Analysis of Savings on Electricity Consumption in Room Air Conditioning by Using R1270 (Propylene) Refrigerant Instead of R32 capacity of 13,000 Btuh

Widodo[1*], Fatkur Rachmanu[1], and Ade Irvan Tauvana[1]

[1]Politeknik Enjinering Indorama, Purwakarta, Indonesia

*widodosaji@yahoo.com

Abstract Global Warming Potential (GWP) is a serious problem whose impact can affect the stability of the atmospheric environment, Refrigerant R-32 (Difluoromethana) contains GWP: 675 but does not contain ODP (Ozone Depleting Potential) while R1270 (Propylene) refrigerant is non-ODP and have GWP: <4. The equipment used in the study was a prototype of a split air conditioner cooling machine for a work room with a cooling capacity of 13,000 Btuh. Methodology by testing the performance of the R32 AC-Split unit according to the 850gram refrigerant mass nameplate at suction pressure: 115 Psig while R-1270 with the refrigerant mass: 300 gram at suction pressure: 90 Psig. The test is carried out until the temperature reaches a stable with an operating time: 90 minutes. From the results of tests and analysis of calculations performed, obtained an average air temperature of the evaporator R-32/R1270: 19.1°/ 19.2°C, cooling effect: 267.9/336.7, compression work: 89.3/80.16, COP: 3.0/4.2, refrigerant mass:850/300gram and electric current: 3.5/2.4 Ampere. Savings in refrigerant and electricity consumption reached 31.4%.

1. Introduction

Synthetic refrigerant contains chloro which can damage ozone (BPO) and fluoro which can cause greenhouse gases when it comes out into the atmosphere. R-32 refrigerant is non ODP refrigerant but has GWP: 675 equivalen to (CO2: 0.5) while R-1270 (propylene) has ODP: 0 and GWP: <4. R-1270 refrigerant has been widely used in several countries in commercial air conditioning units, showcases, cold storage, industrial refrigeration and chillers, so that this refrigerant has potential as a substitute for synthetic refrigerant R-32, R-22, R-410A. Refrigerant R-32 from 1930 has been used in some countries approximately ± 40 countries. In line with the Energy Saving Program launched by the Government since the issuance of Presidential Instruction Number: 02 Year 2008 and Regulation of the Minister of Industry of the Republic of Indonesia: 33/M-IND/PER/4/2007 concerning "Prohibition of Producing Ozone Layer Damaging Materials and Producing Items that Use Layer Damaging Substances Ozone ", two important factors, namely energy saving and environmentally friendly, encourage people and the business /industry world to retrofit with hydrocarbon refrigerants. This hydrocarbon refrigerant has not been widely used in some types of refrigeration machines circulating domestically.

2. Literature review

Refrigerant R-32 has a compound (CH2F2) with a boiling point of -51.6 included in the category of refrigerant able to ignite in the LFL limit (lower flammability Limit): 13% and UFL (Upper flammability Limit): 33%, its own flash point: 530 ° C. ODP: 0 and GWP: 675 belong to the A2L non-toxic middle flammability group.The halocarbon compound refrigerant group is derived from hydrocarbons (HC) namely methane (CH4), ethane (C2H6), or from propane (C3H8) by replacing hydrogen atoms with halogen elements such as chlorine (Cl), fluorine (F), or bromine (Br). If all hydrogen atoms are replaced by Cl and F atoms, the resulting refrigerant will consist of chlorine, fluorine and carbon atoms. This refrigerant is called chlorofluorocarbon (CFC) refrigerant. If only a part of the hydrogen atom is replaced by Cl and or F, then the refrigerant formed is called hydrochlorofluorocarbon (HCFC). Halocarbon refrigerants that do not contain chlorine atoms are called hydrofluorocarbons (HFCs). Refrigerants that have many Cl atoms tend to be toxic, F atoms are added so that the compound becomes stable and compounds that have many Cl atoms will have a higher NBP (normal boiling point). Whereas the increasing number of F atoms tends to decrease the NBP of compounds formed [1]. There are a number of refrigerant requirements in general: have a working pressure that is not too high, has a suction pressure that is not too low, has high thermal conductivity, low boiling point, non-toxic, Non ODP, low GWP, can mix with oil, the price is cheap, friendly to the environment. This R-1270 Hydrocarbon Refrigerant has the chemical element C3H6 which has a purity> 99.5% Non ODP and has a GWP <2. This refrigerant has a boiling point: -42.1˚but has its own flash point: 460 ˚C, LFL: 2.5% UFL: 10.1 % has a pressure in the vapor phase: 8.3 Bar. Below is a graph of the ratio of temperature to pressure for some types of refrigerant. Refrigerant R-1270 has a lower pressure when compared to R-410a and R-22 [2].

