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STUDY CONCERNING THE USE R32 IN THE AIR CONDITIONING SYSTEMS AND HEAT PUMPS

BY

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Abstract. The refrigeration and air conditioning industry has made tremendous progress over the past two decades in reducing the use of ozone depleting refrigerants. The original targets of the Montreal Protocol, established in 1987 to reduce emissions of ozone depleting substances, are being met and exceeded. Another consequence of these initiatives is that during the 1990s and the early part of the present century, there was considerable uncertainty regarding future refrigerant options. The work present a comparative study between the R32 and R22, R410A, R152a, R134a .

Key words: R32 refrigerant; GWP; heat pumps; cooling capacity.

1. General Considerations

The In view of the Ozone depletion and Global Warming phenomena, Montreal and Kyoto Protocols restrict the use of CFCs and HCFCs in the Air Conditioning Systems. The Montreal protocol has given a phase out schedule for the removal of R22 refrigerant from usage.

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For comparison of the theoretical data are chosen the following refrigerants R32, R22, R152a, R134a, R404A.

2. Analyzed Refrigerants

R22 is the most commonly used refrigerant in the world. R22 has been used in residential and commercial air-conditioners owing to its excellent chemical and thermodynamic properties. R22 contains Cl, and when it escapes contributes to the depletion of the ozone in the atmosphere.

R152a is a medium pressure refrigerant for the medium temperature refrigeration range. R152a is not used in its pure form because of its flammability (flammability limits 3.7-21.8% by volume in air). For this reason, R152a must be labelled as “highly flammable”. It is toxicologically safe and chemically stable.

R134a was introduced as the first refrigerant substitute. It may replace R12 in practically all applications, such as in household refrigerators, automobile air conditioners, heat pumps and commercial refrigeration. R134a is nonflammable and toxicologically safe.

R404A is a alternative for the CFC refrigerant R502. R404A is nonflammable, has a toxicity comparable to R502 and is thermally and chemically stable. The recommended TLV value for R404A is 1,000 ppm.

R32 demonstrates very good heat transfer characteristics. R32 has excellent thermodynamic properties as a refrigerant. In terms of refrigeration characteristics, it is similar to the refrigerants R502 and R22. R32 is toxicologically safe and extremely stable thermally and chemically.

In Table 1 are presented the refrigerants physical data.

Table 1
Physical Data of the Refrigerants

Refrigerant	Chemical formula or composition	Boiling point at 1.013 bar °C	Critical values	
			Temperatures °C	Pressures bar
R32	CH2F2	−51.7	78.1	57.8
R22	CHClF2	−40.8	96.1	49.9
R152a	CH3CHF2	−24.0	113.3	45.2
R134a	CH2FCF3	−26.1	101.1	4.06
R404A	R125/134a/143a (44/52/4)	−46.6	72.1	37.4

3. Method of Analysis

The study concentrates on a theoretical investigation on the performance of the vapour compression refrigeration cycle. The refrigerants R152a, R22, R134a, R404A were used as the working fluid for the comparison with the refrigerant R32.

The simulation has been done on a single stage vapor compression cycle. The conditions for the ideal refrigeration cycle are:

− the evaporating temperature t_0 = −30, −20, −10, 0, 10°C
− the condensing temperature t_k = 40°C
− the system capacity = 3.5 kW
− the compressor isentropic efficiency = 1
− the subcooling temperature = 5°C
− the superheating temperature = 10°C

The main parameters of performance analysis such as refrigeration capacity, mass flow rate, compression work, volume flow, pressure ratio, evaporating pressure are investigated for various evaporating temperatures ranging between −30°C and 10°C and a constant condensation temperature of 40°C.

