The Influence Comparison of the Mass Refrigerant towards Coefficient of Performance Car Air - Conditioning Systems with Refrigerant R-134A

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Abstract: ***The cooling machine is an energy conversion machine used to move heat from low temperatures to high temperatures by adding work from the outside. The mass of the refrigerant affects the COP on the refrigerant. From the characteristics of refrigerant can be known the value of COP, compression work, and cooling capacity to the amount of mass of refrigerant given. To find out how big the influence of R-134a refrigerant mass to COP on car air conditioning. The method used in this study charging refrigerant has different mass weight. The mass weight used in this test is 70, 90, 110, 130, 150, 170, 190 gr. The results of testing the mass-weight variation of R-134a with the car air condition of 1000 cc engine capacity shows the COP of the mass weight of 170 and 190 gr is the best with the values of 6.52 and 7.20. Of the 7 variations in mass weight under study the electrical power of the required AC motors varies considerably, for a mass of 70 g of refrigerant requires 737 watts of power and a mass of 190 g requires 1714.9 watts of power. Thus it can be concluded that the increasing refrigerant, the more weight the work of the cooling machine, thus requiring large electrical power. And the mass weight of 170 gr is the most efficient mass weight for this car's air conditioner.***

Keywords: Car Air Conditioning COP, Mass, R-134a

1. Background

The refrigeration system has provided an important things in everyday life, not only limited to improving the quality and comfort of life, but also has the essentials as a supporter of human life. This technology is widely applied to the storage and distribution of food, air conditioning for the comfort of the room both in industry, offices, transportation, and household. The vapor compression refrigeration system is the most widely used refrigeration system in cooling, freezing and air conditioning processes. [1]

The cooling machine is an conversion energy machine used to move heat from low temperatures to high temperatures by adding work from the outside. More specifically, the refrigerant is a device used in the cooling process of a fluid to achieve the desired temperature and humidity by absorbing heat from a low-temperature and supplied to a high-temperature. The steam compression cooling machine comprises four main components: compressor, condenser, expansion valve and evaporator. [2]

Refrigerant is the main working fluid used to absorb and exchange heat in the engine cooling system. Refrigerants absorb heat at low temperatures and low pressure and release heat at high temperatures and pressures. Most refrigerants undergo phase changes during heat absorption - evaporation - heat-condensation release. [3]

In operation, the refrigeration system requires a fluid that easily absorbs and releases heat. Refrigerant is a fluid used to absorb heat through the phase change from liquid to gas (evaporation) and discharges heat through the phase change from gas to liquid (condensation) so that it can generally be said to be a heat exchanger in the cooling system. Each refrigerant has different properties of thermodynamic characteristics, which will affect the effects of refrigeration and coefficient of performance (COP) of the refrigerant itself. [6] In other studies, mass refrigerant can affect the coefficient of performance (COP) of car air conditioners. According to research Zaenal Arifin, the addition of mass refrigerant can affect the performance of the car air conditioner; The addition of the refrigerant mass causes the cooling capacity to increase to a maximum point and then decrease; The addition of mass of refrigerant causes the compression power to increase; And the addition of refrigerant mass causes the coefficient of achievement to increase to the maximum point and then decrease. [2]

From the above background, the mass of the refrigerant has an influence on the coefficient of performance (COP), to prove it needs further research by using R-134a type refrigerant on the car AC with a capacity of 12000 BTU/h and for the car capacity of 1000 cc.

2. Literature Review

Air Conditioning Systems

Air conditioning is a process of air treatment to adjust the temperature, humidity, cleanliness, and distribution simultaneously to achieve the comfortable conditions required by the inhabitants who are in it. Therefore, air conditioning also include heating such as speed regulation, thermal radiation and air quality including particle removal and impurity vapor. [1] The cooling machine is an energy conversion engine that used to move heat from low to high temperature by adding work from the outside. [9]

Refrigerator Classification

Commercial cooling applications are broadly divided into 2, that is window air conditioner and domestic refrigerator (domestic cooling). [14]

1) Room Air Conditioner

The schematic diagram of the window-type air conditioner works with the principle as shown in Figure 1.

Air on the room take by fan and after passing the cooling machine, the air will be cool before flowed into the room. After the heat of the room is taken, the air will return to the cooling machine and the air released into the outer environment will become higher.

