Application Note

Improving Condenser Water Pumping Systems

VLT® 6000 HVAC

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■ The Application

Condenser Water pumps are primarily used to circulate water through the condenser section of water cooled chillers and their associated cooling tower. The condenser water absorbs the heat from the chillers condenser section and releases it into the atmosphere in the cooling tower. These systems are used to provide the most efficient means of creating chilled water, they are as much as 20% more efficient than air cooled chillers.

■ The Traditional Design

The cooling tower cools the condenser water by evaporation. The condenser water is sprayed into the cooling tower onto the cooling towers "fill" to increase its surface area. A fan blows air through the fill and sprayed water to aid in the evaporation. Evaporation removes energy from the water dropping its temperature. The cooled water collects in the cooling towers basin where it is pumped back into the chillers condenser and the cycle is repeated.

Traditionally, the condenser water pump circulates the water at full flow continuously. When control of this system is desired, the temperature of the condenser water is controlled by the cooling tower fan. The lower the condenser water temperature, the lower the energy consumption of the chiller, but the decrease in energy consumption is small and more can be saved by reducing the energy consumption of the cooling towers fans.

The condenser pump is normally oversized for safety margins and field balanced with a throttling valve to prevent too high a flow rate. Excess flow can erode the chillers tubes increasing maintenance. By adding resistance to the system with the throttling valves, the flow rate is reduced to design flow rates.

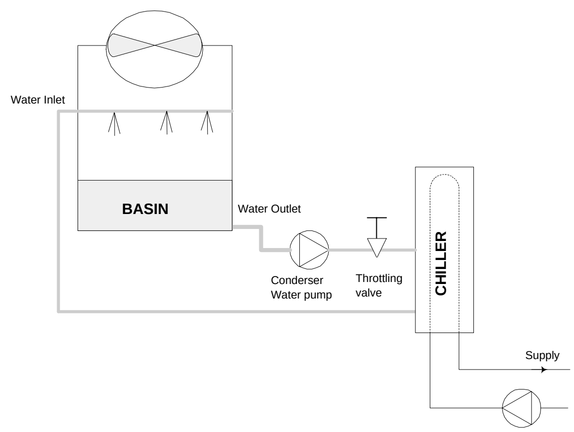

Fig. 1 - Traditional condenser pump system

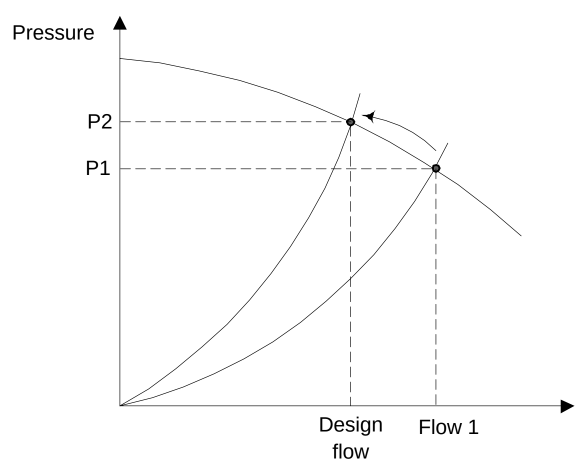

Fig. 2 - Throttling valve picture

■ The new standard

VLT frequency converters can be added to condenser water pumps instead of balancing the pumps with a throttling valve, to control the water temperature instead of tower fans, or to control the water temperature in addition to controlling the tower fans.

Using a VLT frequency converter instead of a throttling valve simply saves the energy that would have been absorbed by the valve. This can amount to savings of 15-20% or more. VLT frequency converters are used to control the water temperature instead of controlling the cooling tower fans when it is more convenient to access the pumps than the tower fans.

Pump control is used in conjunction with fan control to control the water temperature in free cooling applications or when the cooling towers are significantly oversized. In some circumstances the environment itself causes the water to become too cool even when the fan is off. The VLT frequency converter controlled pump maintains the appropriate temperature by increasing or decreasing the discharge pressure and flow rate. The decreased pressure at the spray nozzle in the cooling tower decreases the surface area of the water exposed to the air. Cooling is decreases and the design temperature can be maintained in periods of low loads.