Table 1. Characteristic refrigerant R32 and R1270

No	Description	R-32	R-1270
1	Atmosphere Lifetime Year	5	Less than 1
2	GWP (CO2=0.5)	675	4
3	ODP (R-12=1)	0	0
4	Oil Compatibility	Syntethics	Both
5	Component Change of wear	No	No
6	Potential corrosion	No	No
7	Toxic Thermal decomposition	None	None
8	Long term Health effect	None	None
9	Short Term Health effect	None	None
10	Leak Detection	-	Hydrocarbon
11	Boiling Point(°C)	-51.7	-41.7
12	Critical Temp (°C)	78.1	92.4
13	Flammability limit (%)	LFL: 13%-UFL:33%	LFL : 2.0%-UFL:9.5%
14	Auto Iqnition(°C)	530	480
15	Relative vapor density (air=1)	2.1	1.56
16	Vapour pressure (25°C)	1,701 kPa	551 kPa
17	Melting point(°C)	-136	-187.7

Refrigerant properties can be seen from the COP and the cooling capacity possessed by various refrigerants: R-1270 can be seen in the image below [2]:

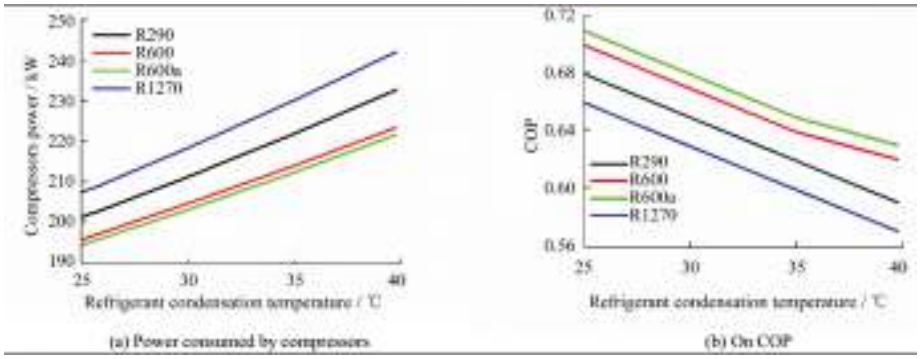

Figure 1. (a) chart of power consumtion versus temperature (b) Chart of COP versus condenser temperature [2]

Table 2. Properties and safety aspect some of refrigerants [2]

Refrigeran		Formula	NBP(°C)	CT(°C)	GWP	Flammability	Safety Class
Natural Inorganic	R717	NH3	-33.3	132.3	0	No	B1
	R744	CO2	-56.5*	31.0	1	No	A1
Natural HCs	R290	C3H8	-42.1	96.7	20	Higher	A3
	R1270	C3h6	-47.7	92.4	3	Higher	A3
	R600a	C4h10	-11.7	134.7	3	Higher	A3
HFCs	R152a	C2H4F2	-24.1	113.3	140	Lower	A2
	R32	CH2F2	-51.7	78.1	650	Mild	A2L
HFOs	R1234yf	C3H2F4	-29.5	99.7	4	Mild	A2L
	R1234ze	C3H2F4	-19	109.4	6	Mild	A2L

Note : NBP: Normal Boiling Point, CT : Critical Temperature * triple point

The selection of refrigerants that have proper thermodynamic properties is usually based on the required refrigeration / cooling temperatures and working pressures that are not too high or too low. For example, for air conditioning 5°C, refrigerators -10 to 2°C, cold storage -25°C, freezer for meat or fish -40°C. For each of these applications a refrigerant with good thermal properties is chosen, such as latent heat, large thermal conductivity and heat, low viscosity, etc.

