Installing, Operating and Assessing Nursery Pumping Systems

Paying attention to the correct installation, operation and maintenance of a new pumping system will pay dividends in having an efficient system with a long service life. The following outlines some of the factors that should be considered when installing, operating, assessing and improving pumping systems.

Installation:

Site the pump as close as possible to the water*, as this reduces the potential for cavitation, minimises friction losses, and reduces energy use.*

Make sure the suction and delivery pipes do not put a strain on the pump casing. *Any strain on the pump may lead to damage and premature pump failure.*

Check that all pipe connections are tight*. This reduces the potential for air to enter the system on the suction side of the pump, and consequently reduce pumping efficiency. Tight pipe connections on the delivery side of the pump minimise pressure and volume losses and reduce the possibility of pipes disconnecting.*

Use a foot valve recommended by the pump manufacturer. *Incorrectly sized foot valves may cause cavitation, restrict flow rates and reduce system efficiency.*

Anchor the pump securely *so that it does not move during operation. Any movement can place strain on the casing and fittings, and could lead to premature pump failure.*

Provide adequate ventilation for the drive unit. *This reduces the potential for the motor to overheat and therefore reduce motor efficiency, or cause motor damage. Keeping Variable Frequency Drives (VFD) well ventilated and cool extends their working life.*

Install loss of prime cut-offs *to prevent the pump operating if there is loss of prime, or flow rates exceed the maximum allowable limits of the pump, e.g., a burst main line.*

Install suction pipes so air cannot build up in them*, and so air can be forced out during priming. Air retained in suction pipes leads to hard to prime systems, reduced suction capacity and increased cavitation.*

Ensure that equipment manuals are obtained when the equipment is installed *as these contain valuable information on pump specifications and maintenance requirements. Lack of information on the initial design of the system and subsequent monitoring makes it difficult to monitor and maintain the irrigation system.*

Define the pumping system

- *Determine current and future energy costs.*
- *Pump and motor specification plate data.*
- *Document operating times.*
- *Measure pump inlet and outlet pressures.*
- *Determine the maximum values and variability in flow rates and pressures.*
- *Obtain pump curves to assess pumping system design and operating points.*

Operation:

Work the pump within its limits*. Operating a pump at its Best Efficiency Point (BEP) maximises efficiency and minimises energy use, repair and maintenance costs.*

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Keep the pump and motor connection aligned. *Misalignment can cause vibration and accelerate wear of pump components.*

Ensure the pump is well primed. *Lack of priming leads to overheating of the pump and can potentially destroy it.*

Keep the foot valve free of debris *to minimise cavitation and maximise flow rates and system efficiency.*

Do not pump corrosive liquids*, as this can reduce the life of the pump through premature wear.*

Make sure the pump discharge valve is open when operating the pump. *If the valve is closed, recirculation within centrifugal pumps will occur, causing cavitation and overheating of the pump. In positive displacement pumps, equipment failure may occur very quickly if the discharge valve is closed.*

Do not operate the pump if it is vibrating excessively*, as this may lead to pump failure due to damage to the pump itself, or failure of other components.*

Maintenance:

Have a regular maintenance programme in place. *Pumping systems are not set and forget. Regularly check the system for leaks and abnormal operation. Check air tank pressures, pipe work condition, control systems, mechanical seals and ampere draw of the pump motor.*

Monitoring pumping performance against specifications should also be done regularly. Noting maintenance history and issues may identify pumps with high maintenance requirements, pumping systems prone to cavitation, wear in pumps, improper packing adjustment causing binding on the pump shaft, and noisy control valves from excessive throttling. This information will be invaluable for troubleshooting.

