EXPERIMENTAL STUDY OF THE ENERGY CONSUMPTION IN THE REFRIGERATION PROCESS OF SMALL CABINETS

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Resumen

Este estudio muestra una comparación de las tecnologías de refrigeración de Difusión-Absorción (RDA) y Compresión de Vapor (RCV), usando un multímetro digital para medir corriente eléctrica y termopares para medir la temperatura en ambos refrigeradores. La tecnología RDA no requiere de compresor, por lo que es muy silencioso, usa una mezcla de amoniaco y agua como refrigerante y tiene convección natural en la cabina de refrigeración. La tecnología RCV es comúnmente utilizada para uso doméstico, opera con el refrigerante R134a, sin embargo, aun afecta el medio ambiente y contribuye al calentamiento global. Este sistema de refrigeración tiene mayor capacidad de refrigeración de 55W y el coeficiente de desempeño (COP) es 2.9. El resultado de la comparación de estos dos sistemas muestra que tienen diferente rapidez de enfriamiento, efecto de enfriamiento, consumo de energía y efecto en el medio ambiente. Especial atención en el tema del medio ambiente nos preocupa, variar de tecnología nos permitiría vivir con mayor conveniencia, pero el consumo de energía y materiales que estamos usando incrementan el efecto de gases invernadero. Por lo tanto, reducir el consumo de energía usando el mejor rendimiento del refrigerante y que sea más amigable con el medio ambiente, sin contaminación, conveniente, saludable y seguro requiere ser evaluado en la mejor selección de tecnología de acuerdo a la aplicación de refrigeración.

Abstract

The study develops a comparison of Diffusion Absorption Refrigeration (DAR) System and Vapor Compressor Refrigeration (VCR) System by using digital multi-meter to measure current and thermocouples to have a measurement in the refrigerators. In the Diffusion Absorption Refrigeration System doesn't have compressor, it is using ammonia/water with natural convection in the system, therefore it can reduce noise. In the Vapor Compression Refrigeration System is using refrigerant R134a, it is used for household refrigerator, but it still affecting environment and global warming. This system had largest cooling capacity of 55W and coefficient of performance is 2.9. In result of two systems, it has different performance of cooling speed, cooling effect, energy consumption and effect of environment. Environmental issue is the most important we are concerning, vary of technologies let ours living have more convenient, but the energy consumption and materials we are using increases greenhouse effect. Therefore, saving energy, using the high-efficiency environmental refrigerant without pollution, convenient, health and safety that must be evaluated in the selection of the technology for application.

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Palabras Clave Vapor compression refrigeration 1; Diffusion absorption refrigeration 2; Energy consumption 3; Global warming 4.

INTRODUCCIÓN

Global Warming

Refrigeration systems and air conditioners are using Hydrofluorocarbons (HFCs), it can affect global warming. The most important index of refrigerant is Ozone Depletion Potential (ODP) and Global Warming Potential (GWP), as index number is lower can reduce the impacts of environment (Tabla 1). [1]

Tabla 1: Refrigerants performance of air conditioning equipment.

Refrigerants	ODP	GWP100	Comment
1. R12	1	10900	Household refrigerator, Automotive air conditioning and Dehumidifier.
2. R22	0.055	1810	Air conditioning, Commercial freezer.
3. R134a	0	1430	Household refrigerator, Automotive air conditioning and Dehumidifier.
4. R410A	0	2100	Household air conditioning.
5. R290	0	~20	Household air conditioning.
6. R600a	0	~20	Household refrigerator, Automotive air conditioning and Dehumidifier.