The cooling machine uses a working fluid called a refrigerant, such as CHClF2 (monochloro-difluoro methane), also called refrigerant 22 (R22).

The device for absorbing latent heat from the air in the room is the evaporator. After evaporation, the refrigerant changes to steam. To be able to condense back and release the heat absorbed from the room and through the evaporator, the pressure is increased by the compressor. High-pressure steam goes into the condenser. The condenser has a high temperature and is circulated with a fan. After taking the latent heat vapor from the condensing refrigerant, the air is flew left out into the environment.

After condensing, the high-pressure refrigerant is reduced to make the pressure lower by passing through a pressure reducer called an expansion device, and so the system is completed. High-speed condenser partition wall from low temperature evaporator. The working principle of large-scale air is also the same, except with air-cooled condenser. [14]

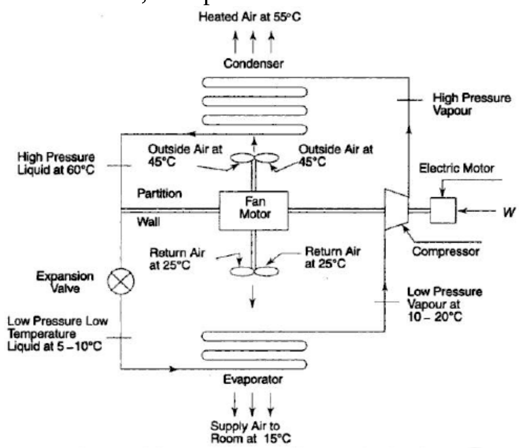

Figure 1: Schematic Diagram of Room Air Conditioning [14]

2) Domestic Refrigerator

The working principle of a domestic refrigerator is a exactly the same as that of an air conditioner. A schematic diagram of the refrigerator is shown in Fig. 2. Like the air conditioner it also consists of the following four basic component: compressor, condenser, expansion tools, evaporator.

But they are some design fiture which a typical of a refrigerator. For the example, the refrigerator is located on the freezer compartment of refrigerator. It forms the cooldest parts of the cabinet with the temperature about -15 °C, while refrigerant evaporates inside the evaporator tube at -25 °C.

The design of the condenser is also a little different. It is usually a wire and tube or plate and tube type mounted at the back of the refrigerator. There is no fan. The refrigerant vapor is condensed with the help of surrounding air which rises above by natural convection as it gets heated after receiving the latent heat of condensation from the refrigerant.

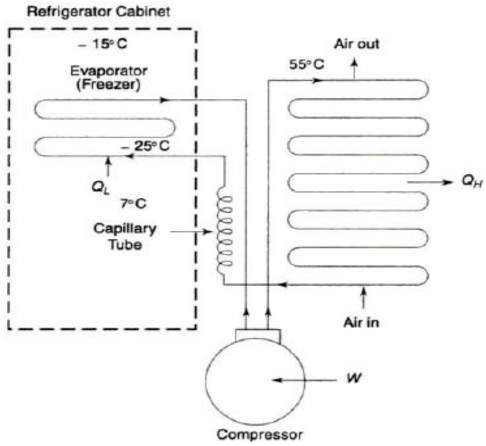

Figure 2: Schematic Diagram of a Domestic Refrigerator[14]

3) Refrigerant

A refrigerant is the primary working fluid used for absorbing and transmitting heat in a refrigeration system. Refrigerants absorb heat at a low temperature and low pressure and release heat at a higher temperature and pressure. Most refrigerants undergo phase changes during heat absorption – evaporation - and heat releasing - condensation. [3]

Coefficient of Performance (COP)

Coefficient of Performance is obtained through the following cycle. Mechanical energy is required by the compressor to circulate the refrigerant, heat dissipation is carried out on the condenser and heat recovery (the place that object will be cooled) occurs in the evaporator. To obtain a good evaporator performance the refrigerant on the condenser is lowered by the pressure of an expansion valve. Here there is a bargain between low refrigerant pressure followed by low temperatures with circulating refrigerant mass flow rates.[15] P-h diagram and vapor compression machine flow diagram can be seen in Figure 3

