Optimizing pump and fan applications

Pump and fan applications account for around 38 per cent of the end uses of motive power in industry.

In pump and fan applications, the power consumed is proportional to the operating speed cubed. Efficiencies of pumps and fans vary greatly and depend on operational requirements. Fine-tuning the system can have a big impact on energy consumption. You should keep in mind that although your pump (or fan) and your system are two separate entities, they are totally dependent on each other. Changing one will have a significant impact on the performance of the other.

The key areas where fluid energy is most commonly wasted are:

- excess head (pressure) that must be throttled
- more flow than necessary to accomplish the purpose of the system
- unnecessary flow paths
- excessive frictional losses.

You can also contact your suppliers and manufacturers of pumps, fans and control equipment such as variable speed drives, to find out what additional support they can offer.

Assessment framework

When improving the efficiency of centrifugal pump and fan systems, it is important that the savings justify the expense and effort. The four-step assessment framework outlined below will help you identify cost-effective opportunities for energy savings on your site, which require minimum effort.

Step one: initial plant review

You can use this table to collect basic plant information for an initial review of your energy-saving opportunities. Or you can develop a more systematic review process by incorporating efficiency and load data into your plant inventory.

Plant identity	Weekly operating hours	Motor size HP	Operating requirements (steady, variable)	% average throttling at outlet	Other e.g. cavitation blocked filters

The following rules of thumb will help you prioritise these opportunities:

1. The longer the operating hours the higher the potential savings. Applications that operate more than 80 hours a week are likely to represent the best opportunities.
2. Applications that have the highest horsepower are likely to produce the highest savings.
3. Steady applications with more than 10 per cent throttling represent opportunities for improved pump efficiency, often at little cost.
4. Variable applications that use throttling as a form of control and operate below full load for a significant length of time offer potential opportunities for higher efficiency through improved control technologies.
5. Applications that have blocked filters, cavitation or poorly maintained pipe-ductwork can deliver savings with improved maintenance.

Step two: gathering data

To examine in more detail the best opportunities determined in your initial review, you will need to collect more data. The purpose of gathering this data is to develop a system performance curve and apply this to the pump (fan) diagram to establish the specific operating points. This step may require the assistance of a qualified engineer, or your pump or fan supplier.

You will require:

- a process and instrumentation (P&ID) diagram - this may be a simple hand drawn sketch showing the equipment, layout, process and instrumentation
- the pump (fan) design data (characteristic curves)
- operational data - flow, pressure, current and duration.

From this data, you can establish the system resistance curve and the load duty cycle. When you consider this information in conjunction with the pump and fan characteristic curves, you will develop a full understanding of the performance enhancement opportunities.

Step three: technical options review

Systems can be classed as one of three types:

1. steady: constant load single operating point
2. discrete: two to four operating points
3. variable: greater than four operating points.

Investigate the following options, including estimated costs and savings. Your equipment supplier may be able to help with this analysis.

Steady	Discrete	Variable
Reduction of impeller diameter	Multiple speed motors	Variable speed drive
Variable inlet guide vanes for fans	Variable inlet guide vanes for fans	Variable inlet guide vanes for fans + multiple speed motor
High efficiency motors	High efficiency motors	High efficiency motors
Equipment upgrade (new pump)	Booster pump/fan<	Booster fan + variable inlet guide vanes

Step four: economic assessment

The last step is to determine which option presents the best opportunity for your site. The best way to do this is to compare the life cycle cost of each option using a 'net present cost' calculation (available in most spreadsheets). This will take into account the capital cost, running costs and your company's investment criteria. It is important you also keep in mind other benefits such as reduced noise, higher reliability and less maintenance that may tip the balance and justify greater expenditure to improve efficiency.

Pump and fan characteristics

Pumps move mainly incompressible fluids (like water) and fans move compressible fluids (gases like air). Pumps and fans each come in two basic types:

Pumps

- Centrifugal - fluid is spun around and ejected by centrifugal action. These are the most common pumps used in industry.
- Positive displacement - a set volume of fluid is physically moved, often by a piston. These pumps are less common, and are used for thick and viscous fluids under high pressure or where the delivery flow must be precise.

