Nursery & Garden Industry Queensland

Designing Nursery Pumping Systems

Nursery irrigation practices are energy intensive, requiring significant volumes of water to be pumped to meet crop water use demands. Careful, well informed equipment selection, guided by irrigation professionals, coupled with a scheduled maintenance program and intelligent water management techniques, can help growers gain significant irrigation system efficiencies and minimise energy costs.

Poor pump selection and installation may lead to poor performance, high energy costs, premature pump performance decline and mechanical seal failure. Poor pump selection can be the result of a number of factors, including; poor advice from inexperienced pump sales personnel, insufficient or incorrect data provided to the pump supplier, changes or expansion in requirements outside the original specification, and haste in replacing a failed pump.

If a pumping system is being designed for a new development, it is critical that the system be carefully designed to ensure it meets the required capacity, while being the most efficient system possible.

Replacing a failed pump is the ideal opportunity to improve the pumping system, but some preparation and system analysis is required well in advance to minimise the down time of the system.

In many nurseries, the irrigation system requirements (the system duty) is likely to have changed over time with changes to growing areas and infrastructure. Because of this, the option of designing a new system should always be investigated. It may be, that over time, this will result in greater cost savings than simply upgrading an existing system.

When designing or upgrading a system, each situation has to be assessed on its merits, and a whole of system approach should be used, considering the following points:

Minimise pumping demand by:

- *Reducing pumping requirements through system design and use.*
- *Minimising pipe lengths between the pump and the delivery point.*
- *Reducing vertical and horizontal distances from the pump to the delivery point to minimise pressure losses.*

Assess and address pump suction requirements:

- *Minimise height of lift from the water surface and determine what high and low water levels are likely to be encountered.*
- *How flooded suction from tanks affects system performance.*

Reduce pumping system flow rates:

- *Minimise pumping through more efficient irrigation layouts.*
- *Review and minimise irrigation run times.*
- *Reduce or eliminate leaks.*

Lowering the operating pressure if possible:

- *Where possible, reduce operating pressures by emitter selection and system testing to identify optimum operating pressures.*

Choose efficient pumping components:

- *Maximise pipe diameters, and design pipe layouts to minimise pressure loss without excessive capital expenditure. Correctly designed piping systems also provide benefits in reduced maintenance.*
- *Minimise the number of fittings and bends to minimise pressure losses.*
- *Use long radius bends.*

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- *Minimise the number of, and correctly size, valves and fittings.*
- *Consider variable-speed drives for flow management, rather than throttling valves or flow bypass.*

Once the pumping demand has been minimised the following criteria can then be assessed:

***System design capacity** is a critical part of selecting the correct pump for the situation, with calculating the maximum amount of flow required to achieve irrigation in the required time frame being the first step. **The flow rates and pressures required at the emitter** are established, and then head (pressure) losses due to friction in the system calculated. This information is obtained from a hydraulic analysis on the system. A full hydraulic analysis can also show areas of the system that are not performing to their maximum efficiency, and suggest changes that may help to reduce operating costs, e.g., altering pipe sizes. Always use the worst-case scenario in calculating pumping requirements.*

***The operational range of flow and pressure requirements**, i.e., the greatest and least flows and system pressures (duty points) required for different irrigation zones. In nursery situations, pumps may need to cover a range of duty points due to variations in pressure and flow requirements for different irrigation zones. The duration of operation at each duty point should also be considered in deciding if a particular pump is the most efficient for the system.*

***Flow requirements for other systems** such as filter system backwash, washdown, and hand-held hosing that may be required to operate during and between irrigation cycles.*

***Suction conditions.** Pumps have a limit of suction lift which, if exceeded, results in cavitation, reduction in operating efficiency and damage to the pump. It should also be noted, that as the height of the pump above the water level increases, the efficiency of the pump also decreases, resulting in decreased flow and pressure.*

Cavitation occurs when the pressure drop that results when water enters a pump falls too low, causing some of the water to vaporize and form bubbles in the liquid, similar to that seen in boiling water. These bubbles collapse violently as they move to areas of higher pressure, and this collapse creates the noise, vibration and damage associated with cavitation.

***What is the available operating window and how often does the system need to be operated?** Identify the hours of operation, whether the system needs continuous or intermittent operation, the number of starts, data recording requirements, and remote access and control. In particular, where irrigation is used for frost protection, the pump must have the capacity to deliver the necessary amount of water in the required time.*

***Physical constraints** such as is a bore hole pump required, and what size is the casing?*

***Pump protection**. Does an electric motor need waterproofing? Does the pump need to be protected from flood water, or designed to be relocated in the case of flood?*

***Reliability required.** In most nursery situations pumps must be highly reliable. This may mean a multiple pump system being installed so the system can still perform at a reduced capacity if one pump fails.*

***Metering and recording systems** to measure and record flows, pressures and energy consumption.*

***The water source and quality** will indicate the potential for corrosion and wear ,and if additional treatment and filtration are required. Poor water quality and particulate matter in the water can lead to increased wear if the pump is not designed to handle the water quality, or filtration is inadequate.*

***The amount and type of energy available**, e.g., single or three phase supply. In some situations, ready access to mains power is not available, or is prohibitively expensive. Other fuel sources such as diesel or solar must then be considered, and may reduce the range of suitable pumps.*

Energy costs *can contribute up to forty percent of the lifetime cost of a pumping system. To minimise running costs, an appropriate electricity tariff should be selected, which may in turn reduce the length of time the system can be run for in a 24-hour period, thus increasing the pump flow rate required. If other fuel sources are an option, the overall cost of these need to be compared before deciding on the best alternative. Always use the latest energy prices and tariffs in the calculation of operating costs.*

