AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
MECHANICAL POWER ENGINEERING DEPT.

PERFORMANCE OF A COOLING SYSTEM USING HYDROCARBON AS ALTERNATIVE REFRIGERANT FOR R22

A THESIS BY

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Submitted in Partial Fulfillment of the Requirements for the Degree of PhD in Mechanical Power Engineering

UNDER THE SUPERVISION OF

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Examiners Committee

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LIST OF PUBLICATIONS

- A. R. EL Sayed, M. EL Morsi, and N. A. Mahmoud, "Thermodynamic Analysis of a Simple Refrigeration Cycle Using Hydrocarbon Refrigerants as Substitute to R22," *Int. J. Adv. Eng. Manag. Res.*, vol. 2, no. 2, 2017.
- A. R. El-Sayed, M. El-Morsi, and N. A. Mahmoud, "A Review of the Potential Replacements of HCFC/HFCs Using Environment-Friendly Refrigerants", *International Journal of Air-Conditioning and Refrigeration*, vol.26 no.3, 2018, doi:10.1142/S2010132518300021.
- A. R. El-Sayed, M. El-Morsi, and N. A. Mahmoud, "Experimental Investigation of a Walk-in Refrigerator Performance using R290 as a Retrofit for R22", *International Journal of Air-Conditioning and Refrigeration*, vol.26 no.4, 2018, doi:10.1142/S2010132518500293.

CERTIFICATION STATEMENT

I declare that this thesis, submitted in partial fulfillment of the requirements for the award of the degree of PhD in mechanical Power Engineering, Ain Shams University, is wholly my own work unless otherwise is referenced or acknowledged.

The document has not been submitted for qualifications at any other scientific institution.

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ABSTRACT

For many decades, refrigerant selection and improvement were the scope of many researches in refrigeration technology. Starting with natural refrigerants like water, ammonia and CO_2, refrigerants had low thermodynamic properties and required high pressure to operate the refrigeration system. Refrigerants evolved until 1930's and CFCs were discovered. These fluids had better thermodynamic properties and were non-toxic and non-flammable. Later, the environmentally harmful effects of CFCs, HCFCs and HFCs appeared and a new generation of HC refrigerants appeared.

In this thesis, it is proposed to find an environment friendly substitute for the environment harmful refrigerant R22. An experimental work is conducted to find a suitable substitute for R22 such as R290. A test rig is constructed and equipped with measuring devices and data acquisition system to control it. The system is tested using R22 with a thermostatic expansion valve and electronic expansion valve. The system is examined at -12, -8, -4, 0 and 4ºC evaporator air temperature and 20, 25 and 30ºC condenser inlet water temperature. The compressor frequency varies from 30-50 Hz, while the frequency of the evaporator fans varies from 25-50 Hz. Finally, the sensible cooling load varies from 0-3.3 kW. These factors are used to provide a detailed indication on the following system performance parameters; pulldown time, ON-time ratio, compressor discharge temperature, refrigerant mass flow rate, evaporator rate of heat transfer, compressor power consumption, volumetric refrigeration capacity, coefficient of performance, daily energy consumption, second law efficiency and exergetic efficiency. Using the electronic expansion valve the system shows an improvement in certain parameters, but other performance parameters get worse.

The system is then retrofitted with a reciprocating compressor initially designed to be used with R290 and tested using an electronic expansion valve. The refrigeration system is tested at different evaporator and condenser temperatures, different compressor and evaporator fans frequencies and different sensible cooling loads. The results indicate that R290 is considered as an acceptable substitute for R22 that can operate more efficiently at the same conditions with lower daily energy consumption.

Keywords: Refrigeration, hydrocarbon refrigerant, efficiency, experimental data, energy consumption, coefficient of performance.

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