THEORETICAL COMPARATIVE STUDY CASE, HYDROCARBONS, DME AND HFC MIXTURE ALTERNATIVES RETROFIT

TEORIJSKA KOMPARATIVNA STUDIJA SLUČAJA - MODERNIZACIJA U KOJOJ SE KORISTE UGLJOVODONICI, DME (DIMETIL-ETAR) I NJIHOVE MEŠAVINE KAO ALTERNATIVE HFC-U

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This paper focuses on the natural alternatives: hydrocarbons DME and their mixtures. Determination of thermodynamic properties and calculation of COP for natural alternatives and mixture were done using the Refprop and EES software. The theoretical study analyzes an air-water heat pump which currently uses R134a as the working fluid. In order to implement the international Legislation, the R134a refrigerant will be replaced with a natural hydrocarbon or ecological refrigerant mixture (with better ODP and GWP). Another important aspect is that energy efficiency is directly related to global warming and greenhouse gas emissions.

Keywords: *ecological refrigerant mixture; TEWI factor; GWP*

Ovaj rad se bavi prirodnim rashladnim fluidima kao alternativnim fluidima: ugoljvodonicima, DME (dimetil-etar) i njihovim mešavinama. Određivanje termodinamičkih svojstava i izračunavanje koeficijenta učinka (COP) za prirodne alternative i njihove mešavine vrši se korišćenjem softvera Refprop i EES. U teorijskoj studiji analizira se toplotna pumpa vazduh-voda koja trenutno koristi R134a kao radni fluid. U cilju sprovođenja međunarodnih propisa, rashladni fluid R134a će biti zamenjen prirodnim ugoljvodonikom ili mešavinom ekoloških rashladnih fluida (koji imaju bolji ODP (potencijal slabljenja ozonskog omotača) i GWP (potencijal globalnog zagrevanja). Drugi važan aspekt jeste da je energetska efikasnost direktno povezana sa globalnim zagrevanjem i emisijom gasova staklene bašte.

Ključne reči: *ekološka mešavina rashladnih fluida; faktor TEWI; GWP*

1. Introduction

To eliminate several types of refrigerants CFC, HFC and HCFC synthetic substances which nature cannot dissociate rapidly and accumulate contribution to global warming and ozone depreciation is made intense research, which analyzes various alternative mixtures.

DME's is one of the refrigerants which used to be used but was dropped at some point because of its main disadvantage (flammability). However due to its qualities (low saturation pressure, high latent heat of vaporization, no emissions and does not destroy the ozone layer) the use of DME's and its mixtures as heat thermodynamic systems is of great interest.

DME is the ecological refrigerant which can be used as a replacement in small and medium refrigeration systems (refrigerators, air conditioning, etc.) having a lower boiling point, better vaporization and a lower price. Another goal is to reduce the amount of refrigerant for a convenient operation of the system and to use refrigerants with low global warming potential. In Table 1 and the graphs in Figures 1, and 2, one can see both the critical and substitute molar mass of the refrigerants and the advantages of each of the two suggested alternatives: Alternative1, Alternative 2 (such as low pressure and high latent vaporization).

Table 1. Thermodynamic properties of R134a and the suggested ecological alternative [1, 2, 3, 4]

Refrigerant	R134a	Alternative 1 R134a /DME (60/40%)	Alternative 2 R134a /DME (80/20%)
Critical temperature [^{o}C]	101.06	119.11	112.89
Critical pressure [bar]	40.59	48.001	45.077
Critical density [kg/m^{3}]	511.9	383.09	440.1
Molar mass [kg/kmol]	102.03	68.66	82.088

