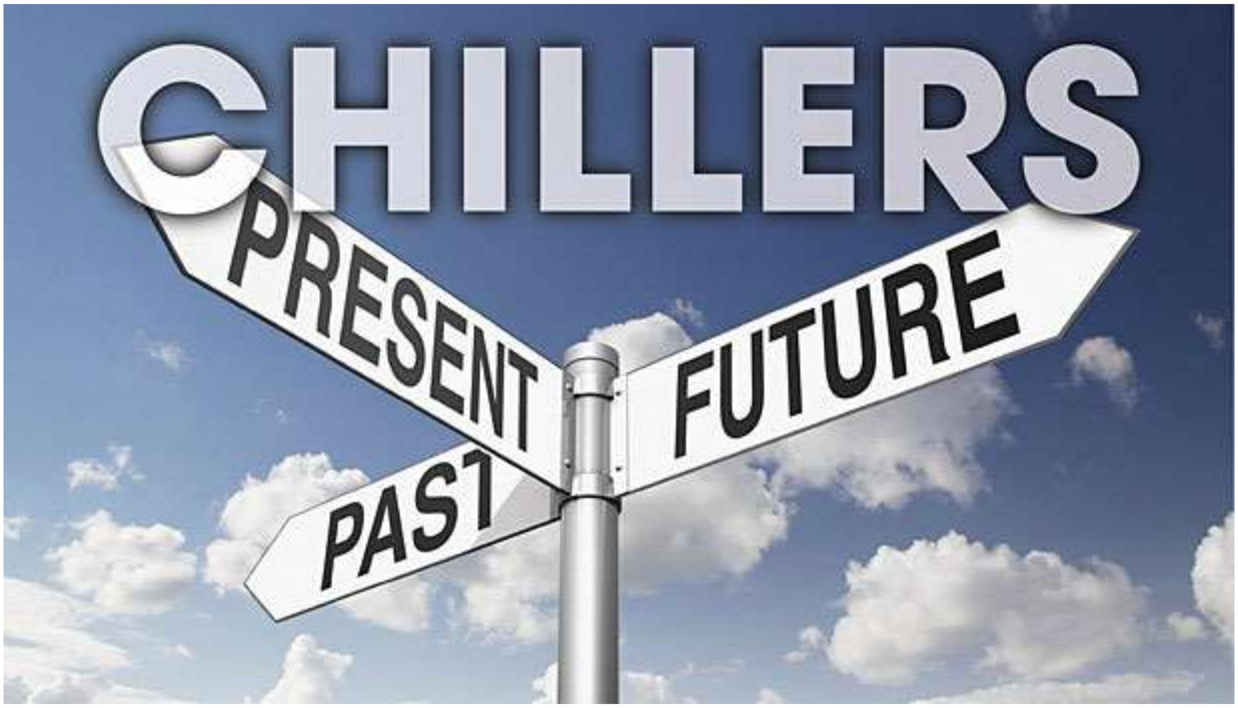
Chillers Best Practices: Past, Present and Future



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Fred Berry and Adam Meddaugh
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The most common mistake I see these days is how chiller plant owners and/or consulting engineers operate their plants the same way they have for the past 25-30 years. While this is almost always based on good engineering data, the data is, unfortunately, based on 25-30 year old products and practices. And, since the typical lifespan of a chiller is 25 years, owners may never have had to purchase new equipment so they don't realize the new improvements available. The fact is, new technologies exist that can greatly reduce the energy used by chillers and chiller plants.

First, the cooling tower has been used for over 50 years with chiller plants and there have been some improvements to that product, but the main item missed by the owner/consultant is the temperature setpoint of the tower. 25 years ago the generally accepted setpoint was 75°F due to the fact that most of the chillers of the time couldn't operate with colder tower water temperatures. Today's chillers can use much colder temperatures, some as low at 50°F, and taking advantage of this capability can save significant dollars. The lower the tower water temperature the less work the chiller compressor has to do and the less energy is used.

“Free cooling” during cooler months is another concept that made sense 25 years ago. Plants would use much less energy if you used the tower water to cool the chilled water loop via a water to water heat exchanger and turn off the chiller. Today’s chillers with VFDs and low ECWT are so efficient that the values are starting to rival those of free cooling. In many instances it is now a 25- to 50-yr payback to purchase the extra heat exchanger, control valves, piping, floor space, and annual servicing requirements of the “free cooling” system. In some cases, there is no payback to the owner.