Capital cost, depreciation, running costs and interest charges. *The cost of, and installation of, a pump is approximately 10-20% of the lifetime cost of the pump. The selection of the right pump, while perhaps being initially more expensive, reduces the total cost of the irrigation system over time through energy savings.*

Consider how the pumping station is laid out *and optimise the design to minimise pressure and flow losses, and protect equipment from excessive heat and exposure to water and light. If there are multiple pumps in a pumping station, ensure they are not working against each other, and controls are set for the pumps to work as designed. Ensure the pumps have been sized correctly for the flow rates of the system, and if combinations of fixed and variable speed pumps are used, that they are properly configured.*

Installation: *Consider capital cost, operational costs, maintenance costs, size, stability, noise, energy source, access for installation and*

maintenance, parts, availability, service, backup, reliability, suction pipe configuration, and delivery piping options.

Variable frequency drive (VFD) controllers *are an efficient and reliable way of using the same pump for varying flows and heads, and still keep it as close as possible to the best efficiency point on the pump curve. This helps to increase irrigation efficiency and reduces electricity costs. When correctly installed, a VFD can reduce annual pump energy use by 30% to 50%, and up to 70%.*

Not all pumps or irrigation systems will benefit from the installation of a VFD controller. Each pump and irrigation system needs to be assessed to determine if a VFD controller is appropriate, and what type of VFD controller should be installed. In some cases, the pump may need to be upgraded before the benefits of a VFD will be achieved.

When considering a VFD controller the basic operating requirements of the system needs to be known, i.e., pump motor type and size (kW), operating RPM's, voltage (single or 3-phase), maximum amps, target operating pressure and flow rate, size of nursery and any change in elevation. All these factors influence the type and size of the VFD to install.

There are three scenarios where a VFD is appropriate and can save operating costs:

- *When a constant pressure/head is needed but flow rate is variable.*
- *When a constant flow rate is needed but pressure/head is variable.*
- *When both flow rate and pressure/head is variable.*

Some potential scenarios when a VFD may not provide acceptable cost savings are*:*

- *When both pressure/head and flow rate are constant.*
- *When an efficient multi-stage or multi-pump setup is currently in use, and meets all pumping requirements efficiently.*
- *Systems with a high static head, i.e., water being pumped to high elevations, or when*

pumps operate for extended periods at low flow conditions.

- *Small pumps (low kW) that only operate for short periods. VFDs should be considered when pumps operate for at least 2000 hours per year, and when flow rates vary by 30% or more.*
- *Retrofitting a single stage centrifugal pump.*

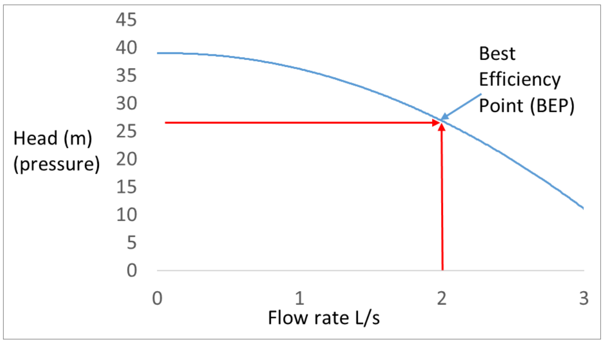
The financial viability of installing a VFD depends on the type of pump motor and operating hours. VFDs are most economical on large motors, and when used for long hours of operation.

Selecting the pump:
Due to their good performance, low cost, low maintenance and long operating life, centrifugal pumps are the most common pumps found in production nurseries and used to transfer water between storages, and for pressurising irrigation water

Centrifugal pumps are designed and built to impart energy into the water through centrifugal force to move the liquid, and increase its pressure by the use of one or more rotating impellers enclosed within a housing or casing. Centrifugal pumps convert energy from an electric or fuel powered drive motor, into impeller speed, and then into water velocity and pressure. Centrifugal pumps may be a single stage, having one flow and pressure generating stage (impeller), or multi-stage having a number of impellers in the one pump casing.

A multi-stage centrifugal pump will contain multiple impellers on a single shaft within the same pump casing, directing the discharge from one impeller to the intake of the next through each stage of the pump. Each individual stage of a multi-stage centrifugal pump imparts energy to the water to increase pressure, but does not significantly increase flow. A multi-stage centrifugal pump is generally more economical to operate than a single stage centrifugal pump when high pressures are required, and are ideally suited to pumping from storages that are located above the pump (flooded suction), such as an above ground storage tank.

Pump characteristic curves provide a graphical representation of the performance of a pump, and are used to select the most efficient pump for a given situation, i.e., the duty point the pump has to operate at. Select a pump that has the duty point as close as possible to the Best Efficiency Point (BEP). Pump manufacturers also have online software that can be used to assist in selecting the most efficient pump for a given situation.



Selecting a pump that is oversized rather than matched to the system requirements may cause it to operate at 'part load' for extended periods, causing reduced efficiency, an increase in noise, vibration and wear, and possible cavitation damage. High efficiency pumps and motors should be selected, and attention paid to correct impeller sizing.

***Put a maintenance schedule in place** and select a service provider who understands energy efficiency and helps with solutions.*

***Go over the design again**; Improve the design and do not assume the first attempt at designing the system is the most efficient outcome. Review the trade-offs; and see if further improvements can be made. Some efficiency options may have a quicker payback than others.*

Additional information can be found in technical articles on VFD and cavitation on the NGIQ technical webpage.

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