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Energy Consumption Comparison of Split Air Conditioner Using R-22 AND R-290 Refrigerant

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Abstract

Growth of Indonesian Industrial sector in 2018 as much as 5.3 % will trigger an increase in refrigeration needs. In terms of regulation of refrigerant with *Chlorofluorocarbon* base (CFC) phase out is targeted in 1995 for developed countries and 2015 for developing countries. *Hydro Fluorocarbon*-based refrigerant (HCF) phase out is targeted in 2020 for developed countries and 2030 for developing countries, so it important to find refrigerant that is environmentally friendly as well as energy efficient. Based on the problem as an alternative refrigerant that is environmentally friendly, currently available technology based hydrocarbon refrigerant (propane) R-290 is considered environmentally friendly. From the conversionprocess from R-22 to R-290 Air conditioning various capacities 1 PK (± 9.000 BTU / h), 1.5 PK (± 12,000 BTU / h), 2 PK (± 18,000 BTU / h); 3PK (± 24,000 BTU / h) in PT.Phapros,. Tbk at comfortable working conditions, obtained energy savings of 10765,44KWh / year.Refrigerant R290 is flammable, special handling is required especially in terms of safety and spare part compatibility when converting.

Keywords: *Hydrocarbon Refrigerant, Energy Efficiency, R290*

1. INTRODUCTION

Refrigeration is one of the significant greenhouse gas contributing activities to the total global greenhouse effect. Especially countries with a fairly rapid rate of industrial growth, including Indonesia. The Ministry of Industry targets the growth of non-oil and gas processing industry in 2018 at 5.3 percent [1].The increase in industrial growth spurred increasing demand for refrigeration or air conditioning, especially industrial sectors, which have an impact on increasing greenhouse gas effect. Citing data from *www.green-cooling-initiative.org*, total greenhouse gas emissions per 3 March 2018 is 3,880 Metric Ton (equivalent C02), while Indonesia contributes 84.2 Metric Ton (equivalent C02) much lower than neighboring countries Malaysia which fertilizes 25.4 Metric Ton (equivalent C02)[2].

The Montreal Protocol is one of the most successful attempts to protect the environment. The Protocol establishes commitments on a time scale for removal of substances that can damage ozone and cause greenhouse effects. In the Montreal Protocol stipulates the obligation of the progressive phase of the removal of ozone-damaging substances and the effect of greenhouse gases for developed and developing countries for all major ozone depleting substances, including CFCs, halogens and less harmful transition chemicals such as HCFC which are currently used as refrigerant used on air-cooling systems in households or industrial sectors. Based on the results of the montreal protocol the refrigerant with ChloroFluoroCabron base (CFC) is targeted not to use in 1995 for developed countries and 2015 for developing countries. HydroFluoroCarbon-based refrigerant (HCF) is targeted for use in 2020 for developed countries and 2030 for developing countries[3]. Based on the problem as an environmentally friendly alternative refrigerant, the technology currently available refrigerant based hydrocarbon (propane) R-290 is considered environmentally friendly because it has a fairly low ozone depletion (ODP) and Golobal Warming Protection (GWP) compared to CFC-based refrigerants or HFC.

In this study the authors will perform the comparison of power consumption on the air conditioning of various capacities 1 PK (± 9.000 BTU / h), 1.5 PK (± 12,000 BTU / h), 2 PK (± 18,000 BTU / h); 3PK (± 24,000 BTU / h) uses 2 different refrigerant types R-22 and R-290 at comfortable working conditions.

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2. METHODS

Data taken from the air conditioner at PT.Phapros, .Tbk that has been done the air conditioner conversion taking into account the safety factor and compatibility of the part to refrigerant R290, refers to the guidelinesthat issued by the competent and reputable institution., by measuring 1 phase electric current of AC with capacity of 1 PK (± 9.000 BTU / h), 1.5 PK (± 12,000 BTU / h), 2 PK (± 18,000 BTU / h); 3PK (± 24,000 BTU / h) Using 2 types of R-22 and R-290 refrigerant in the market. Measurements are made at appropriate temperatures according to ASHRAE Standard for thermal comfort working area between 22,5-26,0 C°[4].