Fans

- Centrifugal - the same principle as the centrifugal pump. These are generally higher efficiency, up to 80 per cent, with the exception of the radial fan, which is around 50 per cent to 60 per cent but does not clog easily.
- Axial propeller-based fans - generally these low efficiency fans are used in free air or where space is at a premium. Aerofoil section blade fans are the exception, with high efficiencies - up to 90 per cent.

The Motor Solutions Online system optimisation information focuses on centrifugal pumps and fans, since these offer the greatest opportunity for energy savings.

Performance characteristics

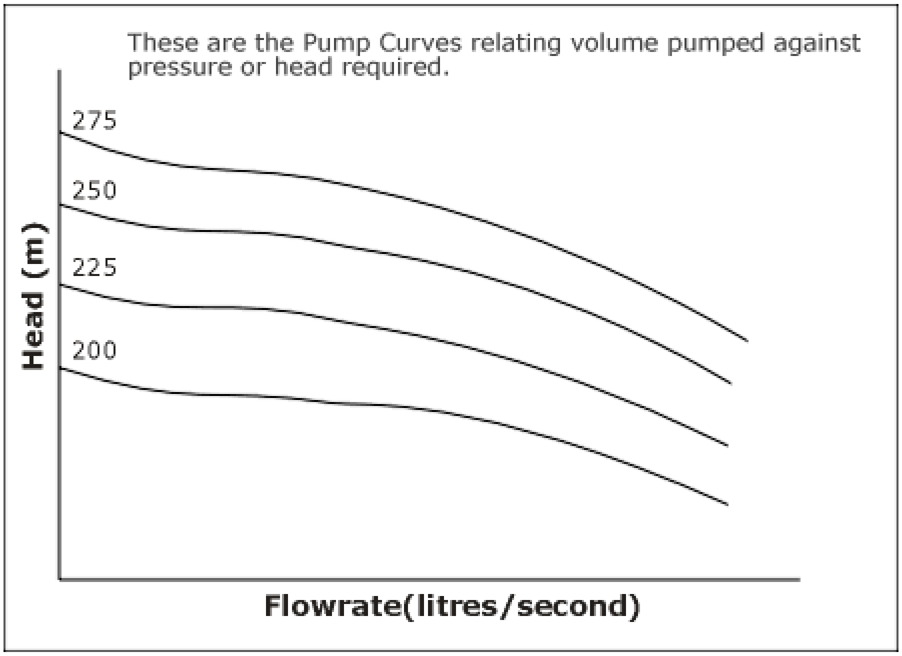
The performance characteristics of pumps and fans are most often presented in a graphic form called 'characteristic curves'. These curves describe characteristics of available head (pressure) and efficiency and power consumption, from zero to maximum flow. A family of performance curves can exist for various impeller diameters.

Understanding performance curves enables you to check the performance of existing pumps, and identify opportunities for reducing your operating costs. For example, reduced operating costs can often be achieved by machining a pump impeller to get a better match between pump performance and the system requirements.

Performance curves are available from your equipment manufacturer and are often found in equipment operating manuals.