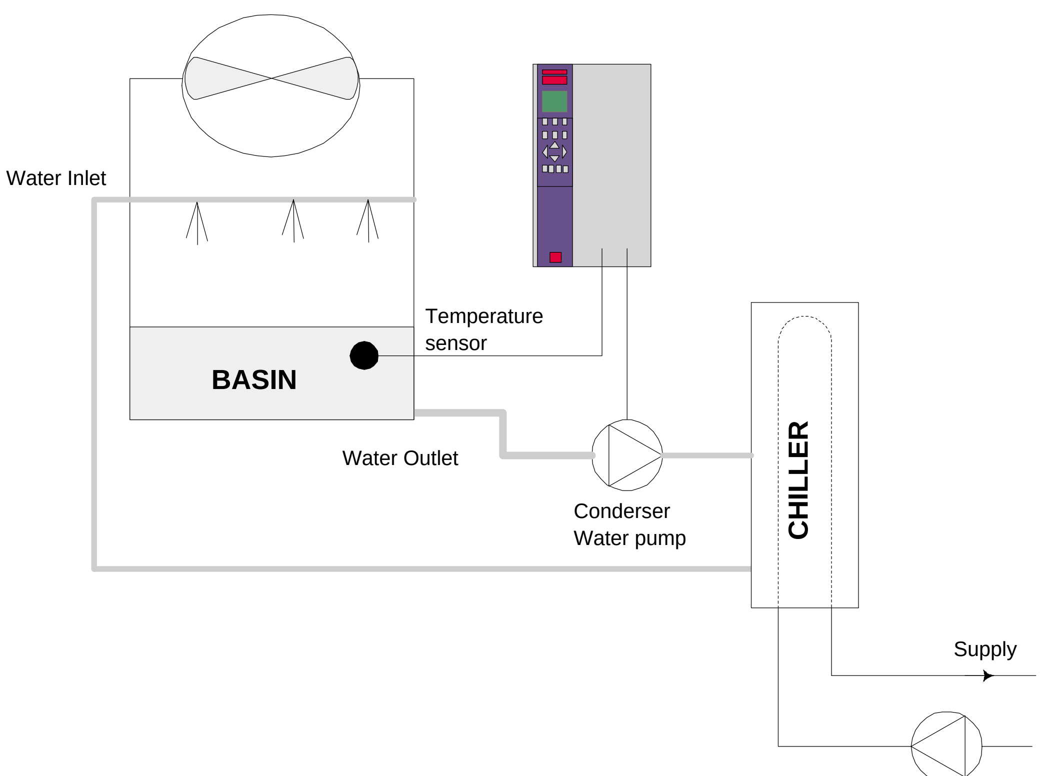

Fig. 3
Condenser system with VLT frequency converters

■ Annual operation load profile:

The load profile indicates the amount of flow the system requires to satisfy its loads during the typical day or time period under study. Figure 4 shows a typical load profile for a condenser water pump. This profile will vary depending on the specific needs of each system due to location and other factors, but is representative of normal systems.
The minimum speed of the pump should be restricted to the flow required to obtain turbulent flow though condenser section, in this case 60%.

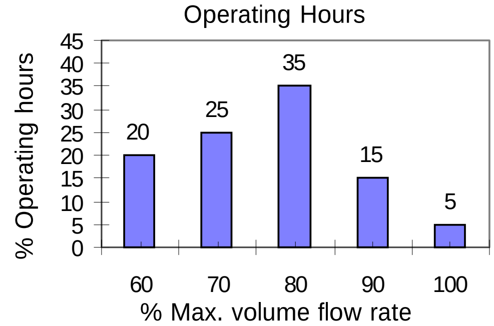

Figure 4

■ Energy saving calculation example

In the following calculation example a 30 kW condenser water pump is controlled to maintain a constant condenser water temperature according to the load profile in fig. 4.
The energy consumption during one year operation is calculated comparing varying the speed to running at full speed with a balanced pump.
The result shows that 39420 kWh is saved in energy consumption using VLT 6000 HVAC.