Several equipment has used vary of refrigerants, used Hydrochlorofluorocarbons (HCFCs) on air conditioner and Chlorofluorocarbons (CFCs) on refrigerator, dehumidifier and automobile air conditioning. However, using these refrigerants will cause global warming seriously though the release of refrigerants and insulation blowing agents directly into the atmosphere and also through the release of carbon dioxide from the generation of electricity to power the system during its lifetime. [2]

Description of the VCR and DAR System

Vapor-Compression Refrigeration System (VCR)

Initially, vapor-compression refrigeration systems were large and were mainly used for ice making, brewing and cold storage. it lacked automatic controls and was steam-engine driven. The continued improvements made it possible to have vapor-compression refrigeration systems that were relatively efficient, reliable, small and inexpensive. [3]

In an actual vapor-compression refrigeration cycle, two common sources of irreversibilities are fluid friction causes pressure drops and heat transfer to or from the surroundings (IMAGEN 1). [4]

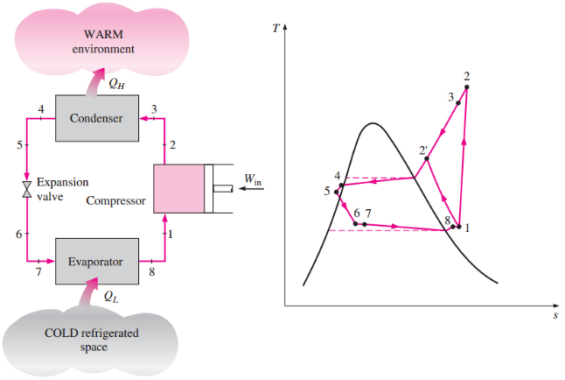

IMAGEN 1: Vapor-compression refrigeration cycle and T-s diagram.

The vapor compressor refrigeration system that has higher coefficient of performance (COP) value and lower thermal resistance. Adopted vapor compressor refrigeration in server equipment for better stability and efficiency of the system. The COP was between 2 and 3. Heydari et al. [5]

Diffussion Absorption Refrigeration System (DAR)

The most widely used absorption refrigeration system is the ammonia–water system, the refrigeration machines based on this principle were being built primarily to make ice and store food. [6]

In the DAR system, the compressor has been replaced by a complex absorption mechanism consisting of an absorber, a pump, a generator, a regenerator, a valve, and a rectifier (IMAGEN 2). Once the pressure of NH3 is raised by the components in the box, it is cooled and condensed in the condenser by rejecting heat to the surroundings, is throttled to the evaporator pressure, and absorbs heat from the cooling cabinet as it flows through the evaporator. [7]

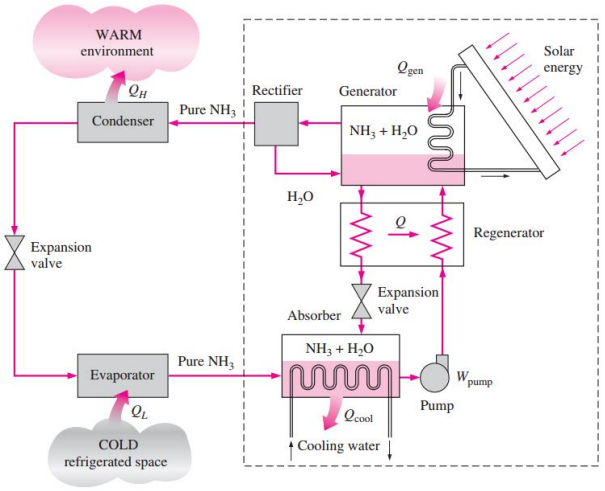

IMAGEN 2: Ammonia absorption refrigeration cycle.

MATERIALES Y MÉTODOS

In this study of energy consumption of refrigerators, it compares two different type of refrigerators, one of this is vapor compressor refrigeration (VCR) system, another is diffusion absorption refrigeration (DAR) system. Using four thermocouples in each refrigerator, and two left of thermocouples, one is for outside of the room, another is for inside the room. This is the equipment and materials we used (Tabla 2).

Tabla 2: Equipment and materials for the test.

