Recovering Thermal Energy with Water Jet Heaters

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Technical White Paper Series
A variety of methods are used to process low-pressure exhaust steam. The most inefficient method is to simply dump it to the atmosphere through an atmospheric vent valve. When energy costs were low, this was acceptable, but with today's higher energy costs and the increasing importance of optimizing energy utilization, recovering thermal energy and reducing operating costs are much more important.

The thermal energy in low-pressure steam can be recovered using shell-and-tube heat exchangers, air-cooled condensers, and thermocompressors. An even more efficient way to recover the energy from low-pressure steam is to use a Kadant Johnson Water Jet Heater, as shown in Figure 1.
The Kadant Johnson Water Jet Heater is a direct-contact condenser. A high-pressure water jet entrains low-pressure steam, or even sub-atmospheric steam, to recover its thermal energy. The high velocity water jet creates a vacuum by means of the Bernoulli principle, entraining both steam and non-condensable gases, and condensing the steam. The water jet diffuser converts the high-velocity mixture to a supra-atmospheric pressure that can then be discharged without a pump.

Figure 2 shows steam flow, suction steam pressure, and recommended inlet size. For example, with a steam load of 2000 kilograms per hour and a suction pressure of 50 kPa absolute, a 200 mm connection is recommended.

Figure 3 shows the relationship between suction steam pressure, the steam flow, and the required water flow. For example, if the suction pressure is 60 kPa absolute, each liter of water at 10 °C will condense 7 kilograms of steam if non-condensable gases are not present. For a steam load of 2000 kilograms per hour, a total of 286 lpm of 10 °C water would be required to maintain the absolute pressure at 60 kPa.

![Figure 2. Inlet connection size and steam flow.](image)
Figure 3. Steam flow per LPM water flow.

Figure 4. Inlet connection size and water flow.
Figure 4 shows the recommended water connection and the water inlet flow rate. For 800 lpm, select a 75 mm connection.

![Graph of Capacity Reduction Factor](image)

**Figure 5.** Capacity reduction factor for non-condensable gases.

Figure 5 shows the reduction in steam flow capacity when there are non-condensable gases (e.g., air) in the steam line. One-half percent or less has no effect on the capacity of the water jet heater. However, one percent non-condensable gas in the steam reduces the steam flow capacity by \((100-60\%) = 40\%\).

Water jet heaters are typically installed vertically with the discharge below the inlet to provide a smooth start-up and stable operation.

If the steam load is constant, no control other than an on/off valve is required. If the steam load is variable, the water rate can be varied accordingly within limits. The water flow turndown, however, should not be more than 50% of maximum water flow.
Figure 6. Piping for a typical water jet heater installation with automatic control of water temperature.

Note: The water jet heater should be a minimum of 4.5 meters above the discharge.
Figure 7. Piping for a typical water jet heater installation with manual control of water temperature.
The picture below shows the installation of a 38 mm Kadant Water Jet heater. The pipeline at the top of the picture shows the modulated water inlet which was designed for 115 to 170 lpm. The steam line, in the middle, was designed for a maximum of 815 kg/hr at atmospheric pressure.

This water jet unit replaced the two shell and tube heat exchangers that were each approximately 400 mm diameter x 2500 mm long, as shown in the following picture. One of the advantages of the direct contact condensor is that it requires a much smaller footprint.
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