CHEMTEX
INTERNATIONAL CHEMTEX CORPORATION

Technical Topics

Centrifugal Chiller Heat Transfer Efficiency

TT-034-0799

The primary goal of a cooling system operator is to achieve and maintain the optimum operating efficiency of the system. A well-designed cooling water treatment program is integral to this process. The treatment program must protect all components of the system to optimize heat transfer efficiency within the cooling system.

In a cooling system utilizing a centrifugal chiller, the chiller is the system component that consumes by far the most energy, thus it is the focal point of the water treatment program, particularly where the prevention of deposition is concerned. A layer of scale $^{1}/_{64}$ inch thick on the condenser tubes can increase electrical usage in a centrifugal chiller by as much as 33%. Biofilms can decrease condenser heat exchange efficiency to an even greater degree. Thus it is of paramount importance to assure that chiller heat exchange surfaces are maintained in a clean condition.

DATA RECORDING

To assure that the water treatment program is successful in maintaining clean heat transfer surfaces, it is necessary to collect and record accurate temperature and pressure data around both the condenser and the evaporator. Since temperatures and pressures will vary based on cooling load, it is imperative that the load be stabilized before data is collected. The data necessary for an evaluation of the efficiency of a centrifugal chiller are as follows:

1. Water temperature entering the condenser.
2. Water temperature leaving the condenser.
3. Liquid refrigerant temperature leaving the condenser.
4. Condenser pressure and corresponding temperature.
5. Water pressure differential across the condenser.
6. Water temperature entering the evaporator.
7. Water temperature leaving the evaporator.
8. Liquid refrigerant temperature in the evaporator.
9. Evaporator pressure and corresponding temperature.
10. Water pressure differential across the evaporator.

These temperatures and pressures should be recorded when the chiller is operating at a stable cooling load with clean heat transfer surfaces. This set of data will represent baseline conditions. Subsequently, when data is collected for purposes of evaluating chiller operation, the baseline cooling load should be duplicated.

PERFORMANCE DIAGNOSIS

Condenser Evaluation

- Increased approach temperature between liquid refrigerant and leaving water indicates water-side fouling. With clean tubes, approach temperature will typically vary from 10^{o} F at 100% load to 1^{o} F at 10% load. This emphasizes the importance of duplicating the baseline load conditions when comparing approach temperatures.

- A lower-than-expected approach temperature, accompanied by high condenser head pressure, high leaving condenser water temperature and higher-than-normal condenser water temperature differential indicate insufficient condenser water flow rate.

- A smaller condenser water temperature differential along with a high approach tem-

perature indicates excessive condenser water flow rate.

- If head pressure is high, and approach temperature and condenser water temperature differential are normal, consult the temperature/pressure table for the refrigerant in use. If the actual head pressure is higher than the theoretical pressure for the measured refrigerant temperature, non-condensable gas is present in the refrigerant, and the system should be purged.

EVAPORATOR EVALUATION

- Low approach temperature and higher-than-normal entering/leaving temperature differential indicate insufficient water flow. Typical full load approach temperature for single pass evaporators is 10 – 12° F; for two pass typical approach is 6 – 8° F; three pass is 5 – 7° F; four pass is 4 – 6° F. These approach temperatures will drop as load decreases. The minimum acceptable flow rate through the evaporator is 3 feet per second (fps).

- High approach temperature and smaller-than-normal entering/leaving water temperature differential indicate excessive water flow rate through the evaporator. Maximum flow rate should not exceed 11 fps.

- High approach temperature with periodic trip out of low temperature control indicates evaporator water-side fouling. It should be noted that glycol use in the chill water loop will result in higher-than-normal approach temperatures and a decrease in chiller efficiency. Also, a shortage of refrigerant can cause high approach temperatures. If high approach is observed, refrigerant level should be checked first before automatically assuming that the evaporator water-side is fouled.

- High approach temperature, low evaporator temperature and pressure, and an inability of the chiller to produce the desired chill water temperature indicate either the presence of air in the chilled water system or a low refrigerant charge. If this set of symptoms is encountered, any air should be vented from evaporator boxes, and the refrigerant level should be checked.

To assure correct evaluation of data, all instruments used for determination of temperatures and pressures should be calibrated for accuracy. This data will serve as an indication of chiller heat transfer efficiency. A thorough evaluation of overall chiller efficiency can only be made by a qualified chiller service technician. A complete evaluation would include conducting a heat balance on the chiller and determination of the kilowatt/ton energy usage at various loads.