

## Control of Water Heat Recovery Chiller Using Split Condenser Templifier Application

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(Received 12 November 2008, Revised 28 May 2009, Accepted 28 May 2009)

**Abstract**— By using the heat recovery of water-cooled chillers, it is possible to reduce the energy operating costs positively and at the same time it could fulfill the heating re-heat air conditioning system as well as the hot water requirements. Basically templifiers are designed to economically to turn the waste heat into useful heat. Waste heat is extracted from a fluid stream by cooling it in the evaporator, the compressor amplifies the temperature of the heat and the condenser delivers the heat to heating loads such as space heating, kitchens and domestic hot water. Design of higher water temperature requirements and split condenser heat recovery chiller system (using of templifiers) produced hotter condenser water approximately up to 60°C and control the entire heat recovery system.

**Key words** : Heat Recovery Chillers, Split Condenser, Templifier

### 1. Introduction

Through cooling towers, water-cooled chiller discharges a significant amount of heat. In this manner all of the building heat and the heat generated by the compressor work leave the building. Reclaiming this heat and using in to heat the building or the domestic hot water can potentially offer huge energy savings. The water temperature must be increased for improving the value of the wasted heat. When there is a source (a cooling load in the building) and a requirement (a heating load in the building) then the heat recovery occurs. The viability of condenser heat recovery can dictates by different Heating, Ventilation and Air Conditioning (HVAC) system types and building uses. From the condenser heat recovery, high domestic hot water usage such as health care, hotels etc can also be benefited.

### 2. Heat Recovery Methods

Generally two kinds of heat recovery methods are widely used. One is using a heat exchanger and another is using additional condenser.

According to the figure-1, outside of the water-cooled condenser one heat exchanger is used. The set up shows instead of rejecting the heat to the cooling tower (finally goes to the environment); heat is recovered from the condenser water and the heating water temperature is lower due to an additional heating transfer heat exchanger.

According to the figure-2, by using an additional condenser bundle (piped in parallel with the standard condenser) the heat recovery could take place directly from hot refrigerant in the refrigeration circuit. Here the cooling tower circuit and the heating circuit are separate. As there is no heat exchanger, the heating water temperature is higher due to direct heat transfer by the heat recovery condenser.

### 3. Major Concerns of Heat Recovery

#### 3.1 Maximum amount of heat recovery

Theoretically, the heat amount is equal to the sum-

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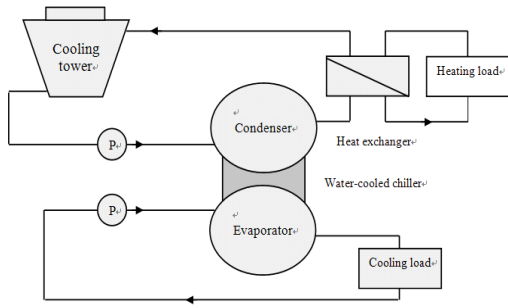


Fig. 1. Heat recovery using heat exchanger.

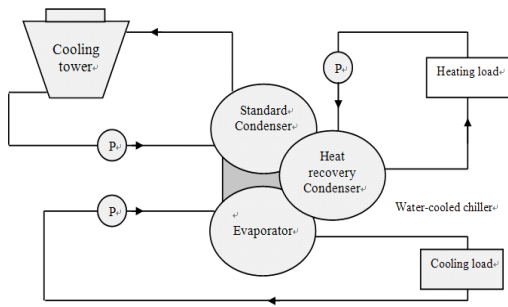


Fig. 2. Heat recovery using an additional condenser.

mation of cooling load and compressor power. By using an additional heat recovery condenser, maximum amount of heat recovery could be up to 100% of cooling capacity for centrifugal water chillers.

**3.2 The highest heating water temperature**

Figure 1 and figure 2 shows, from the cooling load the heat recovery chiller removes heat in the evaporator to the condenser. Then it recovers heat rejection from the condenser to the cooling tower. For making it cooling, heat cannot be recovered without cooling. Here the higher heating water temperature is the lower efficiency and cooling capacity. Heating water at 43°C to 48°C is available for heat recovery centrifugal chillers. Therefore, an auxiliary heat source is needed for higher heating water temperature requirements.