Assessment:

To minimise energy costs and maximise pump life, it is necessary to know how efficiently a pump is operating. Physical symptoms that may indicate a pump is performing well outside its BEP are:

- *Noisy operation.*
- *Frequent replacement of bearings and components.*
- *Damage to impellers caused by cavitation.*
- *Excessive power consumption.*

Oversized pumps result in higher energy costs and require more frequent maintenance. Oversized pumps can be identified as they:

- *Must be throttled to achieve system requirements. Any restriction in flow results in the energy used to pressurise the water being lost without having produced any useful work.*
- *Have a high bypass flow rate.*
- *Have flow rates that vary more than 10-20% from the pumps BEP flow rate.*
- *Have excessive flow noise.*
- *Need frequent replacement of bearings and seals.*
- *Show intermittent operation, i.e., pump cycling.*

A pump without the above symptoms or consistent performance may still not be operating at its BEP.

A simple method of monitoring pump performance is to regularly measure and record flow rate, operating pressure and energy consumption. This information can be used to calculate pump efficiency, energy consumption per megalitre, and identify changes in the performance of the system over time. Measuring the current draw of motors may also give early warning of motor failure.

Determine the flow rate at the BEP. *Most pump manufacturers have pump curves for their pumps, and these can be downloaded from their websites. The optimum flow rate and pressure can be established from the manufacturer's pump curves, and then compared with the measured flow rate and operating pressure of the pump (see "Reading a pump curve"). The illustration shows an example* *of one type of pump curve, but the steps involved in reading other pump curves and determining pump efficiency are the same:*

1. *Determine the operating pressure that corresponds to the BEP flow rate.*
2. *Compare the pump curve values with the flow rate and pressure measured while the pump is operating.*

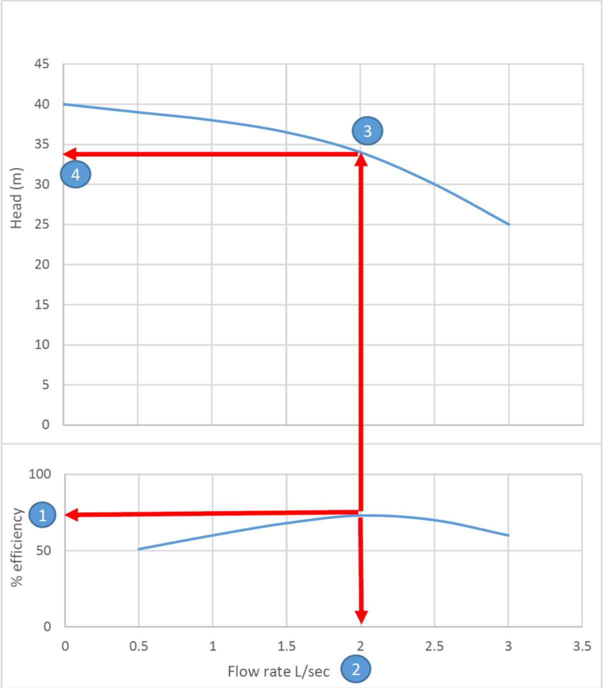
Reading a pump curve

Find the maximum efficiency on the bottom curve. Sometimes the efficiency curve may be displayed as contour lines on the top graph for pumps with multiple impeller options. The BEP will usually be approximately 2/3 of the way across from the left hand side on the pump curve.

Read the flow rate at which the maximum efficiency occurs.

On the top graph identify the point at which the flow rate identified in the bottom graph intersects the flow/pressure curve.

Read across to the left axis to find the head (pressure) the pump will operate at when pumping the given flow rate. Measure the flow rate and operating pressure of the pump during operation and plot these points on the pump curve to compare the result.



If testing finds problems identify components of the system that contribute to the inefficiencies.