By knowing the pressure and the saturated temperature of the refrigerant, it can be seen whether a refrigerant operates in the same pressure and temperature range and can replace one another. From the curve in Figure 2.1 below it can be seen that the R12 curve coincides with R134a and R152a. Thus the R134a and R152a refrigerants can replace the R-12 refrigerants. from this curve it can also be predicted that a mixture of high-pressure R32 with lower-pressure R134a can produce refrigerant to replacement R22. [2]. Flammability is determined by the composition of the air-refrigerant mixture and the flash point of the refrigerant. Based on the ease of burning of the refrigerant is divided into three classes, namely class 1, class 2 and class 3, as stated in SNI. Refrigerants that have a flash point above 750°C are considered non-flammable because the flame temperature has exceeded the melting temperature of the refrigeration component material. This group of refrigerants belongs to class 1. Refrigerants with flash points below 750°C and a lower limit of more than 3.5% by volume (mixed in air), then these refrigerants are class 2 refrigerants. Whereas if the lower limit of ignition is less than 3.5%, the refrigerant enters class 3. Based on SNI the level of poison is divided into two groups namely group A namely non-toxic refrigerant and group B toxic refrigerant. Refrigerants are said to be

non-toxic if they have an LC50 (Lethal Concentration 50%) greater than 10,000 ppm, where as refrigerants are considered toxic if LC50 is less than 10,000 ppm [3].
AC-Split Cooling Machine is a cooling machine that is used as a cooling machine room coolant is designed into two main parts, namely indoor and outdoor units, connected by piping installation with length adjusted to the cooling capacity of the air conditioner. The construction can be seen in the picture below:

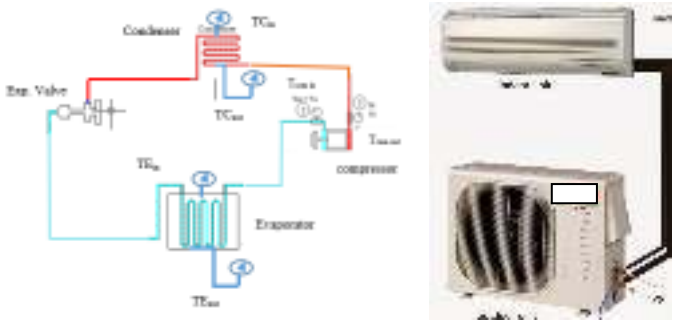

Figure 2. Unit wall mounted air conditioning

Data from the measurements of the evaporator air temperature with continuous operating conditions to a stable condition in accordance with the variations in the table below:

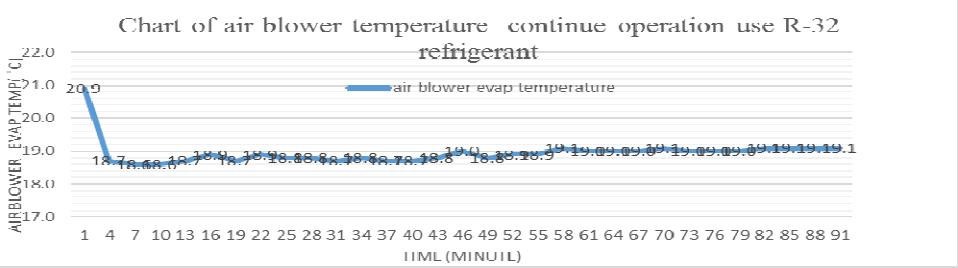

Figure 3. Evaporator air temperature graph of R-32 refrigerant continuous operating conditions

