Performance Comparison of CFC12, HCR12 and HCR12^{+LFS} as Refrigerants

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ABSTRACT

Additional concern about warming of the global environment through the greenhouse effect has necessitated selection of compounds with shorter atmospheric lifetimes and higher energy efficiencies as substitute refrigerants for Heating, Air Conditioning, and refrigerating equipment.

Several substitute compounds of the hidrocarbon were identified by similarities in normal boiling points and corresponding saturated vapor pressure characteristics. Sample quantities were obtained from ITB (Two sample corresponds with CFC12 named Hycool HCR12 and Hycool HCR12^{+LFS}). Performance comparisons among these refrigerants are performed utilizing Air Conditioning System test facility in Laboratory for Thermodynamics, Engines and Propulsion System (LTMP - BPP Teknologi). The results show that these alternatives refrigerants exhibit better performance than CFC12 at the predetermined operating conditions.

Introduction

Indonesia has ratified the Montreal Protocol and its Amendment in 1992, and has decided to ban the commercialization of the CFC started from January 1, 1997. CFC phase out has been creating a strong impact, particularly to those who use the refrigeration. To assist the users in solving to the problem in extending the use of existing refrigeration, various activities related to this purpose has been launched.

The use of R 134a and other equivalent HCFC blends are now becoming popular since most of refrigerators and Air Conditioning system manufacturers are Japanese companies who substitute the R12 with those refrigerants on new products. As an alternative, the Inter University Research Center for Engineering Sciences (IURC-ES, ITB) together with other institutions have launched a program to popularize the use of Hydrocarbon (HC) as R12 drop-in substitute with particular emphasize on the service sector through retrofitting of the already used equipments. The use of HC as substitute refrigerant of R12 for several applications such as for domestic refrigerators, large-scale milk cooling units, automobile Air Conditioning (AC), stationary AC and other related activities have been reported and discussed [1-3].

It was shown that the HC applications as refrigerants in those refrigeration units since 1996 have shown several advantages such as the improvement of performance, no need major replacement of equipment, more competitive refrigerant cost, etc. The disadvantageous flammability risk which is higher than CFC or HFC, for many cases can be avoided by implementing the appropriate standards. One among guideline to use HC safely is to avoid the Low Explosion Limit (LEL) when the HC leaks out from the refrigeration/AC units. The restriction of maximum refrigerant charge related to the volume of space to where refrigerant could leak out is one among the parameters be considered during the refrigerant conversion. For some particular applications this restriction is becoming a constraint.

The development of HC based refrigerant with higher LEL has been developped by IURC-ES ITB on the name of $HCR12^{+LFS}$ and $HCR22^{+LFS}$. The present of HC is only approximately 40 % by weight therefore it will be appropriate to reduce the flammability of refrigerant at least from the HC charge reduction.

This paper present the results of performance test of $HCR12^{+LFS}$ as refrigerant and its comparison to that of CFC12 , and hydrocarbon refrigerant HCR12. The tests are performed as a co-operation program between IURC-ES ITB and Laboratory for Thermodynamics, Engines and Propulsion Systems (LTMP - BPP Teknologi).

Performance Testing of Air Conditioning System.

In order to compare the performance of an air conditioning system utilizing $HCR12^{+LFS}$ as refrigerant to that of CFC12 and HCR12, AC system test facility in LTMP - BPP Teknologi located in Serpong is used as the test object.

The system comprises of AC system components set up in a closed refrigerant loop/circuit as can be seen in Figure 1. The evaporator is installed at the end of an air tunnel providing regulated air-flow in accordance with the required condition. Air-flow, temperature and humidity across the evaporator is set in accordance with the test requirements, simulating the cooling load. Heat sink for the condensor is a closed water loop integrated with chilled water system as is seen as secondary circuit 1 in the figure.