The number of chillers operated in a plant has also changed. Chillers used to be most efficient at or near full-load conditions so owners would run the fewest number of chillers to save energy and maintenance costs. This led to “base loading” of certain chillers and lead-lagging the chillers to minimize run hours on all of the equipment. The use of VSDs and low ECWT makes the chillers more efficient at part load than full load, and some chiller designs do not require a costly run-hr-based compressor teardown. The new data shows it is more efficient to keep more chillers running at part load, even with the extra pumping costs associated with this practice, to save energy. Base-loading a chiller, or chillers, no longer is the best practice.

Finally, using chillers in other capacities is another way for the plant owner to save more money. Boilers used to be the best way to heat water. Unfortunately, the best efficiency is 99%. Some chillers today can now create not only chilled water but also 170°F hot water. This temperature is high enough to eliminate the use of a boiler and sometimes to allow purchase of a smaller or fewer boilers. The chiller is used as a heat pump to “transfer” Btus from the chilled water loop to the hot water loop and can have a COP as high as 6 (or be 600% efficient) instead of creating Btus from natural gas with a COP of 0.99. The rejection of heat to the hot water loop can also sometimes eliminate the need for a cooling tower. The elimination of the tower saves on first cost, space, make-up water, chemicals to treat the water, sewage costs, and tower fan energy.

Using new technology to control all of these new items with a BAS is the best way to optimize the new components and save the most energy and money for the building owner.

Future Trends In Centrifugal Chiller Technology

By Adam Meddaugh, director of positive displacement chillers, Daikin-McQuay

Centrifugal chillers are a major component in a building’s energy consumption. Advancements in the technology of magnetic bearings and variable speed permanent magnet motors with HFC refrigerants are driving future trends in centrifugal chiller applications. Integration of these technologies has opened up significant advancements in the sustainable efficiency improvements in centrifugal chiller design. These technologies allow owners to significantly reduce their operating costs by eliminating the detrimental impact of oil contamination which robs ongoing energy efficiency and causes many lifetime maintenance issues.

The effects of lubricating oil in the refrigeration system have long been identified as a source of efficiency degradation and continuous maintenance in the operation of refrigerating machines. The performance-degrading effects of oil on enhanced tubes have been identified and quantified through ASHRAE and independent university research. Oil entrained in refrigerant migrates to the heat exchangers, coating the enhanced tubes and reducing the heat transfer characteristics.

The lubricating oil is necessary to maintain proper bearing operation and prolonged life. Reports indicate refrigerants commonly contain 10% oil, which reduces heat transfer by 35%.

This presents a paradox for improving centrifugal machine efficiency, which has best been answered by magnetic bearing technology. Magnetic bearing technology allows the manufacturer to eliminate traditional bearings. Since there is no direct contact that requires lubrication, then there is no longer need for lubricating oil in the system. With no contact bearings to inspect or maintain, then there is never a need to overhaul the compressor for bearing replacement. Magnetic bearings also offer efficiency gains of three to five percent over traditional hydrodynamic and roller bearings.

An increasingly large portion of the overall centrifugal market is directed towards replacement of older equipment. The use of HFC-134a offers the advantages of the most compact design as well as compliance with the 1996 Montreal Protocol. The compact design ensures that today's machine will fit in the space vacated by the older machine and greatly eases the installation process. The refrigerant, however, dictates a compressor speed greater than what is available with standard induction motors, without a speed increasing mechanical drive system. This creates another paradox which is conveniently solved with the use of permanent magnet motors. The synchronous permanent magnet motor can be driven to high enough speeds with the use of high-speed VFDs to allow for a direct-drive compressor. Additionally, synchronous permanent magnet motors are three to 30% more efficient than conventional induction motors over the range of compressor operation.

The combination of magnetic bearings and variable speed permanent magnet motors with HFC refrigerants offer solutions to some long-time paradoxes in centrifugal refrigerating machine design. With efficiency gains of 5% to over 30% from traditional designs, and compact, sustainable design with HFC refrigerant and the reduction in lifetime maintenance of over 30%, this technology has become the global trend in centrifugal chiller design.

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