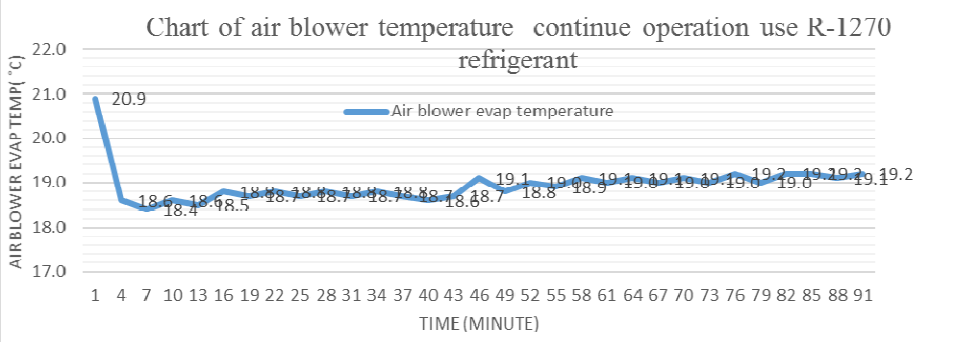

Figure 4. Evaporator air temperature graph of R1270 refrigerant continuous operating conditions

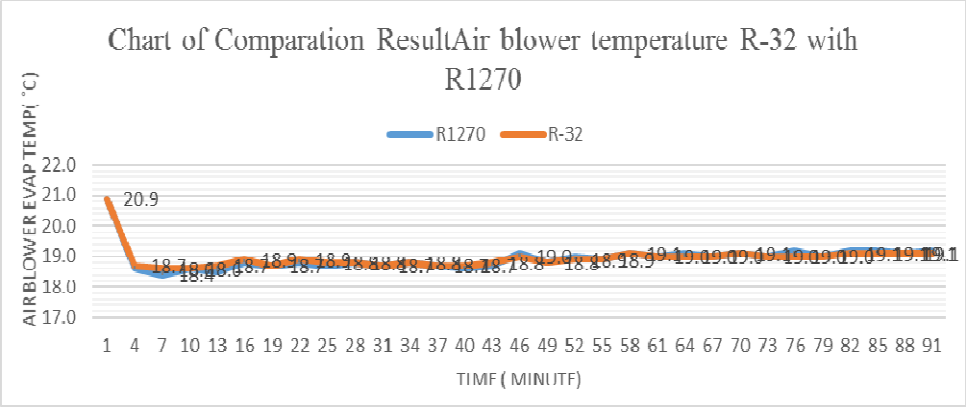

Figure 5. Graph of average temperature of the blower evaporator continuous operating conditions R-32 vs R-1270

From the data obtained in the test is calculated using the software "Mollier Chart" with the following results: Compression work, Refrigeration effects, COP (Coeficient of Performance). Suction pressure R32: 115 Psig evaporator temperature: 19.1 °C condenser temperature: 35°C.

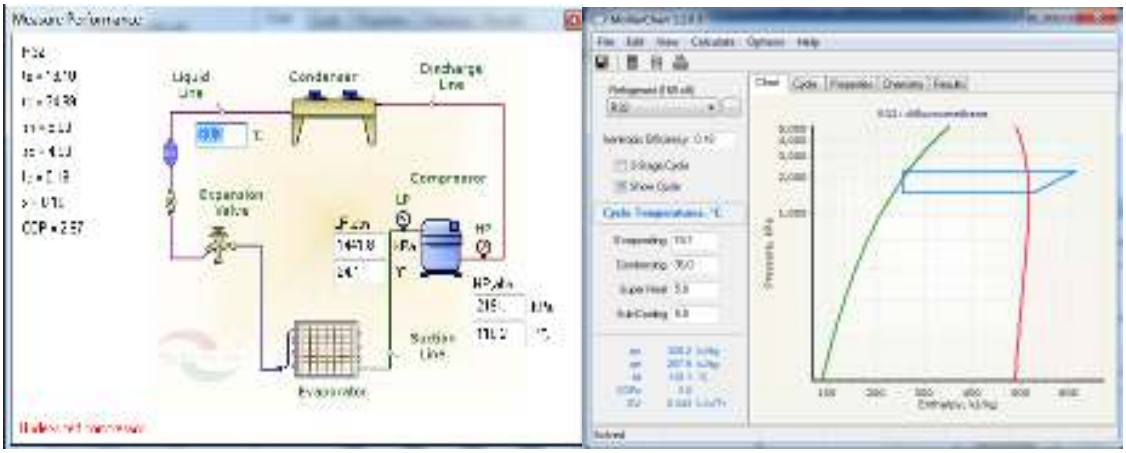

Figure 6. Performance Results for suction pressure: 115 psig, evaporator temperature: 19.1˚C and condenser temperature : 35˚C with R32