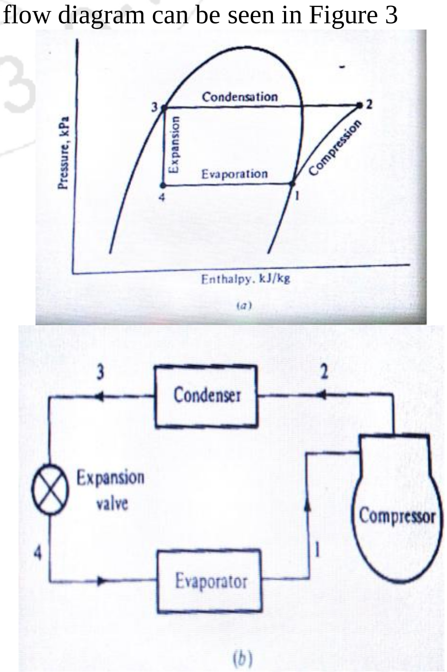

Figure 3 (a) Standard Diagram p-h Vapor Compression Cycle (b) Flow Chart[12]

COP of vapor compression cooling machine is calculated by equation

$$COP = \frac{Wcomp}{RE} ;COP= \frac{(h2 - h1)}{(h1 - h4)}$$

3. Research Methodology

3.1 Flowchart of Research

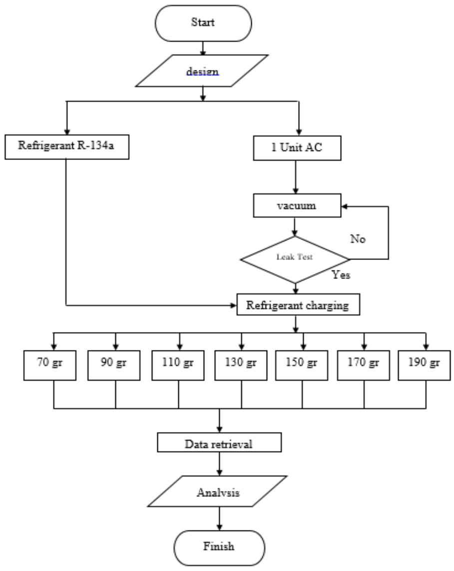

Figure 4: Flowchart of Research

Implementation Data retrieval R-134a

a) Machines AC motor connected to a power source 220 V single phase.
b) Pressure gauge and a digital thermometer will light up after the air conditioner operates several seconds.
c) Temperature and pressure data taken after the number on the display digital pressure gauge and thermometer stable.
d) The data is taken only once for each different refrigerant mass after the air conditioner is on.

4. Result and Discussion

R-134A Test Result With Mass Refrigerant 70 Gram

Table 1: Temperature Results Test of Mass Refrigerant 70 gr

TIME		TEMPERATURE (° C)						
NO	HOUR	TL	T1	T2	T3	T4	TOE	TOC
1	9:20	30	30	60	31	29	31	31
2	9:30	30	30	63	31	28	31	31
3	9:40	31	30	70	31	28	31	32
4	9:50	31	30	72	32	27	31	32
5	10:00	31	30	73	32	27	31	32
6	10:10	31	30	73	32	27	31	32
Average		30.667	30	68.5	31.5	27 667	31	31.667

Table 2: Pressure and Electric Current Result Test of Mass Refrigerant 70 gr

TIME		PRESSURE (Bar Gauge)				ELECTRICAL CURRENT (A)			PRESSURE (Bar absolute)			
NO	HOUR	PG1	PG2	PG3	PG4	R	S	T	PA1	PA2	PA3	PA4
1	9:20	0.204	4.76	4.08	0.884	3.25	3.25	3.25	1.217	6.113	5.773	1.897
2	9:30	0.204	5.1	4.76	0.884	3.32	3.32	3.32	1.217	6.113	5.773	1.897
3	9:40	0.272	5.1	4.76	0.952	3.38	3.38	3.38	1.285	6.113	5.773	1.965
4	9:50	0.272	5.44	4.76	0.952	3.38	3.38	3.38	1.285	6.453	5.773	1.965
5	10:00	0.272	5.44	4.76	0.952	3.4	3.4	3.4	1.285	6.453	5.773	1.965
6	10:10	0.272	5.44	4.76	0.952	3.37	3.37	3.37	1.285	6.453	5.773	1.965
Average		0.249	5.213	4.647	0.929	3.35	3.35	3.35	1.245	6.283	5.773	1.942

Table 3: Enthalpy R-134a With Mass Refrigerant 70 gr

Enthalpy (kJ / kg)			
h1	h2	h3	h4
427.63	456.82	244.83	244.83

1) Refrigeration Effect (RE)

Refrigeration effect is the difference between the enthalpy during the refrigerant out of the evaporator (h1) and refririgeran that goes into the evaporator (h4). The cooling effect can be calculated, to determine the heat absorbed by the evaporator.

