Utilization of the Heat Pump in Water Cooled Chiller Systems in Oman: Potential and Challenges

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Abstract

The volume of water that is used in open-circuit cooling towers is very large. This is mainly because the warm water that is pumped to the cooling tower will be evaporated to reject the heat, causing the remaining water to be cooled. It was indicated that water lost by evaporation is around 70 % that will be compensated by adding fresh makeup water. The more water that is evaporated, the great the fresh makeup water is added. On the other hand, dirt, dust and bacteria may accumulate in the cooling tower basin leading to form a mud and sludge. Therefore, a chemical treatment process for the main supplied water to the cooling tower should be done to maintain the condenser water quality and to avoid the accumulation of solid particles and bacteria activities in the basin of the cooling tower. The limitations of the cooling towers are the issues related to water level maintenance, scales, deposits, corrosion and bacteria activities. If these issues are not well controlled, then serious problems are expected to be taken place in the heat exchange system, particularly through increasing of water consumptions, corrosion and instability of heat transfer. To overcome these obstacles, this research study is designed to investigate the potential and challenges associated with utilizing the heat pump to replace cooling towers in water cooled chillers that operate in hot climate conditions.

The preliminary step was to evaluate the performance of an existing water cooled chiller system in Oman, where the data haven collected and analyzed to understand the operation conditions of the existing cooling system, which are air and water temperature, humidity, makeup water and power consumption. After that, alternatives solutions were generated and evaluated using the collected data of the existing cooling system. Comprehensive thermodynamics calculations for each alternative were implemented to evaluate the optimal alternative solution. The selected alternative solution. i.e. heat pump water-cooled chiller system was experimentally investigated, where the pressure, temperature and enthalpy values were measured at different cooling loads using thermodynamics tables of water and refrigerant 134-a. Heat rejection, heat absorption, power consumption, and the coefficient of performance were then calculated. Scaling up was introduced to meet the actual heating load. The results showed that utilization of the heat pump will reduce water consumption to 0% relative to the equivalent system using cooling towers. The heat pump water-cooled chiller system performance was found to be better than using a cooling tower, in terms of lower power consumptions and zero makeup water. The economic evaluation has been carried out and the heat pump was proved to be reliable, with a long-term performance at a lower cost.