**3.3 Heating water temperature and control**

Generally, for designing heating water temperature, for every 5.6°C temperature increases heat recovery power consumption increases from 7% to 14%. In most cases, the heating water temperature control designs to maintain the return heating water temperature. Allowing the supply

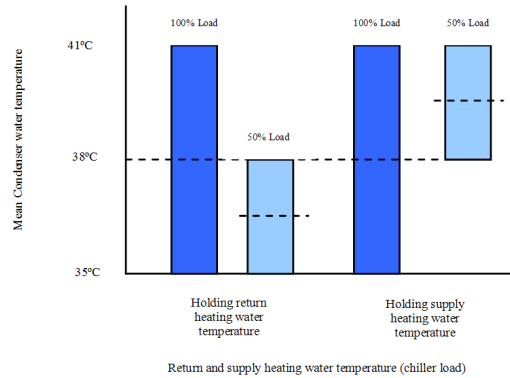


Fig. 3. Heating water control temperature.

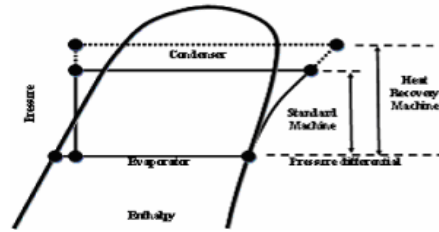


Fig. 4. Refrigerant pressure difference.

heating water temperature to in the system drops as the chiller load decreases and less heat is rejected to the condenser (figure-3). Though the mean water temperature drops the refrigerant condensing temperature and pressure difference at which the compressor is required to produce at part load.

**4. Features of Heat Recovery Chillers**

Heat recovery chillers basically produced higher leaving condenser water temperature. Therefore, it does not duplicate the energy efficiencies of cooling only machines. Figure-4 shows, the typical operating cycles of a cooling only machine and a heat recovery machine. The main differences between the two machines are:

- (a) The pressure difference is much greater for heat recovery cycle than the cooling cycle.
- (b) The amount of heat rejected from the heat recovery condenser is greater than the heat rejected from the cooling only operation.
- (c) The heat recovery machine has lower energy efficiency during heat recovery operations.

The refrigerant pressure difference of the heat recovery machine over the standard machine is observed from the condenser pressure difference of the cycle. The pressure difference is provided by the compressor. In case of heat rejection, the pressure of the heat recovery machine is greater than the standard one in the cycle.

## 5. Working Principle of Templifiers

Templifiers are basically heat pumps that using as water heaters. It is designed economically that turns waste heat into useful heat. Templifiers are non-reversible, water-to-water, Carnot cycle heat pumps. Generally, waste heat is extracted from a fluid stream by cooling it in the evaporator, the compressor amplifies the temperature of the heat and the condenser delivers the now useful heat to heating loads such as space heating, domestic hot water heating and process loads. Templifiers can also be switched over to perform as conventional water chillers, controlling the chilled water temperature and rejecting heat to a cooling tower.

Figure-5 shows the working principle of templifiers. Millions of British thermal unit (Btu) of wasted heat from the air conditioning load throws by the buildings to the atmosphere through cooling towers. For maximum efficiency from the chillers, the cooling tower water temperature is maintained to use this warm water for other purposes such as domestic water and space heating. However, this heat can be recovered by cooling the stream of cooling tower waste heat in the templifier evaporator. The waste heat is transferred to the refrigerant. The compressor increases the temperature and pressure

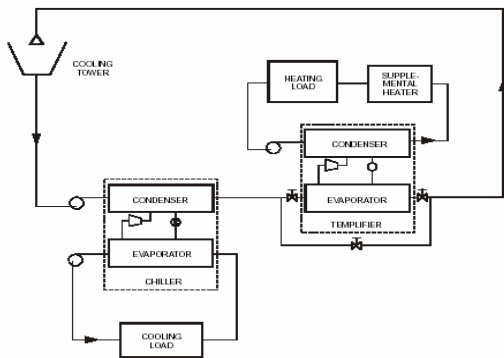


Fig. 5. Flow diagram of templifiers.

of the refrigerant. This higher temperature heat is then transferred from the refrigerant to water flowing through the condenser and delivered to the heating load.

Fossil fired boilers or electric resistance heater generations heat by electric conductors carrying current. The degree of heating for a given current is proportional to the electrical resistance of the conductor. If the resistance is high, a large amount of heat is generated and it includes a coil, wire, or other obstacle which impedes current and causes it to give off heat. Templifier heats the water more economically than fossil fired boilers or electric resistance heaters. It also can off-load overloaded boilers and/or cooling towers thereby delaying or eliminating a capital expenditure required to increase their capacity.

For co-efficient of performance (COP), it is defined as the useful energy output of a templifier unit divided by electric energy input. The COP of templifiers is five times more efficient than the electric resistance heat. That's why templifiers have an attractive and higher COP than resistance heat.

