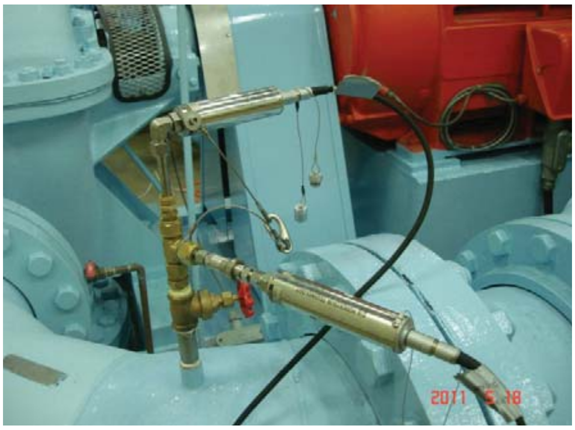
This testing programme goes a long way towards lifting the veil of uncertainty surrounding the actual performance of water pumps as they operate in our current systems, and allows for the assessment of benefits and costs so that financially sound business cases can be made in relation to pump maintenance, including rehabilitation and / or replacement, as well as pump operation. The technologies available for accurate and reliable testing exist and are affordable to implement. However, the real benefits are derived from the information obtained and the savings that can often be realized.

The programme

Over the course of 2011 and 2012, field tests of more than 150 pumps were conducted, using either or both of the thermodynamic and conventional pump testing methods. While both methods are capable of producing reliable results when favourable site conditions permit, it was found that the thermodynamic method – which determines a pump's efficiency by measuring the unproductive thermal energy gain in the pumped fluid (water) – is generally more applicable, accurate and reliable than the conventional method when it comes to most field tests. The thermodynamic method involves the insertion of temperature probes and pressure gauges on both the upstream and downstream sides of the pump (Figure 1), as well as the measurement of power input to the pump's motor.

The pumps ranged in age from less than one year old to 61 years old, and their motor sizes ranged from 22kW (30 hp) to 3000kW (4000 hp). Approximately 15% of all pumps tested were controlled using variable frequency drives (VFDs). As part of the

Figure 1: The thermodynamic testing method



programme, training workshops were held with each of the participating utilities to discuss the technology, the testing methods and the findings, which in addition to providing technical results also implemented financial assessments to demonstrate the potential savings for each of the pumps.

The results

Any given pump has a point of operation where its energy efficiency is highest, known as its best efficiency point (BEP), and the efficiency falls away from this peak as flow either increases or decreases away from this point. There are two general ways in which a pump can lose efficiency: largely physical reasons associated with wear and tear, corrosion, fluid turbulence or cavitation, etc.; and for reasons of sub-optimal operation, where the pump operates away from its BEP. For purposes of this programme, the following definitions were applied and results obtained.

Efficiency loss

Efficiency loss is the difference between the manufacturer's BEP and the tested BEP. This is a measure of how the pump's efficiency has deteriorated since its original manufacture. Any degradation using this measure can typically be recovered, at least partially, through pump refurbishment. The average efficiency loss for all the pumps tested was 9.3%.

Overall efficiency gap

The overall efficiency gap is the difference between the manufacturer's BEP and the efficiency at the current typical operating point of the pump. In addition to the efficiency loss, this measure also includes any inefficiency associated with the operation of the pump outside of its peak range. This measure provides an indication of the degree to which both pump refurbishment (as above) as well as improved operational strategies may improve overall pump efficiency. The average overall efficiency gap for all the pumps tested was 12.7%.

The average efficiency for all the pumps tested was found to be 73.7% (not including any inefficiencies imposed by pump motors or drives), compared with the average taken from the manufacturers' specifications at the pumps' BEPs, which was 86.4%. This is a sizable departure, however, what is perhaps more interesting is that the average wire-to-water efficiency (which includes motor and drive efficiencies) for all the pumps tested was 69.4%, meaning that more than 30% of the electrical energy input to