Materials and equipment	Model	Quantity	Comment
1. C Series Temperature Input Module	NI-9213	1	16 channels
2. CompactRIO Controller	cRIO-9030	1	1.33 GHz Dual Core RAM: 1GB Hard Drive: 1GB
3. Refrigerator	Dometic RM2193	1	Absorption refrigerator
4. Refrigerator	Dometic CR65	1	Vapor compressor refrigerator
5. Digital Multimeter	MUL-630	1	PC – Link (USB connection)
6. Thermocouples	Type K	10	Error: +/- 2.2°C

We set up four of thermocouples at different position which located at low, medium, top and evaporator in the VCR and DAR cooling cabinets (IMAGEN 3), two of thermocouples are in inside of the room and outside of the room. However, thermocouples are connecting with temperature input module NI-9213, controller cRIO-9030 and computer. Running

Labview and software of PC-Link digital multimeter, it can monitor the system, record the temperature in one time per minute and collect the data of current in ten times per minute.

IMAGEN 3: VCR system (left) and DAR system (right)

T as or cooling c ed and 7 for s ere one day. T d c erators in D and VCR systems, evaluate heat removed in refrigerator and the most important is energy consumption issue we also could have the information in this study.

RESULTADOS Y DISCUSIÓN

VCR system and DAR system in low level case, the initial temperature is 28℃ (IMAGEN 4) and the maximum current of VCR system is 0.78A (IMAGEN 5), DAR system is 0.91A. In the DAR system doesn't have compressor, thus the variation of temperature is more stable than VCR system. But DAR system has more energy consumption to keep the cabinet from variable temperature (IMAGEN 6).

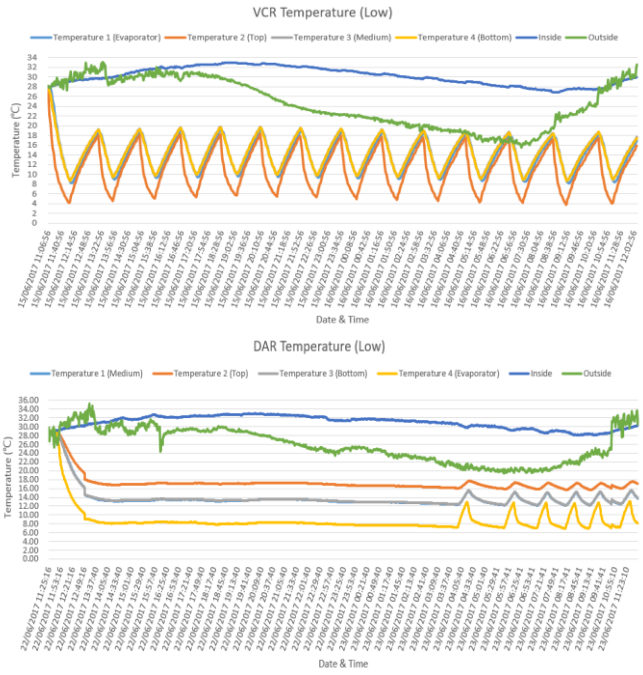

IMAGEN 4: Temperature of refrigeration systems in low level.

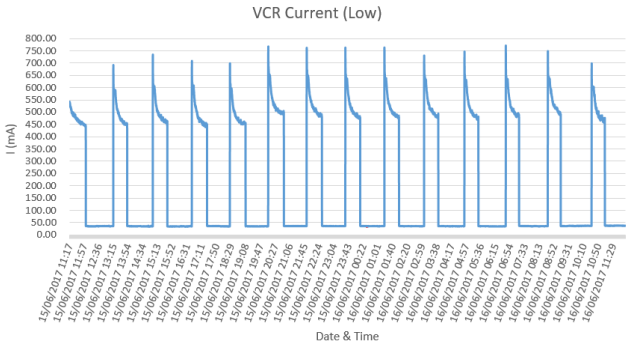

IMAGEN 5: Current of VCR system in low level.

