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"EXPERIMENTAL STUDY ON EXPANSION VAPOR COMPRESSION REFRIGERATION SYSTEM (EEVCRS) FOR DOMESTIC REFRIGERATOR WITH MULTI EVAPORATOR"

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ABSTRACT

Refrigeration is a cyclic process that keeps the system temperature lower than the ambient temperature. According to the second rule of thermodynamics, heat cannot be moved from a low temperature to a high temperature in a cyclic process without external energy. The vapour compression cycle is commonly employed to produce refrigeration, and it requires a large amount of electrical energy to drive the mechanical compressor. For EEVCRS and VCRS, the COP rises as the degree of subcooling of the condensed refrigerant rises. For the identical input conditions with varied degrees of sub cooling from 5-20 °C, the COP for EEVCRS is 2.89-3.37, while it is 2.56-2.81 for standard VCRS. With increasing degrees of sub cooling from 5 to 20 °C, performance improves by around 14 percent over VCRS. According to the findings, the performance of EEVCRS is superior to that of traditional VCRS. EEVCRS is an excellent alternative to VCRS because of its efficient expansion work recovery.

Key Words: *Refrigeration, Cyclic Process, Heat, VCRS, EEVCRS*

I. INTRODUCTION

Refrigeration is a cyclic process that keeps the system temperature lower than the ambient temperature. According to the second rule of thermodynamics, heat cannot be moved from a low temperature to a high temperature in a cyclic process without external energy. The vapour compression cycle is commonly employed to produce refrigeration, and it requires a large amount of electrical energy to drive the mechanical compressor. Refrigeration is in high demand in a variety of fields, including air conditioning, residential refrigerators, deep freezers, ice manufacture, hospitals, hotels, pharmaceutical product maintenance, and so on. The invention of motors, which became the driving components for the compressors, marked the beginning of the genuine progress in refrigeration systems. The heat-transporting fluid is referred to as refrigerant. Chlorofluorocarbons (CFCs) like as R-12 and R-22 were the most common refrigerants utilised in these systems. However, studies have shown that the use of these refrigerants destroys the ozone layer in the stratosphere due to the reactivity of chlorine atoms in the refrigerants. As a result, research changed its attention over time to finding new CFC-free refrigerants. Hydro-chlorofluorocarbons (HCFCs) are the interim substitutes for CFCs, which destroy stratospheric ozone to a lesser amount than CFCs. Hydrofluorocarbons (HFCs) will eventually take the place of HCFCs. HFCs have no ozone depletion potential (ODP), unlike CFCs and HCFCs. R134, R410A, R407C, and R507 are some examples of HFCs. Other important criteria for an ideal refrigerant today are zero ozone depletion potential (ODP) and zero global warming potential (GWP).

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Different methods of refrigeration

- Vapor compression refrigeration cycle (VCR)
- Vapor absorption refrigeration cycle
- Air refrigeration cycle
- Thermo electric refrigeration system
- Ejector cycle