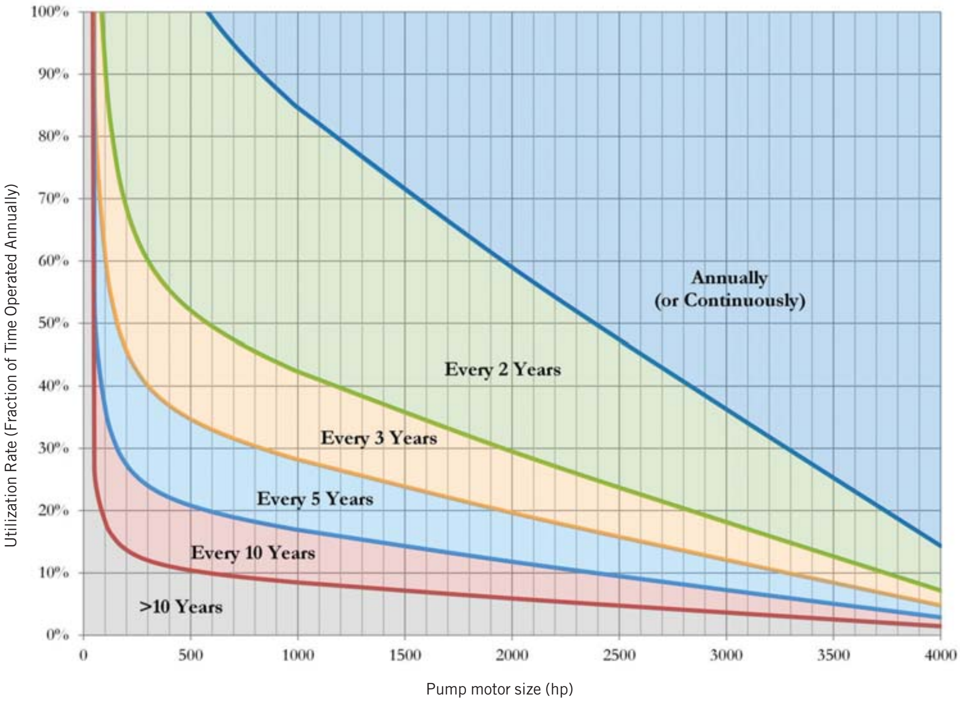


Figure 2: Graphical testing frequency guideline

the pumping units was essentially lost or wasted.

These results provide a rather clear indication that there is opportunity for improvement and that industry practices ought to consider actual pump efficiencies in a serious manner. In fact, refurbishments conducted on two pumps during the programme resulted in the recovery of 65% and 71% of their respective efficiency losses.

Benchmarking

One of the most important contributions of this programme is the benchmarking information that the more than 150 tested pumps provides. Both the newly developed Pump Energy Indicator (PEI) and the IWA Standardised Energy Consumption Performance Indicator (Ph5) were shown to be superior to any other metric or performance indicator available in the industry. These two metrics are quite similar and relate energy consumption to both the flow and the head produced by the pump. The subtle difference between these metrics is that the PEI is an instantaneous measure while Ph5 is a long-term average (typically one year).

The averages of these performance indicators for the pumps tested were found to be: PEI – 3980 kWh/Mm^3/m water; and Ph5 – 0.398 kWh/m^3/100m water (assuming direct extrapolation to an annual basis). It is noted that these results are 18.8% higher than the original manufacturer's specifications, more accurately reflecting the gap in current versus potential performance levels.

Testing frequency

The programme developed several financial models to support decisions regarding potential interventions such as pump refurbishments or modifications to operating practices. One of the more useful outcomes of such modelling was the development of a graphical testing frequency guideline (see Figure 2), which relates the financial importance of pumps to their (motor) size and utilization rate. This particular guideline as shown is based on cost assumptions that are relevant to the Canadian context and may not be directly applicable elsewhere. However, the concept remains and the graph can be adjusted for different geographies as well as over time as conditions change within each.

Closing thoughts

Pumping is central to water supply, transmission, and distribution systems, and often represents one of the largest cost items for a utility. Measuring and monitoring the energy efficiency of pumps during their productive life can yield many positive results, financial and otherwise, and thereby achieve multiple goals of financial and environmental sustainability. ●

For more information on this pump performance and energy efficiency testing program, or to request a copy of the final report, visit: www.hydratek.com/opa

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