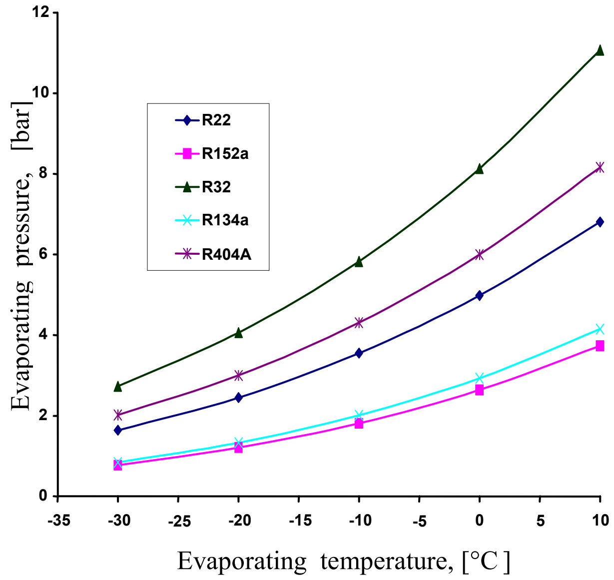

Fig. 1 − Evaporating pressure *vs*. evaporating temperature.

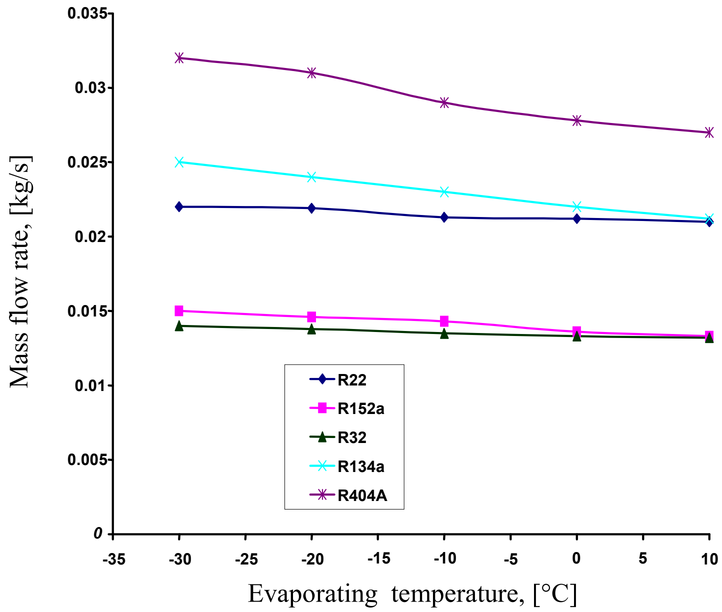

Fig. 2 − Mass flow rate *vs*. evaporating temperature.

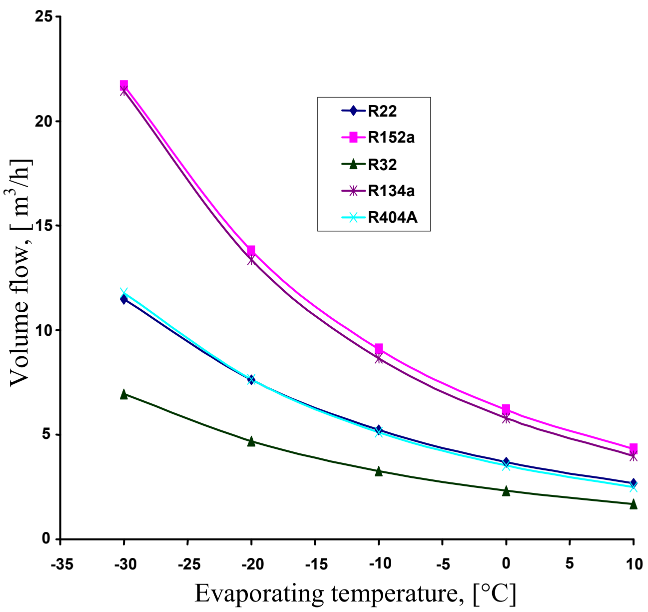

Fig. 3 − Volume flow *vs*. evaporating temperature.

