Multivariable Control of Vapor Compression Refrigeration Systems. Part I: Dynamic Model

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A first-principles dynamic simulation model for the identification and control of vapor compression refrigeration systems is presented herein. The overall system simulation relies on the model development for each of the system components: heat exchangers (condenser and evaporator), variable speed compressor (VSC) and variable orifice electric expansion device (EEV). The heat exchangers sub-models were put forward based on the mass and energy conservation principles applied to each of the flow regions (superheated, two-phase and subcooled) according to a moving-boundary approach. Semiempirical models were also devised for the compressor and the expansion valve. The resulting set of differential-algebraic equations was solved by the ODE23S method for stiff set of differential equations. A purpose-built testing apparatus comprised of a variable speed compressor, a pulse-width modulated EEV and a device for varying the refrigerant charge was used to collect the required data for the system identification exercise. It has been found that the model reproduces quite well the experimental trends of the working pressures and power consumption even in conditions far from the operation point used for the system identification exercise, with a maximum deviation of ±5 %. In the second part of the study, the model was employed to design a controller that keeps the evaporator feeding and matches the thermal loads to the cooling capacity.