In order to measure the current load used, an electric current (Ampere) is measured, using Kyoritsu® Power Quality Analyzer (calibrated) using ampere meter pliers on their electrical panel (AC 1 phase). Measurements are made three times, the results are then performed on average to see the energy consumption used. To see the measured room temperature in accordance with ASHRAE thermal comfort area, a Testo® 174H (calibrated) thermohygrometer device is used to measure the same room variables at Temperature (22,5–26,0)°C [4].

Figure 1: Ampere Meter Kyoritsu

Figure 2: Electrical current measurement

Refrigerant is a liquid used in air conditioners and refrigerators, to absorb the heat from the contents of the refrigerator or space and dissipate heat in the Earth's atmosphere. A refrigerant undergoes phase change from liquid to gas (at absorbing heat) and returns to liquid (when compressor compresses it)[5]. In this study used 2 kinds of R-22 refrigerant containing HydroFuoroCarbon (HCFC) and R-290 containing Propane (Hydrocarbon)

3. RESULT AND ANALYSIS

A. Electrical Current Measurement

Based on the measurement of Electric current, the following results are obtained:

Table 1: Results of AC 1 PK measurement

Room	BRAND	CAPACITY	RESULT	
		(PK)	R-22 (A)	R-290 (A)
Rapat 1	A	1	4,4	3,5
Rapat 2	B	1	3,1	2,8
Sekretariat	A	1	3,6	3,2
Man. Keu	A	1	3,8	3,2
Man Pengadaan	C	1	3,2	3
Man Akun	A	1	3,6	3,2

Ass. Man Keu	E	1	3,9	3,7
Kasir	D	1	2,5	2,2
Meeting Akun	A	1	3,9	3
Pajak	A	1	3,7	3
PABX	B	1	3,6	3,4

Table 2: Results of AC 1,5 PK measurement

Room	BRAND	CAPACITY	RESULT	
		(PK)	R-22 (A)	R-290 (A)
Dir Keu	A	1,5	4,9	4,3
Sekretariat	A	1,5	5,3	4,2
Man. SDM	E	1,5	5,6	4,4
Meeting 1	A	1,5	4,6	3,9
Meeting 2	E	1,5	4,7	4,3
ERM	C	1,5	4,2	4
SAI	B	1,5	5,8	4,7
SAI	B	1,5	5,8	4,9
R. Server IT	A	1,5	5,9	4,5
R. Server IT	B	1,5	4,1	3,5
Akuntansi	F	1,5	3,8	3,4
IT	B	1,5	4,6	4,2

Table 3: Results of AC 2 PK measurement

Room	BRAND	CAPACITY	RESULT	
		(PK)	R-22 (A)	R-290 (A)
SDM 1	F	2	7,8	6,9
SDM 2	F	2	7,9	7
SDM 3	F	2	7,7	6,3
SDM 4	F	2	7,9	6,7
Meeting 3	G	2	10,3	8,7
PPIC 1	A	2	8,3	6,3
Admin Keu 1	A	2	7,7	6,4
Admin Keu 2	G	2	7,2	5,3

Table 4: Results of AC 3 PK measurement

Room	BRAND	CAPACITY	RESULT	
		(PK)	R-22 (A)	R-290 (A)
Dirut	H	3	12,5	12
PPIC 2	A	3	7,8	5,8

Pengadaan	G	3	8,3	7,8

Based on the results of the measurements, table 1, table 2, table 3, table 4 all show the reduction of electric current measurement (ampere) from the previous using R-22 refrigerant to R-290, of 0.2-2 A.