Temperature and pressure sensors are installed at inlet and outlet sides of each component. For refrigerant flow measurement, a coriolis flowmeter is installed in condensor outlet. Specification of the main components in the test system are as follows :

1. Compressor : Open type/ reciprocating, 15 kW maximum power, 2980 rpm
2. Evaporator : Finned tube type, 16 kW max thermal capacity, with dimension of 890 x 531 x 270
3. Condensor : Vertical shell and coil type, 26 kW max thermal capacity, 400 mm length, 219 mm diameter
4. Expansion valve : Needle valve type.

On refrigerant charging, water temperature in secondary circuit for condensor cooling is set to 26° C and water flow is set to 0.61 kg/s. Air temperature in secondary circuit for evaporator loading is set to 27° C with airflow of 0.6 kg/s and air humidity of 75 %. The condition is maintained during the test .

To get approximately similar condition, refrigerant charging is performed until the following condition are achieved : condensation temperature of 39° C and evaporation temperature of 1° C . Ambient temperature during the test is 30 – 31 ° C , and humidity of 88 %. This condition is set as basic test condition for performance comparison of the refrigerants.

Performance comparison of CFC12, HCR12 AND $HCR12^{+LFS}$

Test conditions for comparison purposes are set to be similar for these three different refrigerants, and the results show the differences in performance parameters for these refrigerants.

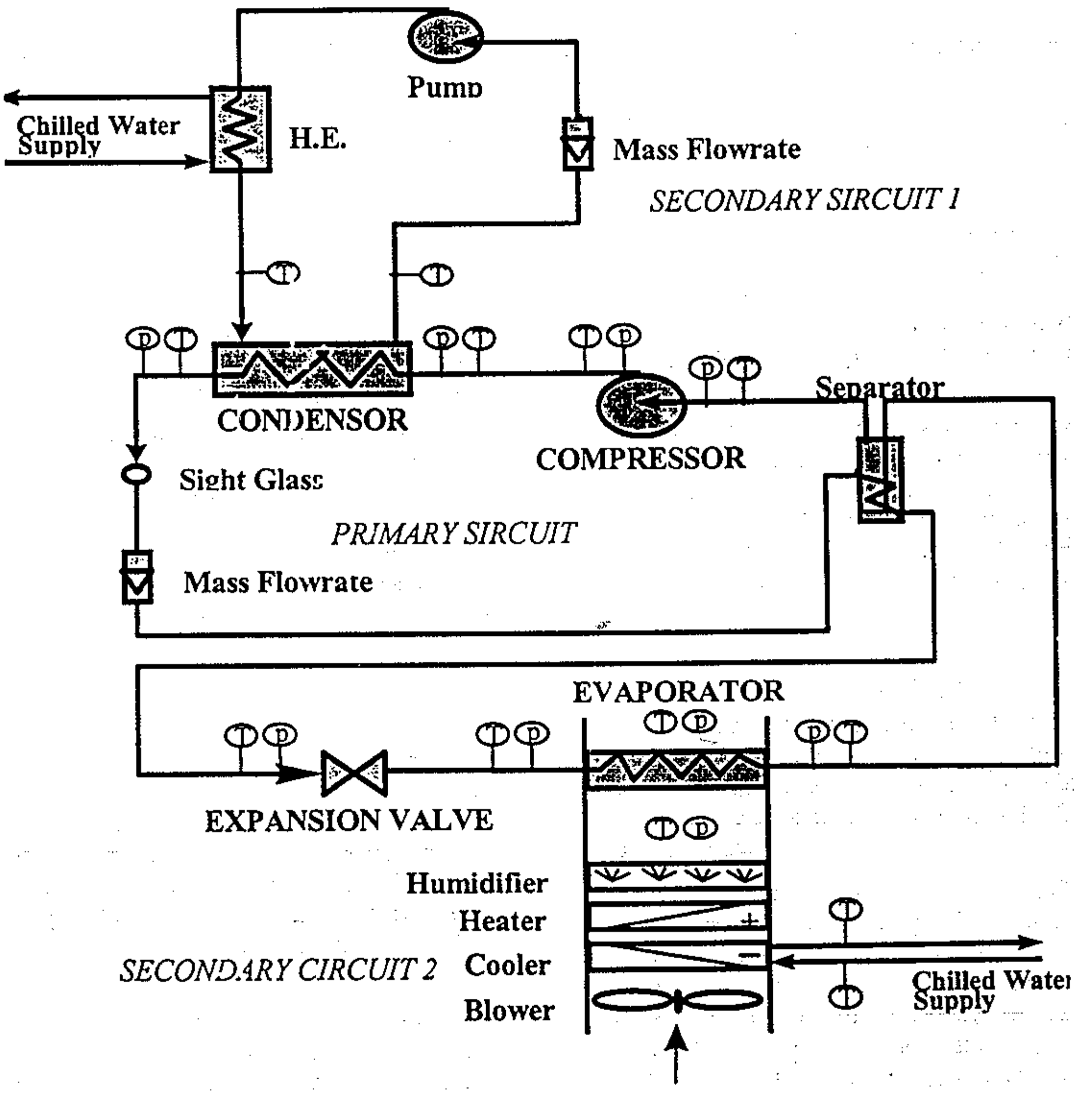
Table 1 summarize the performance comparison between CFC12, HCR12 and $HCR12^{LFS}$ for the above set condition. Limited information on physical properties for these alternative refrigerants make it difficult to evaluate the coefficient of performance for these refrigerants using the refrigerant side refrigerating effect and compressor thermal power. Therefore, the measured air-side refrigerating effect and measured compressor electrical power are used for determining system Coeficient of Performance (COP). Parameters that are considered for comparison purpose are : system COP, and refrigerant flowrate/kW. Among CFC12, HCR12 AND $HCR12^{+LFS}$, $HCR12^{+LFS}$ show the highest COP, and also the lowest refrigerant flow rate per kW of refrigeration effect. For first evaluation, $HCR12^{+LFS}$ can be considered to be the best refrigerant for the purposé, as it shows the best performance parameters among the tested refrigerants. Considering the safety aspect, the reduced HC concentration in the $HCR12^{+LFS}$ refrigerant, which will reduce the flammability of HC refrigerant, also makes it favourable for public unit applications.