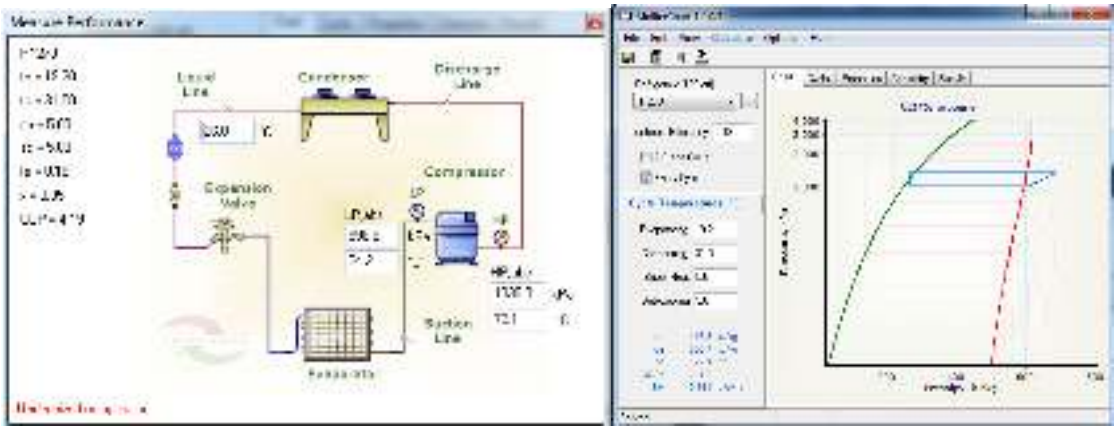

Figure 7. Performance results for each component at suction pressure: 90 psig, evaporator temperature: 19.2˚C and Condenser Temperature. : 31˚C with R1270

In the performance of the compressor there is a pressure drop from 115 Psig to 90 Psig from the effect of this pressure drop the compressor becomes lighter compared to using R32. This will affect electricity consumption is low and makes the compressor become more durable. Compression ratio is also lower when compared to R32 refrigerant, so the compression work done by the compressor is also lighter so that electricity consumption is lower. Judging from the density of refrigerant, R1270 has a lower density and has a large latent heat that is relatively large so that using 30% of the previous amount of refrigerant is sufficient for the cooling process with the same volume.

Table 3. R32 and R1270 (propylene) performance results

Parameter	R32	R1270	Remarks
Suction Suction (Psig)	115	90	25 Psig
Discharge Pressure (Psig)	400	220	180 Psig
Compression Ratio	3.5	2.4	1.1
Evaporator Temperature (°C)	19.1	19.2	0.1(°C)
Refrigeration Effect (kJ/kg)	267.9	336.7	53.9 kJ/kg
Work of Compression (kJ/kg)	89.3	80.2	9.1 kJ/kg
COP	3.0	4.2	1.2
Electric current (Ampere)	3.5	2.4	Saving: 31.4%

3. Conclusions

From the results of calculations and analysis we can conclude the following:

a. Achievement of average cooling on the evaporator blower in the indoor unit area for R32: 19.1°C and R1270, 19.2°C, 0.1°C lower.
b. Coeficient of performance (COP) for R-32: 3.0 and R1270: 4.2, 1.4 points higher.
c. The difference in electricity consumption is seen through the current strength there is a difference: 1.1 from R32: 3.5 and R-1270: 2.4 so it can reduce electricity consumption by: 31.4%.
d. To maintain the stability of the atmospheric environment, it is very necessary to use Non ODP refrigerant and GWP.
e. As a follow up to this research, it is necessary to develop the cooling resistance obtained with a longer testing time in accordance with the durability test performance standard.

References

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