A typical pump curve

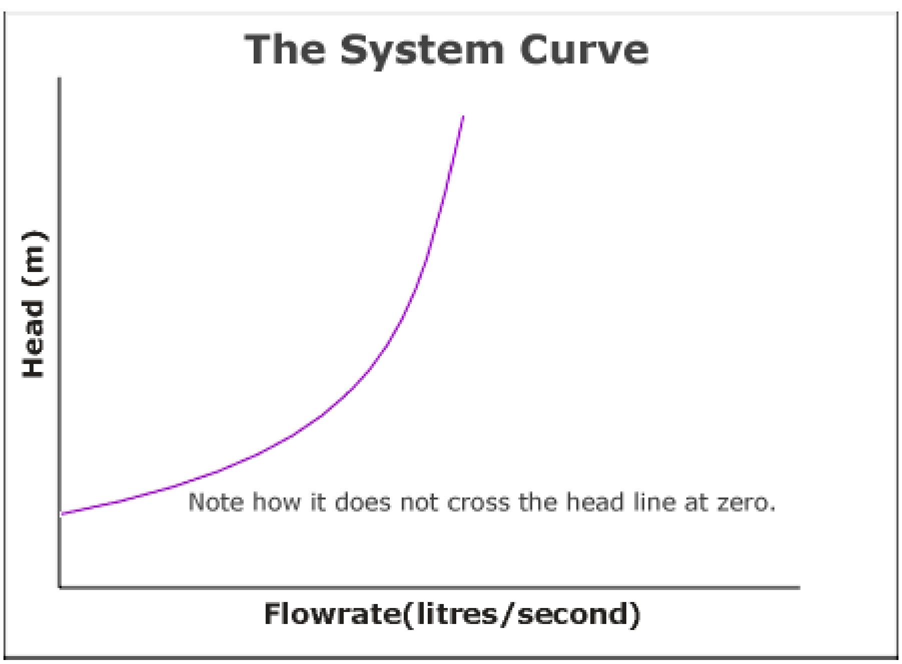
This is an animated graphic showing a typical pump curve. It will keep cycling so do not worry if you miss it the first time.



System curve

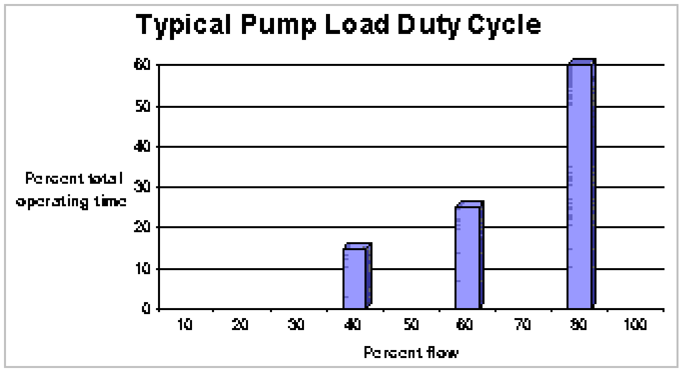
A pump or fan can operate at any point on its performance curve. The actual operating point is determined by the system requirements of flow and pressure. It is important that you select or modify your pump or fan so the operating point occurs in a zone of high efficiency. As you can see, pump efficiencies can vary significantly. In the diagram below, for example, efficiencies vary from 40 to 80 per cent.

In the next example, a system curve is superimposed on the pump curves so you can see the operating point.



Load duty cycle

The load duty cycle depicts the operating points and their percentage of total operating time. Analysis of the load duty cycle is the key to determining the most viable optimisation techniques.



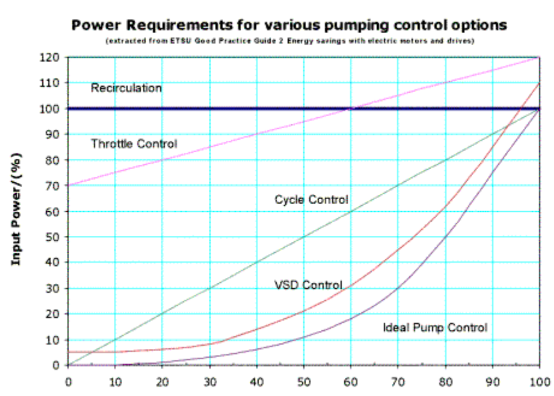
Control options

The most basic form of control is to manage flow by adding friction at the pump or fan outlet. For pumps, this is achieved by a throttle valve. For fans it is done with a damper. It is effective, but inefficient. For example, in situations where maximum flow is not required, and where throttling or damping is used continuously, efficiency can often be improved by reducing the diameter of the impeller. This is called trimming and is best done with the support of your original equipment supplier.

