ABSTRACT

The system performance and supervisory control of direct-fired (natural gas) double-effect water-LiBr absorption chillers for commercial cooling applications is investigated using both computer simulation and field monitored data. Two direct-fired double-effect absorption chillers of 200 and 400 ton capacity at two different sites were monitored during the 1993 and 1994 cooling seasons and these data have been made available for this research. The transient simulation program TRNSYS was used for a system simulation consisting of models for a 400 ton direct-fired double-effect absorption chiller, a chilled and cooling water pump, a cooling tower, and a cooling water bypass valve. Optimal supervisory control of the chiller system was determined, and energy usage under optimal control was compared to other control strategies.

A steady state computer simulation model of a direct-fired double-effect water-lithium bromide absorption chiller in parallel flow configuration was developed from first principles using an equation solver program, EES-Engineering Equation Solver. Unknown model parameters such as component nominal UA values were determined by matching the model's calculated state points and COP against manufacturer nominal full-load operating data and COP. After the UA values were determined, they were adjusted for part-load operation using the appropriate mass flow rates and accepted heat transfer correlations. The model compares favorably with manufacturer performance ratings for varying chilled and cooling water temperatures at full-load and part-load performance at nominal temperatures. The model can be used to predict the performance under different operating conditions for which manufacturer data are not available. A component model of a direct-fired double-effect absorption chiller was developed for TRNSYS using the performance results (COP curve fits) from the steady state mechanistic model. The results were normalized with respect to the

nominal parameters and include operation over a range of outlet chilled water and inlet cooling water temperatures, and chilled and cooling water flow rates.

A global optimization algorithm (statistical search method) recently implemented for use in TRNSYS was used to determine the optimal supervisory control of the absorption chiller system for different control options. Optimal supervisory control resulted in an approximate 15 to 21 percent reduction in the total energy cost for a week simulation compared to the base case control. Variable speed pumping for the cooling water resulted in a 27 percent decrease in the electric cost and 4.3 percent decrease in the total energy cost compared to a constant flow system. Optimal control of a two-speed cooling tower and the inlet cooling water temperature seems most attractive. Control laws for the inlet cooling water temperature, cooling water flow rate and cooling tower fan speed were developed from the optimal control investigation and are in good agreement with the optimal control results. Guidelines for control of absorption chillers are presented.

The obtained field monitored data were analyzed and portions of the raw data are presented. The field monitored performance of both absorption chillers and the supervisory controls have been evaluated and the performance of both chillers was less than expected. A number of operational problems were discovered. The 200 ton absorption chiller did not modulate the gas use as the load changes, and the 400 ton absorption chiller cycled excessively. The observed cycling is most likely due to improper and inappropriate controls, and the system piping and hydronic configuration.