## 6. Heat Recovery Operation Using Split Condensers

Split condenser chiller is most common and widely used system for heat recovery operations. Figure-6 shows a split condenser heat recovery chiller system, which does not require a heat exchanger. As the chillers produced hotter condenser water, it work harder and its performance drops when compared to conventional chilled water production. This loss must be weighted against the value of producing usable hot temperature water. Maximum heating systems are designed to operate at

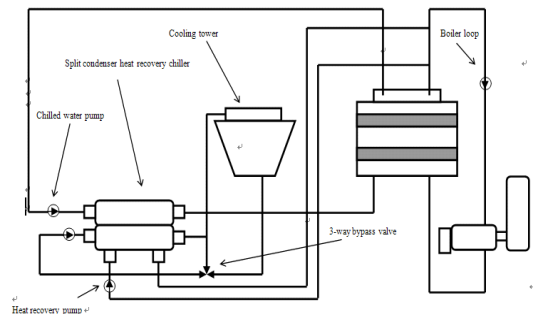


Fig. 6. Split condenser heat recovery chillers.

82.22°C supply water. During heat recovery mode, the heating system must be able to meet the requirements of the building with only 40.55°C to 43.33°C water. This may require changes to the heating system design that will increase capital cost as well as operating cost.

Secondly, several heat pumps (templifiers), which recover low-grade heat and convert the low-grade heat into high-grade heat. In the condenser water application it produces 60°C to 71.11°C hot water from condenser water heat. Higher water temperature produce by the templifiers reduces the impact on the entire heating system but it has a minimal impact on the chilled water plant operation. The templifier can produce enough hot water to directly heat the storage tank.

The system has the following advantages:

- The system can recover large amount of heat that somehow rejected from the building and then use it for other purposes such as building heat or domestic hot water heating.
- The system can be used with any kind of water-cooled chiller plant and any HVAC system that has simultaneous heating and cooling requirements.
- Heat recovery chillers are only preheat the domestic hot water make up but using of templifier causes heat of domestic hot water up to 60°C even if there is no flow in to the storage tank.

Besides this some limitations of using templifiers in the system are requirement of water heating is not much higher (but useful for less heat water requirement), Using of more templifiers sometimes require more spaces on the ground (in case of parallel set up of templifiers for more heating requirements) and it increase plant complexity and cost, Heat recovery chillers sometimes requires to change to the heating system (with cooler hot water) system which increase the capital and operating costs.

## 7. Design For Higher Water Temperature

Figure-8 shows, two chillers overlap in series which recovering cooling load heat rejection from the first stage chillers condenser water on the way to the cooling tower. Then delivering the heat to the heat load by the second

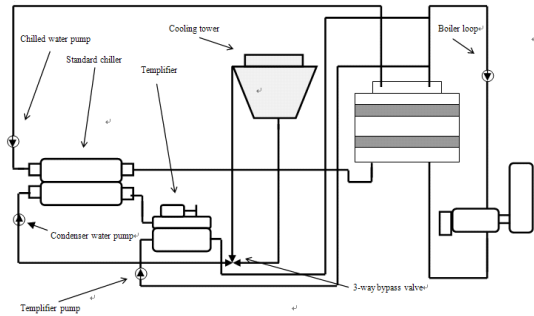


Fig. 7. Templifier application in split condenser heat recovery chillers.

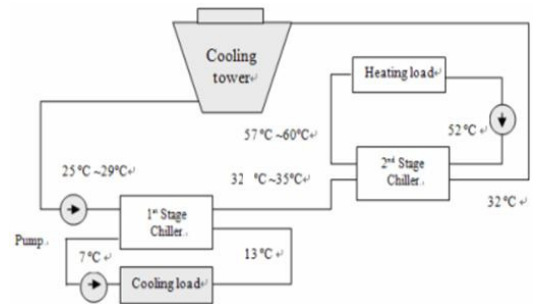


Fig. 8. Design for higher water temperature.

stage chiller in series for higher heating from water temperature up to 60°C. Heat removed from the cooling then delivered to the heating load through the following water circuit loop, cooling tower, the first stage chillers condenser, the second stage chillers evaporator, cooling tower. If the heating load could not match the cooling load, the cooling tower rejects any leftover heat to the atmosphere.

## 8. Conclusions

Water heat recovery through condenser could be used whenever there are simultaneous heating and cooling loads. Heating load could be either for domestic hot water or building heating. Using split condensers in the heat recovery system produces higher temperature water and the heat recovery chillers can provide more heat with less efficiency than operating in cooling only mode. Therefore, the major concerns of heat recovery system and the two chillers overlap in series can control the water heat recovery and higher water temperature.

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