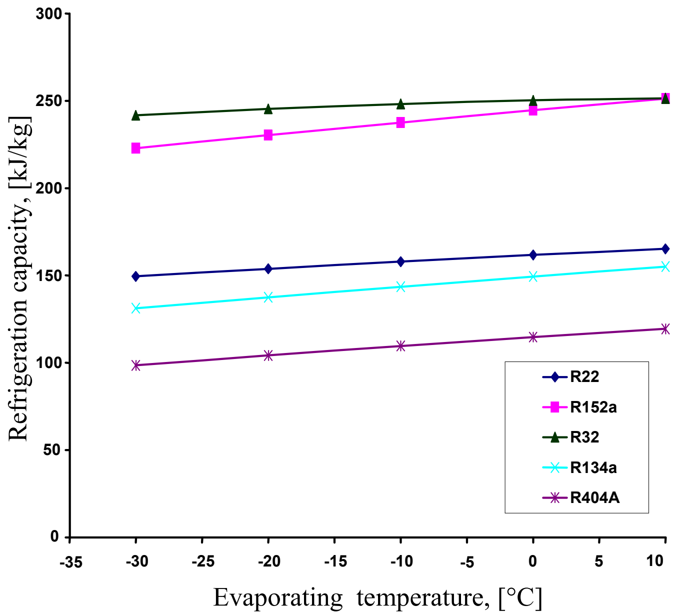

Fig. 4 − Refrigeration capacity *vs*. evaporating temperature.

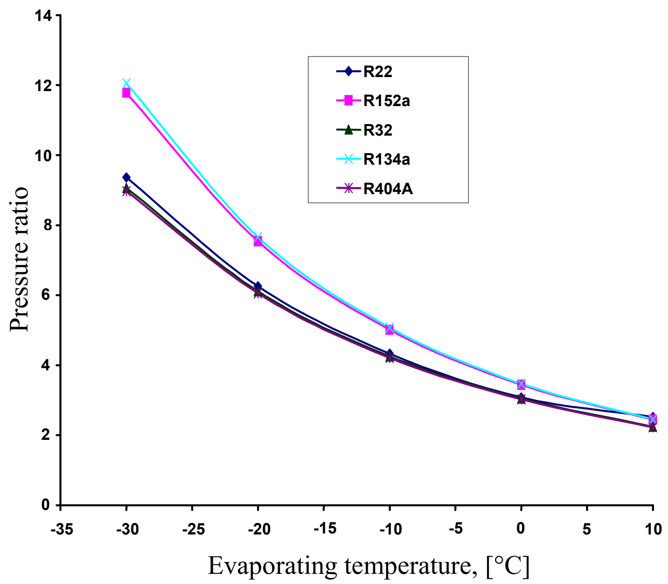

Fig. 5 − Pressure ratio *vs*. evaporating temperature.

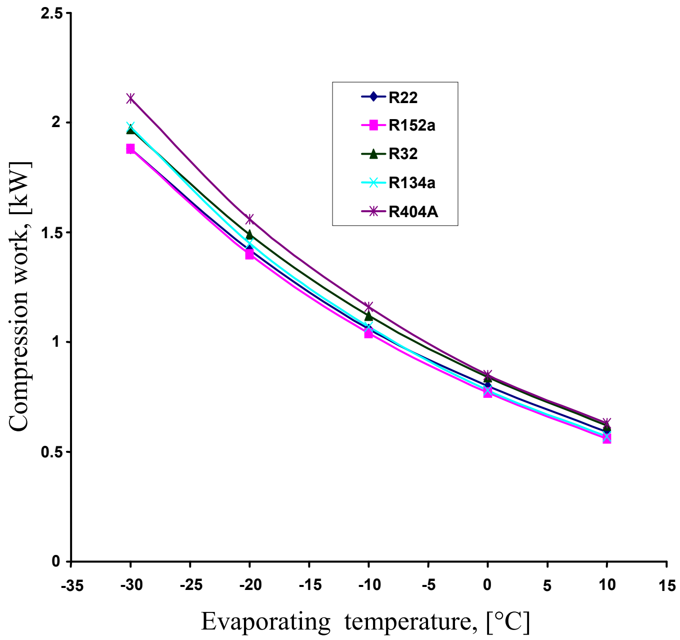

Fig. 6 − Compression work *vs*. evaporating temperature.