B. Energy Efficiency

The above measurement results are used as data to be converted into used electric power using the following formula[6]:

$P = VxIxCosQ\ (phi)$

P = Power (Watt)
I = Current (Ampere)
V = Voltage (Volt)
Cos Q = Power Factor (0,9)

Based on the formula got the following results:

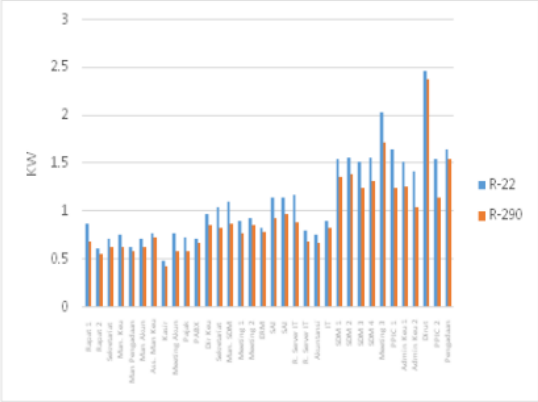

Figure 3: Power Consumption Comparison

The result obtained by total power of AC with refrigerant R-22 equal to 38,025 KW and R-290 32,418 KW, difference of refrigerant usage decrease power consumption 5,607 KW. If it is assumed for 1 working day for 8 hours, one month 20 days effective then the potential cost savings that appear during 1 year as follows:

Savings = 5,607KW x 8 h x 20 d x 12 months

Savings = 10765,44 KWh/Years

R290 refrigerant have better COP and EER compare to R22 refrigerant. The usage of R290 refrigerant can reduce energy consumption up to 11 % [7]In addition to that, the amount of refrigerant required by R290 is relatively half of that required by R22 refrigerant. Due to R290 chemical properties, this refrigerant can easily compress and expand compared to R22 refrigerant. As a result of these properties, the compressor requires less energy to compress the refrigerant which in turn increases the life span of the compressor. The only limitation of R290 is flammability. [7]

4. CONCLUTIONS

Based on the experiments comparing the consumption of electrical energy between air-cooled and R-22 and R-290 refrigerant, the result of power capacity of 1 PK (± 9,000 BTU / h), 1.5 PK (± 12,000 BTU / h), 2 PK (± 18,000 BTU / h); 3PK (± 24,000 BTU / h) in PT.Phapros,. Tbk by using R-22 refrigerant of 38,025 KW while with refrigerant R-290 obtained power consumption of 32,418 KW or decrease of 14.75%. If assumed usage of day for 8 hours and one month for 20 days then obtained energy saving equal to 10765,44 KWh/ Year. The hydrocarbon refrigerant R-290 (propane) has a high latent heat of vaporization meaning that the heat absorbed per one unit of refrigerant lifetime in the evaporator is greater when the refrigerant has a large latent evaporative heat and vice versa. Or in other words refrigerant that has high latent heat of evaporation is more advantageous because for the same refrigeration capacity, the amount of refrigerant circulating becomes smaller, it is only take 40-50 % from HCF refrigerant[8], so that the compressor work becomes lighter resulting in decreased electrical load. It should be noted that the process of conversion the air conditioner from R-22 refrigerant to R-290 should be done by a certified and qualified technician and must meet the latest standard operating procedure that have been recognized by an authorized institution, due to the natural properties of refrigerant R-290 is flammable[8].However, in doing this, Authors do not assume liability (*in law term*) for any statements or any actions taken by its readers or users, which may cause unintended damage, injury or other impacts as a result of any recommendations or inferences made within this article. Information provided herein does not relieve reader or user from their responsibility of carrying out its own evaluation and analysis of the situation, and readers or users assume all risks and liability (*in law term)* for use of the information, actions and events obtained. Readers or users should

not assume that all safety data, measures and guidance are indicated herein or that other measures may not be required. Here only experimental data presents, which do not compensate for individual guidance and instructions. National laws and guidelines must be consulted and adhered to under all circumstances. The handling of flammable refrigerants and its associated systems and equipment is to be done by qualified and trained technicians only. At this time special split air conditioner technology using refrigerant R290 already produced mainly in India [9]and in China[10], Regarding that technology then the chances to conversion will decrease further from the side of the regulation for reasons of safety and compatibility since the air conditioner parts that are not designed specifically for R290 refrigerant.

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