The following are possible causes of pumps operating outside their BEP:

- *Undersized or oversized pumps.*
- *Throttling valves and other flow restrictions.*
- *Large flow rate and pressure variations.*
- *Low flow rate and high pressure situations.*
- *Bypass flows.*
- *Blocked foot valve strainers.*
- *Undersized foot valve strainers restricting flow.*
- *Blockages in the suction line.*
- *Air pockets or air leaks in the suction line.*
- *Suction lift being too high, e.g., as the water level in the dam decreases the suction lift increases.*
- *Incomplete priming of the pump.*
- *Reduced discharge pressure caused by an undersized impeller.*
- *Blockages of the impeller from inadequate straining of the suction.*
- *Damage to the impeller caused through cavitation, abrasive sand or normal wear.*
- *Air leaking into the pump casing.*
- *Incorrect pump speed.*
- *The pump not rotating in the right direction – can occur if the motor is not correctly re-connected after repairs.*
- *Mechanical defects.*
- *Discharge head too high. At high pressures and low flow rates more cavitation can occur and reduce pump efficiency.*
- *Blockages within the delivery system.*
- *Leaks within the delivery system.*
- *Changes to the system, such as adding extra sprinklers to an irrigation layout, without taking into account the extra volume of water and pressure required, and how this will affect pump performance.*

Much of the above analysis requires the services of an irrigation specialist.

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While a pump may be operating at its BEP there are management options that can be applied to reduce overall energy use of the system by reducing system demand, such as:

- *Reducing water consumption through irrigation scheduling changes and run times.*
- *Reducing leaks.*
- *Lowering pumping system flow rate and or operating pressure. Note that this option needs to be considered carefully if this results in the pump operating outside its BEP .*

Improving pumping system efficiency:

Impeller trimming. *An impeller may only need to be replaced or trimmed rather than replacing the pump. Trimming is limited to about 75% of the pump's maximum impeller diameter. Excessive trimming can result in a mismatch between the impeller and casing, leading to greater flow recirculation within the pump and reduced pumping efficiency.*

Pump wear *can cause reductions in efficiency of 10-12.5%. Most wear occurs in the first few years, until clearances within the pump match the abrading particles. Symptoms include cavitation, increased clearances between fixed and moving parts, wear in rings and bearings and packing adjustment on the pump shaft. When a pump wears, the BEP moves to the left on the pump curve.*

Review flow rate controls:

- *Bypass lines are the least energy efficient but avoid deadheading (pump operating with no flow).*
- *Throttle valves control flow by increasing upstream backpressure, which reduces pump flow and dissipates fluid energy.*
- *Multiple pumps can provide more flexibility in the flow rates delivered. When compared to a single pump this gives greater operational flexibility, the system is still able to function if a single pump fails, there are lower maintenance requirements, and the system will have a higher efficiency. Another alternative is to have a single smaller pump to operate at low flow rates and large pumps to provide maximum design flow.*
- *VFDs are more efficient than bypass and throttle valves, less efficient than fixed speed pumps, but are more efficient than fixed speed pumps when a range of flow rates are required, but with a resultant reduction in motor life expectancy.*

Optimisation of piping *is best done during initial design as it is difficult to fix once installed. Minimise pressure drops by avoiding sharp bends and sudden changes in pipe size, and keeping piping as straight as possible. Use low loss valves and fittings. Pipe selection is a compromise between initial cost of the pipe and the cost of pumping fluid through it, i.e., larger pipes are more expensive, but pumping costs are reduced due to lower friction losses.*

Review the drive unit. *Oversized motors may be specified to enable an increase pumping capacity in the future, where there are load fluctuations, where there are voltage imbalances, and where a motor of the exact size required is not available. Some motors have been developed that can accommodate short term overloads and prevent the need to oversize.*

Installing high efficiency motors *can provide:*

- *Significant savings in energy costs.*
- *Reduced breakdowns due to improved design and construction.*
- *Reduced sensitivity of power factor and efficiency to voltage and load fluctuations.*

Changes need to be prioritised *according to the degree of energy efficiencies likely to be realised. The following is a guide as to the range of energy savings that can be achieved from specific system changes:*

- *Replacing throttling valves with variable frequency drives - 10-60%.*
- *Reducing pump speed with a fixed load - 5-40%.*
- *Installing multiple pump systems for highly variable loads - 10-30%.*
- *Replacing motors with high efficiency motors - 1-3%.*
- *Replacing pumps with more efficient models - 1 -2%.*

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