II. DESCRIPTION OF THE MODEL

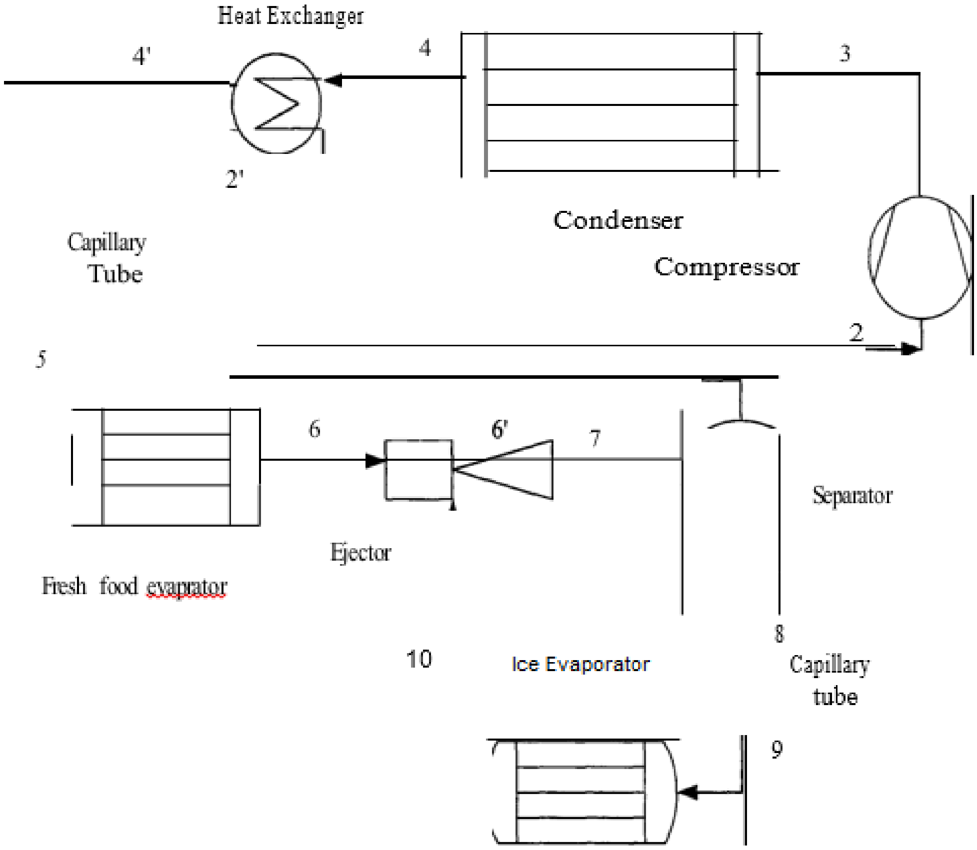

Figure 2.1. Schematic diagram of EEVCRS

Because the compressor inlet is low pressure vapour from the evaporator in conventional VCRS (Figure 2.1), a high compression ratio is desired to achieve the condenser pressure, whereas in EEVCRS, some pressure recovery is done by the ejector, requiring a comparatively low compression ratio to be maintained by the compressor. The compressor effort is reduced by proper pressure recovery in the ejector, and isentropic expansion boosts the cooling effect, boosting the COP. Many academics provide a full description of the ejector's design and operation. In this study, an ejector is a device that uses a two-phase primary fluid from a food evaporator to entrain a low-pressure secondary fluid from the evaporator to produce ice without the use of external energy. Motive fluid, or primary fluid, from the food evaporator expands at constant entropy (6-6') in the primary convergent-divergent nozzle.

III. VALIDATION OF THE MODEL

The acquired results are compared with numerical and experimental data from the literature in order to validate the existing model. Dalikilic et al.'s[8] experimental data at constant condenser temperature 50°C and evaporator temperature variations from -30 to 5°C validates the traditional VCRS. R-l34a is the refrigerant utilized. As demonstrated in Table 3.1, the variation in the current VCRS model is less than 1%..

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Table 3.1: *Comparison of simulated and experimental result for VCRS*

Evaporator Temperature (°C)	*-30*	*-20*	*-10*	*0*	*5*
Experimental results, Dalikilic et al.[38}	*1.81*	*2.25*	*3.1*	*4.1*	*4.7*
Simulated results	*1.892*	*2.318*	*3.08*	*4.063*	*4.72*

Huang et al. [8] used experimental data for an evaporator temperature of 8°C and boiling temperatures of 78, 84, and 95°C to validate the ejector's performance. Table 3.1 depicts the contrast. The findings obtained for the full vapour compression system using an ejector are compared to Wang et al. [5] for R600a at - 5°C for the food evaporator and -25°C for the ice evaporator while maintaining a refrigerating capacity ratio of 1.03. The same results were obtained for R600a using the same experimental data.

Table 3.2: Comparison of simulated and experimental result for ejector

Input conditions			**Simulated Entrainment ratio**	**Experimental Entrainment ratio Huang et** al. **[18]**	**Error %**
Pg, (Mpa)	**Tg, (°C)**	**AJ/At**			
0.604	95	8.28	0.28	0.2814	0.4
0.465	84	8.28	0.414	0.4241	2
0.4	78	8.28	0.481	0.4889	1.6

Effect of various parameters

The temperature of the fresh food evaporator and the ice evaporator, respectively, is -4°C and -20°C. The condenser temperature is 40°C, and the refrigeration capacity ratio (r) used in this system is 1.04, indicating that the ice evaporator has a higher refrigeration capacity than the fresh food evaporator. The study's compressor is a reciprocating single acting compressor with an 8-cubic-centimetre swept volume and a volumetric efficiency of 0.75. The compressor's motor spins at 2875 rpm. The refrigerant used in the study is R134a, with isentropic efficiencies of 0.9, 0.8, and 0.8 for the nozzle, mixing chamber, and diffuser, respectively. The temperature of the subcooling ranges from 5 to 20 degrees Celsius. Variables' effects on system performance are described as follows:

Effect of degree of sub cooling

For the given input parameters, the COP determined without sub cooling in the standard VCRS system and EEVCRS .

