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White Paper

Lowering the cost of operating hydraulic systems

Saving money is at the forefront of most businesses agendas. The operating costs of hydraulic systems are often overlooked. A brief introduction into some of the concepts for saving money when operating hydraulic systems is explored in the following document.

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Introduction

Savings made on operating costs of hydraulic systems has become increasingly important. The cost of manufacturing downtime is increasingly expensive in efficient factories. The cost of oil has increased as has the cost of energy.

We will explore ways in which the costs of ownership can be reduced.

Saving Operating Costs

There are two scenarios we will explore:

1. The system has already been installed and is operating.
2. The system has not yet been designed.

1. Existing Systems

There are many ways in which the performance of existing systems can be optimised. Making savings would come from reducing energy costs, reducing oil consumption and reducing breakdowns.

Little can be done in terms of major changes to the system design to improve efficiency, unless a reasonable budget and time is available. Reducing energy consumption can be achieved by;

a) Operating the system at the optimal temperature for the oil. A reduced viscosity will ensure reduced pressure drop through the system and a reduced pressure at the pump. If oil viscosity is too high then a less viscous grade could be used. Be aware that less viscous fluids can affect the lubrication performance of the oil, which can damage components such as pumps.
b) Changing filters when they become blocked. Bypass type filters will bypass at 7 bar for pressure filters thereby increasing the pressure drop by 6 bar when compared to a new clean filter element.

Oil consumption can be reduced by monitoring for leaks and repairing them immediately. Leakage costs have increased as the table below shows;

One drop per second 1 minute loss – 2.8 ml 1 hour loss – 168 ml 1 day loss – 5 litres 1 week loss – 35 litres 1 month loss – 147 litres **Total cost per month** - £169	**Two drops per second** 1 minute loss – 5.6 ml 1 hour loss – 336 ml 1 day loss – 10 litres 1 week loss – 70 litres 1 month loss – 296 litres **Total cost per month** - £338
A drop breaking into a stream 1 minute loss – 60 ml 1 hour loss – 3.6 litres 1 day loss – 86.4 litres 1 week loss – 605 litres 1 month loss – 2541 litres **Total cost per month** - £2,922	**Small stream** 1 minute loss – 221 ml 1 hour loss – 5.3 litres 1 day loss – 127 litre 1 week loss – 889 litres 1 month loss – 3,734 litres **Total cost per month** - £4,294

Oil consumption can be also be reduced by ensuring the oil in a system is not changed on a timescale. A lot of hydraulic power unit maintenance manuals recommend a change of oil each year. It is recommended that oil is only changed when analysis reveals that the additive package is diminished or the oil is too dirty to clean economically.

Breakdowns can be reduced by monitoring the performance of the system. Contamination is the biggest cause of failure so oil analysis on a frequent basis and trending of the results is highly recommended. Ensuring a clean system will lead to a good probability of high system reliability. Other monitoring methods include;

a) Pump performance analysis, to determine the efficiency of the pump and when it will require replacement.
b) Analysis of operating parameters such as the speed of a cylinder moving, comparing it against a fingerprint of the speed when the system was first commissioned. Changes in speed and pressure to operate can indicate degradation in control components.
c) Thermal imaging of systems to determine wear by pin pointing hot spots where internal leaks occur.

2. New Systems

Whilst not at the forefront of most system designer's minds, energy efficient and through life cost reducing designs are becoming more important. The areas of cost savings we will look at are;

a) Reducing power consumption through efficient selection of pumps and the design of the prime mover.
b) Reduction of energy usage through reduction in pressure drop across the system.
c) Reducing the changing of components due to condition or failure

2a) The simplest method to reduce power consumption is to turn off the pump. This is fine if the drive electric motor is not started more than 4 times per hour (motor manufacturer recommendations). However most hydraulic systems have little idle time and more working time. Typical fixed displacement pump systems unload the pumps during idle which reduces the current draw. There is still a power loss with the pump flow disappearing to tank at low pressure. Energy usage can be reduced by using accumulators, which store the energy in idle periods. This allows the pump to be smaller as the accumulators supply flow when required. If the idle time is very short then accumulators may not provide an advantage.

Piston pumps could be considered and a study we did two years ago came up with some interesting figures. Please see below;

We have carried out a simple theoretical comparison of the two types of systems, being driven by an 11 kW motor. It has been assumed that the piston pump is operating at full pressure continually (pressure compensated) and energy is being lost down the case drain. The gear pump on the other hand is only on load when required.

For an 18 second cycle we have assumed that the system will be unloaded for 10 seconds, operating below relief valve pressure for 6 seconds and working at relief valve pressure for 2 seconds. ***The result is that the piston pump wastes less than 50% of the power than the gear pump****.*

If we assume that electricity costs approx. £0.35 per kWh then the cost ***saved*** *by using a piston pump per day for an 11 kW system would be £9 per day and* ***£2,700*** **per year**. This could *easily cover the differential in price between the two types of pump within one year.*

Would this be enough to persuade most end users to use variable delivery pumps?

Variable speed drives may also provide an economical solution for fixed displacement pumps. Please note that most pumps have a minimum speed of around 500 rpm so this is a limitation with variable speed drives. However when controlling the speed and the flow of the pump, flow controls and proportional valves will not be needed, thereby saving on component costs.

2b) Pressure drop across the system can be reduced by carefully selecting components and pipe work. Valves and filters can be sized to minimise pressure drops under reasonable working temperatures. It is economically better to slightly oversize filter assemblies, which reduces pressure drop and reduces the frequency of filter element changes. Valves such as servo valves have been traditionally designed with a 70 bar pressure drop. Heat creation across these valves is very high and extra cooling is often necessary on these systems.

Pipe work should be routed to minimise sharp bends and tees. Pipe work sizes should consider minimising pressure drop, whilst bearing in mind the cost of larger pipe and fittings.

Selecting the correct viscosity of oil is important. The oil should lubricate the system and also reduce pressure drop. A low viscosity oil may have a low pressure drop but may not adequately lubricate. If the operating temperature of the oil is known then oil can be accurately selected. There may be problems during cold weather when the system is left idle. The starting viscosity may very high and the system sluggish. Heaters can be used to warm the system up to reasonable temperatures such as 20 degC, thereby reducing pressure drops on start up.

2c) Good quality components last many years and save money. Good quality valves and pumps have less internal leakage and lower operating costs.

The two most changed out components on a hydraulic system are hoses and filter elements. Hoses have a life expectancy due to fatigue but many fail before their expected life period as they are damaged or poorly fitted. Poorly fitted hoses tend to be bent to a smaller radius than the specified bend radius, which puts a strain on the end fittings. Always ensure that the bend radius is larger than the recommended minimum. Damage through wear and snagging is common. Hoses should be routed so that damage by external machinery is unlikely. Protection can be applied externally that can protect against abrasion and heat.

Oversizing filter assemblies means that the frequency of changing filter elements is reduced. Downtime for changing the element is consequently reduced. Purchasing a slightly larger and slightly more expensive filter has its benefits.

Conclusions

If reducing the cost of ownership is taken into account during the design stage of a hydraulic system then the facilities, the components and positioning of the components will yield medium to long term economic benefits. Attention should be paid to potential energy usage, the likelihood of failure and the frequency of changing components.

For existing systems maintenance is very important; keeping the oil clean and at the optimum temperature is vital to reducing failures and energy usage. Knowing the condition of your hydraulic system will ensure unplanned failure and costly downtime do not occur. Leakage of oil is expensive and avoidable. Hence regular checks of any hydraulic system are recommended.