PERFORMANCE OF A REFRIGERATOR USING ECO-FRIENDLY HC BLEND REFRIGERANT R290/R 600a (CARE 30)

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Abstract Chlorofluorocarbons (CFCs) have to be phased out as per the Montreal Protocol. There are 2 options for phase out. First option is to use HFCs and then change to Hydrocarbons. The second option is to directly go for hydrocarbons. The second option of direct conversion to hydrocarbons appears to be more suitable in implementing CFC phase out in India. This paper reports on the performance characteristics of 165 litres (16y old refrigerator) retrofitted with HC blend refrigerant (CARE 30, mixture of iso-butane and propane) along with CFC-12 as baseline. The following tests 1. Rated Energy Consumption Test & 2. No-load Pull down test was carried as per BIS-1476. The safety measures and performance test procedure have been taken in detail with a case study. It was found that the performance well with the HC blend Refrigerant compared to its performance with CFC-12.

Key words: HC blend, Refrigerator, CFC-12 and Eco-friendly Refrigerants

INTRODUCTION

The Indian household refrigerator industry is about 46 years old. Nearly 15 million refrigerators are in use in India and these refrigerators ranges in capacity from 65 litres to 580 litres. In India, Refrigerators are used for considerably longer period ranging between 10 to 15 years with due maintenance. The 165-litre model is most commonly used in India and the share of the above model in the Indian market is 85% by sales volume. The Refrigeration market growth rate is about 20 – 25%, which is expected to be steady for another 5 years.

Nearly all the refrigerators that are currently produced use CFC based refrigerants but for some exceptions that use HFC based refrigerants. The choices of HFC based refrigerants currently used are narrowed to the following two refrigerants, namely HFC–134a and HC-600a. The possibilities of use of HC blend have been reported by Cool Concerns (1997), Devotta and Kulkarni (1996). The performance of refrigerators retrofitted with HC blend have also been reported by Devotta et. al., (1999). This study examines the energy consumption of a typical 165 litres refrigerator manufactured in the year 1984 (16 years old fridge) and it was retrofitted with HC blend refrigerant (Refrigerants Brand Name: CARE 30) HC-290/HC-600a (50/50 by weight%). The following tests: 1. Rated Energy Consumption Test and 2. No-load Pull down Test was carried as per BIS-1476. CARE 30 is a HC based refrigerant manufactured by CALOR Gas Refrigeration, UK that is commercially available non-azeotropic refrigerant mixture of HC-290/HC-600a.

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The main aim of the research was to find out if a refrigerator that is more than 15 years old will be suitable for retrofitting and to prepare a report on its performance using HC Blend Refrigerant along with CFC as baseline.

PROCEDURE FOR RETROFITTING

CFC-12 is recovered from the refrigerator and the whole system is first flushed with Nitrogen and sealed. The Nitrogen is charged to a pressure of about 10 bar and the system is kept under pressure with nitrogen for about 24 hours. The system is thoroughly checked for any leaks using soap solution. Then the system is evacuated and charged with HC-Blend through the suction side of the compressor. The amount of HC-Blend charged should be 40% of the CFC-12 charge by weight. In our refrigerator the amount of CFC-12 charged was 150 grams and the amount of HC-Blend (CARE 30) charged was 60 grams after evacuating the CFC-12 Refrigerant. Then the system is sealed and once again checked for any leaks using Soap solution. The system is allowed to run for nearly 24 hours before the first performance test is carried out.

EXPERIMENTAL PROCEDURE AND SAFETY PRECAUTIONS

The 165 litre refrigerator selected is a single evaporator natural convection type and the evaporator is roll bond type with an external condensor, which is also natural convection type. First the rated energy test was conduced as per the guidelines in BIS 1476 except for

the ambient temperature as the test was conducted in open environment. Next the Pull-Down Test was conducted as per the guidelines in BIS 1476 except for the ambient temperature as the test was conducted in open environment. The tests were conducted in an open environment purposefully so as find out the performance of the Refrigerator before retrofitting and after retrofitting in an open atmospheric condition.

The optimum charge 60 grams of HC-Blend which is 40% by weight of CFC-12 Refrigerant whose weight is 150 grams is charged after evacuating the CFC-12 Refrigerant by following the standard Retrofitting procedure. While retrofitting, proper measures has to be taken to insulate any sparking connection/ change conventional switches which sparks at every ON and OFF action. Care should also be taken to avoid conventional centrifugal switches used in single phase induction motors that spark due to electromechnical contact at high speed.