Flow (%)	Hours (%)	Hours run	Power Consumption (kW)		Energy input for 30 kW Pump motor	
			Throttling	VLT 6000 HVAC	Throttling	VLT 6000 HVAC
60	20	1752	26	7	45552	12264
70	25	2190	26	10	56940	21900
80	35	3066	26	14	79716	42924
90	15	1314	26	20	34164	26280
100	5	438	26	27	11388	11826
	100%	8760 Hours			227760 kWh	115194 kWh

Fig. 5

The second calculation shows the energy consumption of the condenser water pump balanced with a throttling valve vs. a VLT 6000 HVAC.
The pump is assumed to be 15% overheaded.
The result shows that 112566 kWh is saved in energy consumption using VLT 6000 HVAC (fig.5).

Example:

A 30 kW condenser water pump is operating by a constant flow at 100% for 24 hours every day.

Total annual operating hours is:	24h x 365 days	= 8760 hours.
Energy consumption per year:	30 kW x 8760h	= 262800 kWh
Energy saved by using a VLT:	15% of 262800 kWh	= 39420 kWh
Annual money saved by using a VLT:	39420 kWh x US$ 0,10	= US$ 3942

Simple payback: $\frac{\text{Drive price}}{\text{Energy savings}}$ ≈ 1.5-2.5 years

Sensor Type And Placement

The energy savings capabilities of a properly installed VLT frequency converter system is well known. In the case of temperature control of the condenser water pumps, the sensor is simply placed in either the cooling tower basin or anywhere in the return line. Using condenser pumps to control the temperature of the return water is usually done when controlling the tower fans is not practical.

Using VLT frequency converters to balance the pumps in place of throttling valves can be done manually or with a flow meter placed at the discharge or inlet of the condenser section of the chiller. This can be done in addition to controlling the tower fans without difficulties.

In large installations or locations requireing air conditioning during the winter, it may be desirable to control the temperature of the water with both the fans and pumps. In these cases, even with the fans off, the tower has excess capacity and subcools the water. The energy consumption of the pumps can then be reduced by decreasing the flow rate. It is not recommended to control both the fans and pumps on the temperature sensor simultaneously as it may lead to instability.

On retrofit applications, thought should also be given to the condenser waters design flow rate. Due to increases in chiller efficiency, it may be advantageous to reduce the design flow rate by as much as a third. This reduction will increase the energy consumption of the chiller, but in many cases the energy savings in the pump will more than offset this cost increasing system energy savings. VLT frequency converters can be used to obtain the optimized flow rate without requiring new pumps, wasting energy with throttling valves, or reducing pump efficency and adding labor costs by trimming impellers.

The chiller manufacturer should be consulted before varying the flow rate of the condenser pump.

Comparison of installation and maintenance costs

Aside from the potential energy savings, the cost of using a VLT frequency converter can be partially paid for by the savings on installation and maintenance costs. The traditional system not only requires the throttling valves and balancing valves, but also needs at a minimum: 6-wire motor cable, a softstarter, and power factor correction capacitors.

Utilizing the Danfoss VLT frequency converter makes the valves, softstarters, power factor corrections, and extensive cablework superfluous. Manual speed adjustment or a simple voltage (0...10V) or current (0/4...20 mA) control signal and flow meter is sufficient to vary the flow.

Maintenance is limited to a minimum, and installation costs and space can be saved. The VLT frequency converters IP 54 enclosure allows it to be mounted in the mechanical equipement room close to the pumps on the wall.

Falling expenses for electronic equipment and increasing costs for labour have brought the investments for both regulation methods to a similar level. The above comparison of energy consumption shows why the utilization of VLT frequency converters is doubtless the better choice.

MN.60.F1.02 - VLT is a registered Danfoss trademark

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