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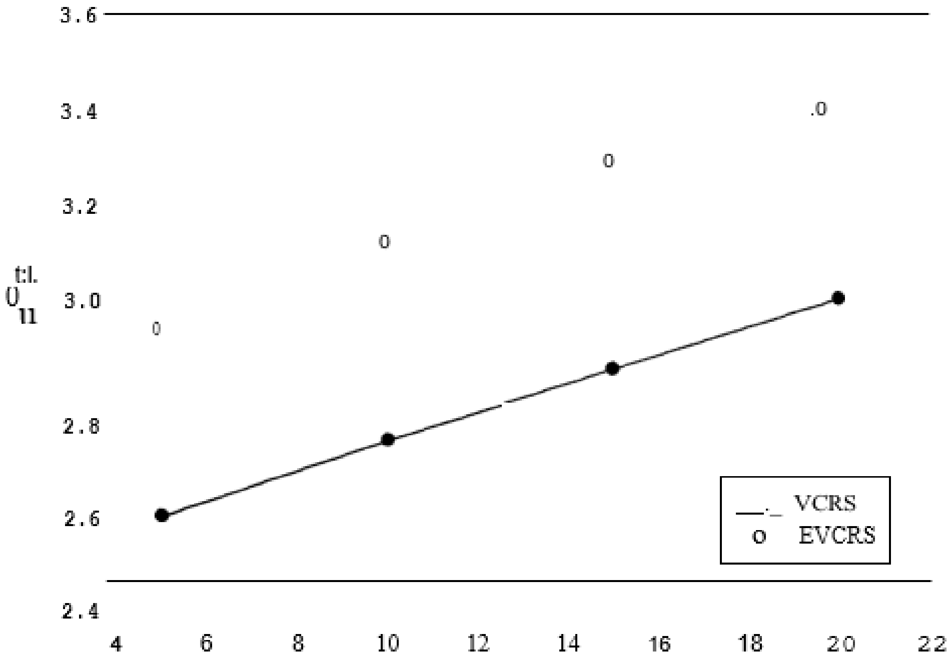

Figure 3.1: Variation of COP with degree of sub cooling

COP, entrainment ratio, pressure at diffuser output, volumetric refrigeration capacity, and EEUF are all functions of the degree of sub-cooling. Figure 3.1 shows the effect of the degree of sub cooling on the performance of EEVCRS and traditional VCRS when all other parameters are kept constant. When compared to traditional VCRS, the COP improves by 14%. The entrainment ratio and the pressure lift ratio are the most important factors in determining the COP of EEVCRS. The entrainment ratio is exactly reason of Entrainment & pressure lift Ratio, as seen in Figure 3.2 and Figure 3.3.