The following switches: 1. Non-contact type centrifugal switch using magnetic fluid and 2. Smart centrifugal switch using magnetic fluid are found to be most suitable as they are non-contact type which have simple structure, accurate switching action, inertia less speed sensing and the most important is its spark-free operations.

RESULTS AND DISCUSSION

Rated Energy Consumption Test

Table.1 presents the Rated Energy Consumption Test results for CFC-12 Vs HC blend (CARE-30). The energy consumption of HC blend (CARE-30) was 3.04 kWh/day at an ambient temperature of 29.5 °C while that of CFC-12 was found to be 2.8 kWh/day at an ambient temperature of 26.1 °C. As there was no relay in the Refrigerator (as old fridges do not have the relay), the percentage running time was 100% in both the cases. The energy efficiency (EER) was found to be 3.24 and 3.52 for R-12 and HC blend (CARE-30) respectively. The energy efficiency ratio was found to be high for HC blend refrigerant.

Pull Down Test

Table 2 shows the pull-down test results for the refrigerator. The pull-down time was found to comparable lower for HC blend (CARE-30) as against CFC-12. The pull down time for CFC–12 was 120 minutes at an ambient temperature of 26.4 °C and the freezer attained a temperature of –11.1 °C. The pull down time for HC blend (CARE-30) was 100 minutes at an ambient temperature of 29.5 °C and freezer attained a temperature of –12.4 °C. The pull down time was very much reduced when R-12 is replaced by HC blend refrigerant.

The energy required for pull down was found to be 0.27 kWh for R-12 and 0.24 kWh for HC blend (CARE-

Table-1: Rated Energy Consumption Test

PARAMETERS	(CFC-12/ Mineral oil)	HC BLEND (CARE 30/ Mineral oil)
Ambient Temperature, °C	26.9	29.9
Freezer Air Temperature, °C	-4.1	-3.9
Average Fresh Food Compartment Temperature, °C	6.9	6.7
Energy Consumed For 6 hours, kWh	0.7	0.76
Energy Consumed Per day, kWh/day	2.8	3.04
Energy Efficiency Ratio	3.39	3.52

Table-2 No-Load Pull-Down Test

PARAMETERS	(CFC-12/ Mineral oil)	HC BLEND (CARE 30/ Mineral oil)
Ambient Temperature, °C	26.4	29.5
Freezer air Temperature, °C	-11.1	-12.4
Average Fresh Food Compartment Temperature, °C	7.03	7.1
Pull-down Time (29 °C to 5 °C), in minutes	120	100
Energy Consumed during Pull-down (6 hours) in kWh	0.73	0.79
Energy Consumed, kWh/day	2.92	3.16
Energy Efficiency Ratio	3.54	3.66
Energy required for pull down (in kWh)	0.27	0.24

30). Thus the amount of energy consumed for the pull down test was less for HC blend refrigerant compared to R-12.

CONCLUSION

A single door 165 litres refrigerator has been tested with CFC-12 for baseline data and the same fridge was retrofitted and tested with HC blend (CARE-30) refrigerant. The refrigerator that was about 16 years old was found to work satisfactorily after retrofitting with HC blend (CARE-30) Refrigerant. The tests were not conducted in controlled ambient temperature in order to assess the performance in open environment The EER was found to have improved under retrofit conditions thereby improving the COP for CARE-30 when compared to CFC-12. The amount of electrical energy consumed was found to be slightly higher for CARE-30 when compared to CFC-12. This difference is due to the varying ambient temperature and environment conditions under which the test was conducted. Performance test for R-12 was conducted at a lower ambient temperature of 26.4 °C (pull down test) and 26.9°C (rated energy consumption test) when compared to tests conducted on the refrigerator after retrofitting with HC blend refrigerant at an ambient temperature of 29.5 °C (pull down test) and 29.9 °C (rated energy consumption test).

The energy required for pull down test was found to be 0.27 kWh for R-12 and 0.24 kWh for HC blend refrigerant shows clearly that the energy consumption is reduced when retrofitted with HC blend refrigerant. Moreover, these HC blend refrigerant are Eco-friendly as they are non Ozone depleting substances. From the above tests, it has been found that the performance of the refrigerator has improved after retrofitting using Hydrocarbon refrigerants. The cost of the HC blend refrigerant is cheaper compared to the cost of R-12 refrigerant. Moreover there is no modification to be done in the refrigerator that has to be retrofitted. These above advantages concludes that HC blend retrofitting technology is a promising technology for developing countries like India, Bangladesh, Pakistan and etc. as the retrofitting is done on existing old refrigerators at a lesser cost without any modification in the refrigerator. Thus, the best option for retrofitting in existing refrigerators in order to phase out the ODP refrigerants is HC blend Refrigerants.

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