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Verification of the universal thermodynamic model for cooling systems on two water chillers in the field

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ABSTRACT

An analysis and verification study was conducted into the Universal Thermodynamic Model for cooling systems, which claims to accurately assess the performance of all refrigerating machines from only a few, non-intrusive measurements. The model and its derivation were studied to confirm its applicability to vapour-compression water chillers and its accuracy was practically investigated via tests on two such chillers serving the air-conditioning system of an office building. The two chillers used employ reciprocating and centrifugal compressors, respectively.

The experimental method entailed recording a number of measurements under normal, or fault-free, conditions and, for each set of data, calculating the COP obtained directly from measurement and that predicted by the model. Comparisons between the two values for each data set were used as an indication of accuracy. The predicted COP for the reciprocating machine was shown to be very accurate with a 2.97% maximum difference between COP values, while that for the centrifugal chiller was even more precise, yielding a maximum difference of 1.14%.

An additional test was conducted on the centrifugal chiller that simulated an operational fault – excessive fouling in its condenser – and the model showed the presence, though not the nature, of this simulated fault. Comparisons between key constants and graphs obtained under normal and throttled conditions allowed for some fault diagnosis. The predicted and measured COP values under the faulty conditions were also calculated and shown to correspond within 2.45%.

The Universal Thermodynamic Model proved to be an accurate and reliable performance assessment tool for the two chillers. In every case the difference between predicted and measured COP was less than the experimental uncertainty of the latter. It was also shown that the model could be used for limited fault diagnosis through simulation of a practical operation defect and analysing certain parameters. Practical recommendations for similar future work are provided based on experimental shortcomings of this study.