4. Conclusions

1. Looking to Figs. 1 and 5, we can see that despite the evaporating pressure of R32 refrigerant is the largest, the pressure ratio of the same refrigerant is one of the lowest, which leads to the conclusion that, from energetic point of view, R32 is very good for use in air conditioning systems.

2. In Fig. 2 the mass flow rate versus evaporative temperature is presented. From this figure it can be seen that, for the same refrigerating capacity, R32 presents the lowest mass flow rate. This is an advantage for using R32 like refrigerant in air conditioning device, because it leads to a smaller amount of refrigerant in refrigerating system. This graphic is in accordance with Figs. 3 and 4. Because R32 has a large refrigeration capacity, the mass flow rate (and the volume flow rate) will be small. Consequently, the pipes diameters will be smallest and, in the same time, the heat transfer surface area of the heat exchangers (evaporator and condenser) will be smallest. For example, if we consider an air conditioning system with R22, R410A and R32 like working fluids, if the volume ratio of external unit for R22 and R410A is 100%, for R32 will be 85-95% (ASHRAE Standard 34).

3. In Fig. 6 the compression work vs. evaporating temperature is presented. It can be observed that, despite R32 has the smallest mass flow rate and pressure ratio, the compression work is not the smallest. Due to isentropic

process slope, the enthalpy variation during compression process is larger than for other refrigerants considered in this study.

REFERENCES

*** ASHRAE Standard 34: *Designation and Safety Classification of Refrigerants.* American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 2004.

*** Cycle_D Vapour Compression Cycle Design. NIST Standard Reference Database 49 - Version 4.0.Gaithersberg, MD:National Institute of Standards and Technology, 2004.

*** Next Generation Refrigerants. A Daikin Perspective, www.daikin.ro.

Antunes A.H.P., Bandarra Filho E.P., Mendonza O.S.H., Souza L.M.P., Bertoni M.A.R., *Experimental Evaluation of Refrigerants R290, R32 and R410A in a Refrigeration System Originally Designed for R22.* 10th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics 14–16 July, 2014, Orlando, Florida.

Boloji B.O., *Experimental Study of R152a and R32 to Replace R134a in a Domestic Refrigerator*. Energy, **35**, *9*, 3793−3798, 2010.

Park K.J., Jung D.S., *Thermodynamic Performance of HCFC22 Alternative Refrigerants for Residential Airconditioning Applications*. Energy and Buildings, **39**, 675–680, 2007.

Park K.J., Seo T., Jung D.S., *Performance of Alternative Refrigents for Residential Air Conditing Applications*. Applied Energy, **84**, *10*, 985−991, 2007.

STUDIU PRIVIND UTILIZAREA AGENTULUI FRIGORIFIC R32 ÎN SISTEMELE DE AER CONDIȚIONAT ŞI POMPE DE CĂLDURĂ

(Rezumat)

Lucrarea prezintă utilizarea agentului R32 ca o alternativă pentru sistemele de aer condiționat rezidențiale. În comparație cu ceilalți agenți analizați (R22, R410A, R152a, R134a) agentul frigorific R32 dovedeşte proprietăți fizico-chimice superioare, pentru funcționarea în sistemele de aer condiționat. Agentul frigorific R32 nu are impact asupra mediului, nu este inflamabil şi este extrem de stabil din punct de vedere termic şi chimic.