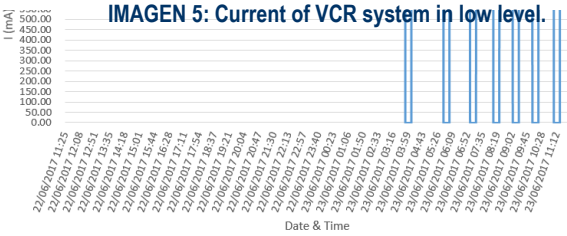

IMAGEN 6: Current of DAR system in low level.

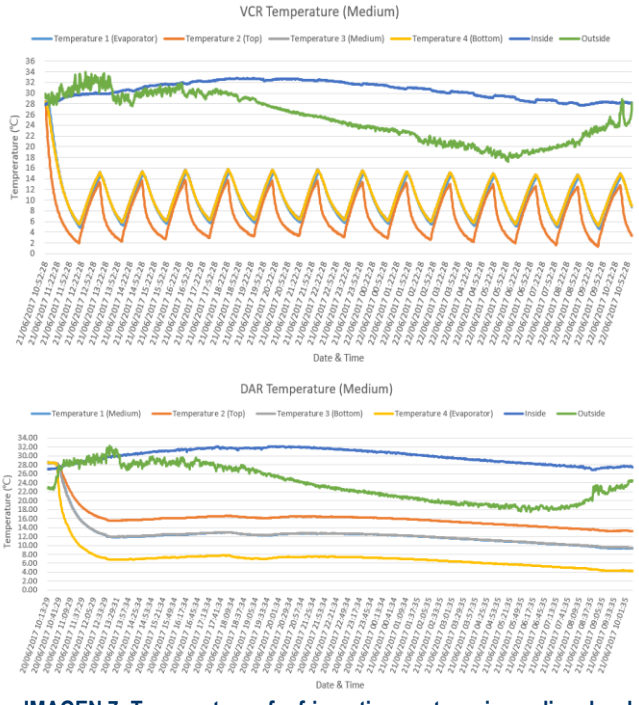

IMAGEN 7: Temperature of refrigeration systems in medium level.

In the medium level case, initial temperature of VCR system and DAR system is 28~28.4℃

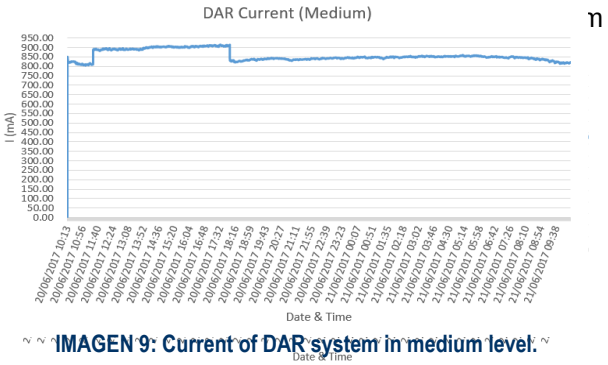

IMAGEN 9: Current of DAR system in medium level.

IMAGEN 8: Current of VCR system in low level.

Initial temperature of two system are 23~24 ℃ (IMAGEN 10), VCR system spent one and half hours on cooling cabinet, it is longer than medium level case (IMAGEN 11). DAR system used 0.85A to cool the cabinet for one day (IMAGEN 12).