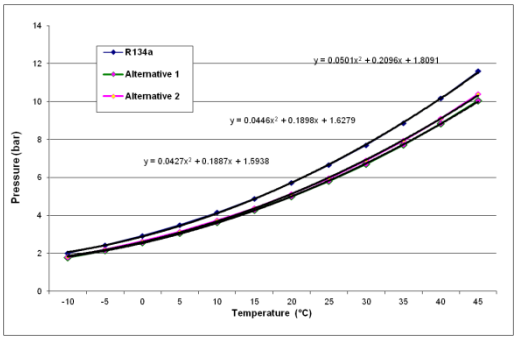

Fig.1 Vapor pressure refrigerants vs. temperature

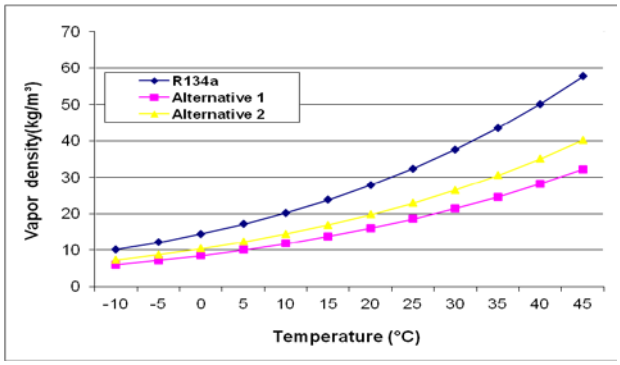

Fig. 2 Vapor density refrigerants vs. temperature

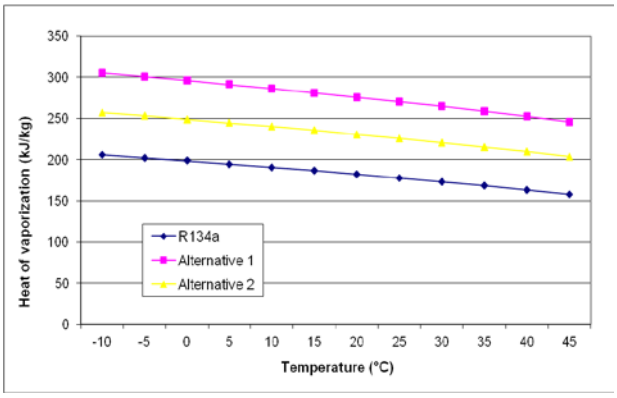

Fig. 3 Heat of vaporization vs. temperature

In Figure 1 and Figure 2 the vapour pressure and density differences versus temperature of the suggested replacement refrigerants.

2. Theoretical study

The study compared several configurations of the air-water heat pump [5, 6] in terms of its contribution to global warming. The analysis was performed for two ecological alternative refrigerants mixtures (with ODP and low GWP) as replacement for R134a. Comparative analysis was done between the TEWI factors of an air-water heat pump working with R134a and 2 ecological alternatives (Alternative 1 - 60/40% and Alternative 2- 80/20%).

The theoretical study of the heat pump was made at a vaporization temperature t0 = -10 ° C and a condensing temperature tc = +45 ° C.

The TEWI factor was determined taking account of the Standard SR EN 378-1[3]:

The paper exposes (depending on the amount of refrigerant and power consumption) the total equivalent warming impact of refrigeration system that works with refrigerants R134a, Alternative 1 (R134a/DME) and Alternative 2 (R134a/DME).

The following assumptions were made to calculate the TEWI factor: mass of Ecological Alternative 1 – 0.583kg, Alternative 2 – 0.670kg and 0.780 kg for R134a. The refrigeration system operated 24 hours per day, 365 days per year. The leakage of refrigerant was 8% from refrigerant charge with a recovery factor of 0.75. Operating time of the system was 15 years, and the CO2 emissions were 0.6 kg / kWh.

3. CONCLUSIONS

The comparative study of the air-water heat pump ensued with obtaining viable alternative refrigerants. Ecological alternative 1 (R134a/DME) has the best TEWI factor (GWP = 781.2)]. A disadvantage of this mixture of DME is that it is placed in group component safety A3 in terms of flammability.

On the other hand, the latent heat at vaporization of alternative 2 (R134a / DME) has the advantage.

In terms of cost, the refrigerant mixture (Alternative 1) is more convenient.

Table 2. The theoretical results

Refrigerant	R134a	Alternative 1 R134a /DME 60/40	Alternative 2 R134a /DME 80/20
Refrigerant charge [kg]	0.780	0.583	0.670
ODP	0	0	0
GWP	1300	781.2	1040.6
TEWI Tons of CO_2	31192.98	22991.81	26423.83

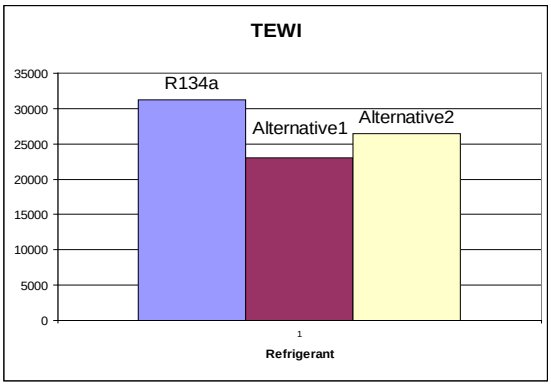

Fig. 4 TEWI factor was shown in the study case

4. References

[1] ASHRAE – Thermophysical Properties of Refrigerants, -Chapter 20, 2009

[2] Regulation (EC) No 842/2006 of the European Parliament and of the council on certain fluorinated greenhouse gases.

[3] Standard European EN 378-1:2008

[4] National Institute of Standards and Technology (NIST) - REFPROP V 8.0, Reference Fluid Thermodynamic and Transport Properties

[5] Ţârlea G. M., Vinceriuc M., Tarlea A., Popescu G., Theoretical Comparative Study Case, Hydrocarbons and HFC Mixture Alternatives Retrofit, The 10 th IIF/IIR Gustav Lorentzen Conference on Natural Refrigerants, Delft, The Netherlands, June 25-27, 2012

[6] Ţârlea G. M., Vinceriuc M. - Alternative ecologice de agenti frigorifici pentru o pompa de caldura aer-apa, Volumul Conferintei Tehnico - Stiitifica cu participare internationala, ,,Instalatii pentru constructii si economia de energie", Editia XXII, 5-6 iulie Iasi 2012, Editura Societatii Academice ''MATEI-TEIU BOTEZ" ISSN 2069-1211;