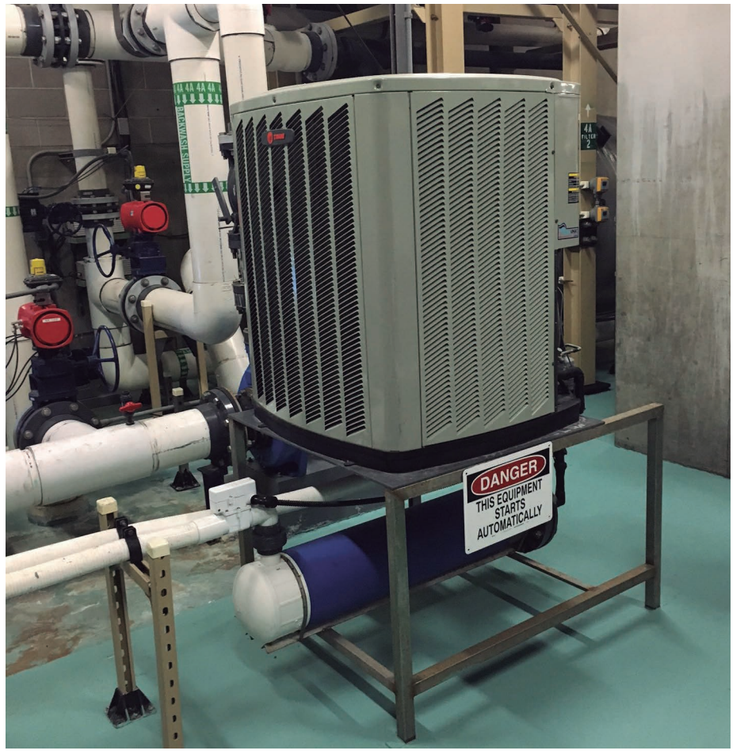
Chillers and Heat Pumps

*by Amy Stone**

Chillers and heat pumps are not always necessary in aquaculture, but they are needed when consistent temperatures are critical to animal growth. With an increase in the number of recirculating systems being built, they are becoming a necessity for growth control. Both work on similar refrigeration principles but this article will address them separately.



5 hp air cooled chiller.

Chiller Mechanics

For the most part, the commercially available systems consist of either water-to-water or air-to-water condensers. These condensers utilize either tube in shell or plate & frame heat exchangers. They all have their advantages and disadvantages. Basically, the coolant (refrigerant gas) is removing heat from the system water and rejecting it through the condenser to the atmosphere, either by fan or by cooling water.

To break it down even more, imagine the outside condensing unit (Noisy box with large fan) on your air conditioner at home. This equipment is basically an air to coolant condenser that is sending coolant into your air handling (evaporator) unit in the house to cool the air. Now imagine the same condenser hooked up to a shell & tube or plate frame heat exchanger and now you have exactly what we use for the smaller horsepower chillers. Water to coolant condensers use cool water to remove the heat from the system coolant (refrigerant). Water cooled condensers are less common in aquaculture but should be used when there is a steady source of reusable clean cool water to increase efficiency.

Heat Pump Mechanics

Heat pump (HP) condensers are essentially the same equipment found in chiller applications, except HP's both heat and cool. They lose efficiency when the ambient air temp is below 8C (48F). If they are to be used in chilling mode when the ambient air temperatures are below 8C, they can be outfitted with a low ambient control which essentially maintains the system pressure by cycling off or varying the condenser fan speed. In cooler temperatures, the coolant reacts differently, and this low ambient kit helps the unit perform at lower ambient temps by controlling coolant pressures. To be clear, the low ambient control kit only works when the heat pump is in chiller mode.

Heat Exchangers

The two most common types of heat exchanger are tube in shell and plate & frame (PHE). Tube in shell is exactly how it sounds. It is comprised of a coil of tubes that are encapsulated in a shell. In general, the tubing in designs for aquaculture is comprised of titanium or stainless-steel. Some are made with cupronickel or other metal alloys. We tend to avoid using metal or copper alloys as they tend to leach into the water and may be toxic and less corrosion resistant in salt water. My personal recommendation would be using titanium as it is the most durable in saltwater and never fails from corrosion.

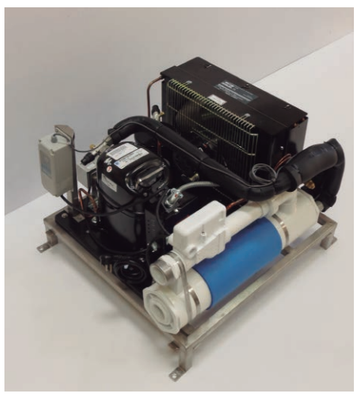
This shell and tube style of heat exchanger will perform well even with suspended solids in the water. It is very robust, and requires minimal preventative maintenance compared to PHE styles. It has been my go-to style for aquaculture because of its durability and ease of use. It is also preferred when the temperature differential is high, as it is more cost effective.

The other option that we often see is the plate frame style heat exchangers (PHE). This style consists of multiple metal plates compressed between gaskets to create a specific gap and allow water to flow through in alternating directions. The plates often have corrugated surfaces. This creates turbulence and forces the process water to transfer energy (chill or heat) to the system water through the very thin (0.05 mm) Stainless Steel or Titanium plates. That turbulence helps scour the plates and increases the efficiency of the temperature exchange. It typically requires higher head-pressure pumps to push the system water through the exchanger. Often times, we use a dedicated booster pump to recirculate water from the filter system through the heat exchanger and back to the aquatic system.


20 hp Heat pump.

System Considerations

There are several pieces of important information that influence the sizing of chillers and heat pumps. One of


Delta Star Interior Compressor view.


Water to water HEX Clipped.


Cyclone Chiller with Drop-in Coil.

the critical factors when designing or engineering a chilling system is the type of aquatic system and where it is going to be used. The surface area, geometry and material of the tanks all play roles in the sizing calculations. Other factors include ambient temperature (air temp), incoming water temperature, system water exchange rate… and the list goes on from there.

Believe it or not, every piece of the puzzle impacts the size of a chiller and/or heat pump. First, let's start with the culture tank. How big is it? What is the surface area of the water that is exposed to the ambient air? Consider that a large shallow tank will lose or gain temperature much faster than a deeper tank. Open channel piping, drum filters, de-gassing towers and moving bed or trickling biofilters will affect the loss or gain in temperature that the system will see.

Dual Ton chillers in Shrimp farm.

Imagine trying to keep water at 12C with an air temperature of 20C and a system that consists of a drum filter, a large centrifugal pump, a low head oxygenation system and a de-gassing column. Depending on how much water is being exchanged in the system, that could translate to a rather large chiller plant. Of course, many of those factors can be manipulated to minimize the heat gain but it all comes at a cost to control aquatic water temperatures.

When designing aquaculture production systems, it is best to balance all aspects including the capital costs as well as the operating costs. Chillers and heat pumps have a starring role since they are critical components.


Ton chiller in shrimp farm.

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