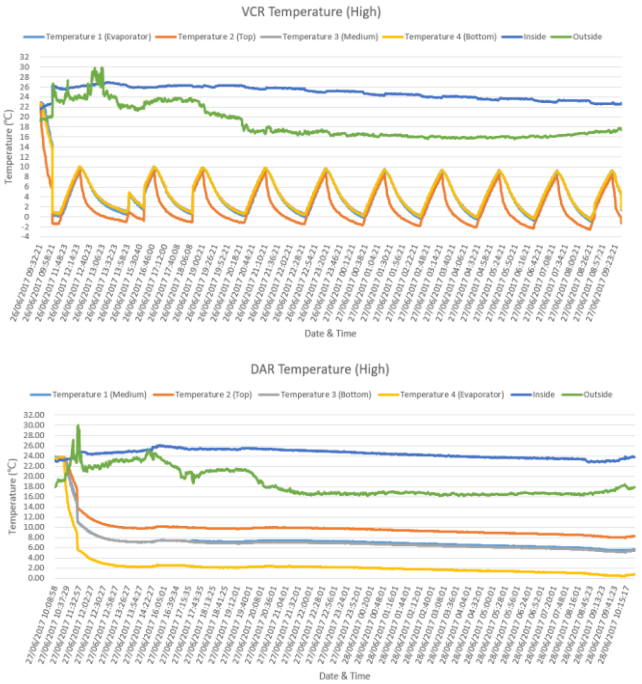

IMAGEN 10: Temperature of refrigeration systems in high level.

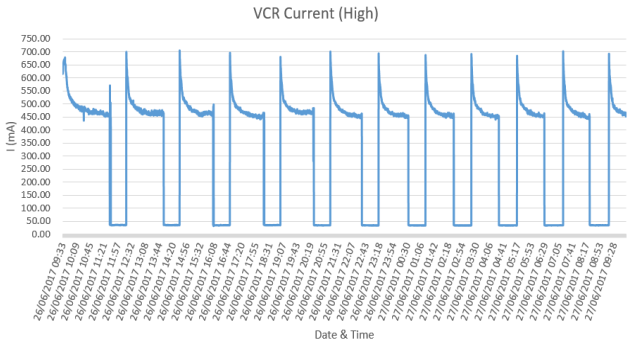

IMAGEN 11: Current of DAR system in high level.

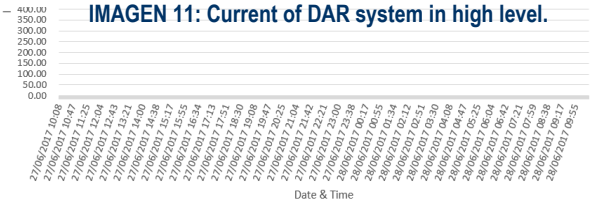

IMAGEN 12: Current of DAR system in high level.

DAR and VCR systems have different performance, energy consumption, refrigerant, cooling speed and purpose (Tabla 3).

Tabla 3: Comparison of refrigeration systems.

		Refrigerators	
		DAR System	VCR System
1.	Energy Consumption (per month)	71.4 (kW · h)	24.24 (kW · h)
2.	Averge Current (mA)	826.42	280.52
3.	Refrigerant	Ammonia/water	R134a
4.	Coefficient of Performance (COP)	0.12	2.14
5.	Cooling Speed	Slow	Fast
6.	Other	Silent	Noisy

7. Purpose	High quality hotels and hospitals	Household

CONCLUSIONES

In the two systems, DAR system consumes 71.4W and VCR system consumes 24.24W, DAR system costs 3 times more power energy, if DAR system combines with solar energy to replace the heat resistance and it can save more energy. VCR system, it used refrigerant R134a for the most refrigerators, we can use R600a to replace R134a in the future, it will keep greenhouse effect and global warming from growing up quickly.

DAR cooling cabinet costs 3 times energy to keep the temperature at low degree. VCR cooling cabinet uses the refrigerant R134a for cooling cycle. If refrigerator uses friendly refrigerant and controls frequency of compressor to reduce the energy wasting.

AGRADECIMIENTOS

The authors would like to thank many people who contributed to this study. I am grateful for the cooperation and the professor, Dr. Arturo, who took part in this project. It was not possible without his assistance, who supplied equipment for me and friendly study place, also taught me the knownology that I needed. Moreover, when I had questions, he always helped me to solve or find the answers.

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