Before, during and after each test, thorough checking of the system are performed. No leak or visible damage found, and no part replacement required.

TABLE 1 . PERFORMANCE COMPARISON OF CFC12, HCR12 AND HCR12^{+LFS}

Type of refrigerant	Compressor inlet temp. °C	Evaporation pressure kPa	Condensation pressure kPa	Compressor ratio	Refrigeration effect KW	Flow rate/kW Kg/s / kW	Electrical Power kW	COP
CFC12	28.2	320	1108	4.60	19.8	5.5×10^{-3}	12.0	1.65
HCR12	25.4	326	1013	3.74	21.5	2.5×10^{-3}	11.7	1.84
HCR12^{+LFS}	25.2	332	1132	4.32	20.9	1.2×10^{-3}	10.8	1.94

Figure 1. Schematic diagram of AC test installation



Conclussions

The test confirms that application of HCR12 and HCR12^{+LFS} refrigerants in air conditioning system improve the performance and there is no need of any replacement of equipment. The disadvantageous flammability risk which is higher than CFC or HFC, can be avoided by implementing the appropriate standards, and in the case of HCR12^{+LFS} this risk is lowered.

The results also show that HCR12^{+LFS} gives better performance improvement compare to HCR12 . But it should be stressed that this test results are for tests done on this one specific piece of hardware, and may not be generalized to all situations. The relative rankings of the refrigerant may not hold true for conditions typical of other applications. Similar tests should be conducted for other application to confirm these results.

Performance comparison for CFC12, HCR12 and HCR12^{+LFS} refrigerants performed in air conditioning system test installation at this stage confirm the results gathered during previous studies. Further study for the impact of these alternative refrigerant application on broader aspects is still on-going, and should be continued .

Acknowledgement

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