Most industrial systems have pumping requirements with several operating points or variable flow and pressure requirements. Picking the pump (fan) with the optimum efficiency for a specific delivery is only part of the story. The other part is controlling the flow rate to match the process requirements. You can do this in several ways:

1. recirculation - continuously runs the fluid round the system through a buffer tank
2. throttle control - uses valves or flaps to control the flow rate
3. cycle control - turns the pump on and off to control the flow
4. VSD or ASD - stands for variable or adjustable speed drive, and controls the pump's speed to control the flow.

The most efficient control option is the one that most closely matches the ideal pump curve, which is shown in the graph below.



To select the appropriate control option you need to balance the capital cost of the control equipment against the savings you will achieve. Although the more efficient control options generally have higher initial set up costs, they can result in large and reoccurring energy savings over the life cycle of the equipment.

Variable speed drive manufacturers often help their customers analyse potential saving that can be achieved through variable speed drives for pump (fan) control. In some situations the savings will quickly pay back[1] the cost of the equipment, and from then on the savings go straight to your bottom line.

For fans there is an additional form of control - variable inlet guide vanes. These can control air flow and maintain efficient fan operation, if minimum flow requirements are approximately 85 per cent of maximum flow conditions. For flow requirements below 85 per cent, variable inlet guide vanes can be combined with multi-speed motors to extend their effective range. Variable inlet guide vanes are relatively inexpensive but may not be suited to all situations. For example, they are unsuitable in dirty or corrosive atmospheres.

Fine-tuning pump and fan applications

Fine tuning your pump and fan applications helps you achieve improved efficiencies and savings. You can use several low-cost measures or minor modifications to fine-tune your pump and fan system performance. Generally, these can be implemented with only minor interruption to the process.

The easiest options to implement include:

- eliminating unnecessary flow paths
- reducing excessive frictional losses
- improving inlet and outlet conditions
- maintaining performance.

When making changes or looking for opportunities for savings, it is important that you keep in mind the relationship between your pump or fan and your system. If you adjust the system in a way that changes its initial design, you will need to plot a new system curve to find your new operating point and ensure you are optimising the equipment's efficiency. Information about plotting systems curves is in pump and fan characteristics.

Eliminating unnecessary flow paths

Flow paths (for getting the fluid or gas from the pump or fan to where it is required) should be as simple and practical as possible. Avoid any unnecessary lengths of pipe or ducts, or high resistance fittings such as elbow, bends or Tees, as they all add to the work the pump or fan has to do.

Pipes and ducts also need to be sized to suit the volume of fluid or gas that they transport. Increasing the width of pipes or ducts to decrease the level of resistance and therefore the load on the pump or fan. Engineering handbooks provide a guide to suitable pipe and duct sizes and the effect of bends and elbows on required pump horsepower.

Reducing excessive frictional losses

Pump and fan systems often become inefficient as a result of the build-up of contamination or dirt in filters, strainers, coils, pipes or ducts. Unexpected and gradual increases in load can be a good indicator of when such a build up is happening. In situations where buildup is likely, it is important that you have an inspection and maintenance program to monitor increases in load and ensure the system continues to perform as designed by preventing buildup. Protective and monitoring systems are only effective if you set against the maximum *expected* load on the pump or fan rather than the maximum load stated on the nameplate.

Improving inlet and outlet conditions

The efficiency of your pump or fan applications can be reduced by turbulence at the inlet, an improper discharge connection, or improper inlet connections or conditions. The manufacturer of your pump or fan will have specified inlet and outlet conditions that are necessary for acceptable performance. Reviewed inlet and outlet conditions periodically to ensure your system meets the requirements. Poor inlet conditions can also result in cavitation in pumps. Cavitation will significantly reduce efficiency and, in the long term, can cause extensive damage to equipment.

Maintaining performance

To ensure that the performance of pumps and fans does not deteriorate, you should inspect impellers regularly for erosion or product build-up. During any maintenance activity, check that the internal running clearances between rotating and non-rotating parts are maintained within the manufacturer's specifications.

http://www.greenhouse.gov.au/motors/systems/sog2.html