

Design and implementation of closed-loop PI control strategies in real-time for Linear ARMAX Models of Vapour Compression Refrigeration System using R600a Refrigerant

Abstract

The objective of the research undertaken in this paper is to design a control strategy using a Linear Auto-Regressive Moving-Average Exogenous (ARMAX), which is a mathematical modelling method in real time, which to be implemented into the closed-loop Proportional-Integral controller. The ARMAX model is developed using SIMULINK tool from the MATLAB R2020a software. The Vapour Compression Refrigeration System consists of an evaporator, an expansion valve, a condenser and a compressor which was modified to a variable speed compressor. This modification is required due to the usage of R600a refrigerant that has thermophysical properties that can be described as with a slight change in its pressure will cause a considerable change in its temperature [1]. R600a refrigerant was chosen for this paper, despite the difficulty is due to it is more environmental-friendlier refrigerant compared to other types of refrigerant [2]. Two types of ARMAX model were designed, the first type of ARMAX model will have a polynomial order of $n_a= 2$, $n_b= 2$, $n_c= 1$ while the second type of ARMAX model will have a polynomial order of $n_a= 2$, $n_b= 2$, $n_c= 2$. Both types of controller were tested and compared the performance in terms of settling time, steady-state error, overshoot and peak-time. From the test conducted, it was found that the controller with the ARMAX model will have a polynomial order of $n_a= 2$, $n_b= 2$, $n_c= 1$ has a better overall performance.

Keywords

Auto-Regressive Moving-Average Exogenous (ARMAX) model; Closed-loop Proportional-Integral (PI) controller; R600a refrigerant; Vapour Compression Refrigeration System (VCRS)