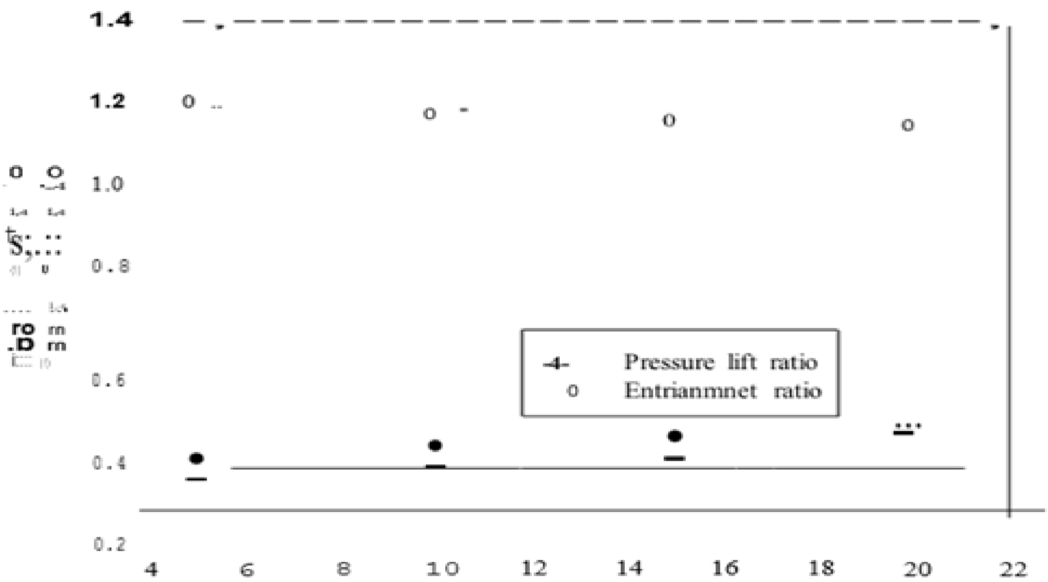

Figure 3.2. Variation of Entrainment & pressure lift Ratio

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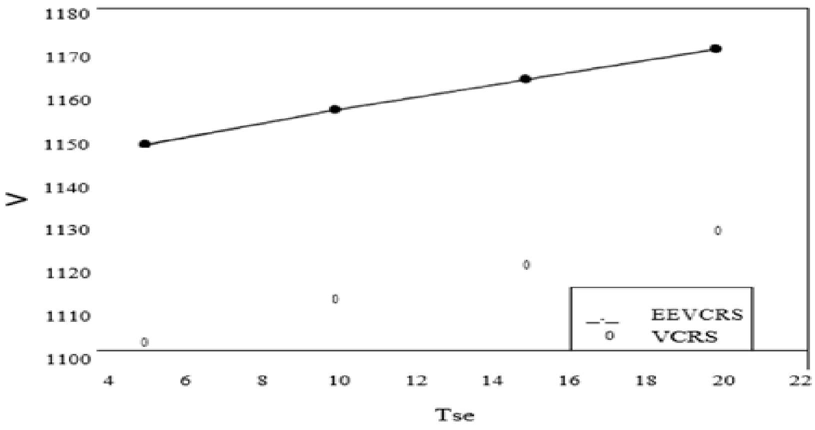

Figure 3.3 Variation of Entrainment & pressure lift Ratio

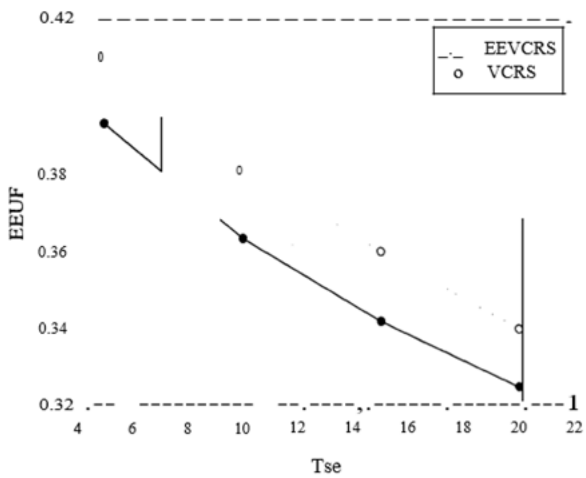

Figure 3.4: Variation of Entrainment & pressure lift Ratio

The volumetric refrigeration capacity (VRC) increases as the degree of subcooling is increased from 5 to 20 degrees Celsius, as illustrated in Figure 3.4. The Electrical Energy Utilization Factor (EEUF) falls as the degree of sub-cooling is increased from 5 to 20 degrees Celsius. This is because the refrigeration capacity of both evaporators has increased as the degree of sub-cooling has increased. The EEUF for VCRS is higher than that of EEVCRS.The findings show that EEVCRS outperforms traditional VCRS in terms of performance.

IV. CONCLUSION

The two-phase ejector cycle with low-pressure working fluid R134a was studied in this thesis. The COP enhancement of the EEVCRS for two-phase over the traditional VCRS in multi-evaporator household refrigerator was demonstrated using a numerical model. The ejector's excellent pressure recovery decreases the mechanical compressor's compression work by a significant amount. As a result, the use of an ejector as a two-phase expansion device is advantageous in a vapour compression system. The following are the primary results drawn from this research:

For EEVCRS and VCRS, the COP rises as the degree of subcooling of the condensed refrigerant rises. For the identical input conditions with varied degrees of sub cooling from 5-20 °C, the COP for EEVCRS is 2.89-3.37, while it is 2.56-2.81 for standard VCRS. With increasing degrees of sub cooling from 5 to 20 °C, performance improves by around 14 percent over VCRS. According to the findings, the performance of EEVCRS is superior to that of traditional VCRS. EEVCRS is an excellent alternative to VCRS because of its efficient expansion work recovery.

The temperature of the condenser and evaporator have an impact on the governing parameter of the ejector and EEVCRS. As the temperature of the condenser rises, the entrainment ratio falls and the pressure lift ratio rises. The

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system's performance improves as the condenser temperature drops, and it decreases when the evaporator temperature for the ice evaporator drops.

The degree of subcooling, condenser temperature, and evaporator temperature all affect the major ejector design parameters of entrainment ratio and pressure lift ratio.

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