RE = h1 - h4 (kj / kg)

Explanation:
h4 : enthalpy into evaporator
h1 : enthalpy exit evaporator

From these equations then get the car air-conditioning refrigeration effect using R-134a with a mass of 70 grams is

RE = 427.63 - 244.83
= 182.8 kJ / kg

2) Refrigerant Mass Flow Rate ($\dot{m}$)

Refrigerant mass flow rate is the amount of refrigerant flowing in the evaporator per second. Influenced the refrigerant mass flow rate capacity and refrigeration effect, and obtained the formula $\dot{m}$ = Capacity / RE (kg / s).

Conversions:
3.35 x 220 Volt = 737 Watt = 737 J / s
= 737 Watt
= 0.737 KW
= 0.737 kJ / s

$$\dot{m} = \frac{Capacity\ (kilowatt)}{RE\ (\frac{kj}{kg})}$$

= (0.737 kJ / s / 182.8 kJ / kg)
= 0.0040 kg / s

3) Work of Compressor (Wcomp)

Compressor power is the power generated by the compressor in the unit Watt influenced by entalphy exit / entry compressor and refrigerant mass flow rate ($\dot{m}$).

Wcomp = h2 – h1

Explanation:
Wcomp = Work compression (kJ / s)

h1, h2 = Enthalpy of refrigerant at points 1 and 2 (kJ / kg)

From these equations then get the car air-conditioning compressor using R-134a with a mass of 70 grams is

Wcomp = 456.82 - 427.63
= 29.19 kJ / kg

4) Coefficient of Performance (COP)

Coefficient of performance (COP) is the engine performance results obtained from the cooling of the refrigerating effect with the work of compression.

$$COP = \frac{Wcomp}{RE} = \frac{\dot{m}\,(h1-h4)}{\dot{m}\,(h2-h1)} = \frac{(h2-h1)}{(h1-h4)}$$

From these equations then get the car air-conditioning compressor using R-134a with a mass of 70 grams is

COP = 182.8 / 29.19
= 6.26

The above calculation, obtained from the diagram ph R-134a with a mass of 70 grams as shown below

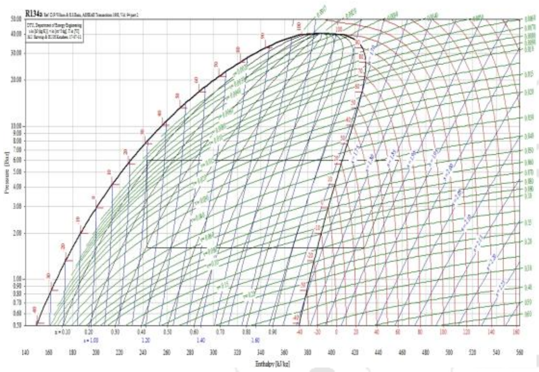

Figure 5: p-h Diagram with Mass Refrigerant 70 gr

R-134A Test Result with Mass Refrigerant 90 Gram

Table 4 Temperature Results Test Of Mass Refrigerant 90 gr

TIME		TEMPERATURE (° C)						
NO	HOUR	TL	T1	T2	T3	T4	TOE	TOC
1	13.05	33	30	68	32	27	31	32
2	13:15	33	30	68	32	27	31	32
3	13:25	33	30	72	32	25	31	32
4	13:35	33	30	73	32	25	31	32
5	13:45	32	31	74	32	25	31	32
6	13:55	32	31	75	32	25	31	32
Average		32.67	30.33	71.67	32.00	25.67	31.00	32

Table 5 Pressure and Electric Current Result Test of Mass Refrigerant 90 gr

TIME		PRESSURE (Bar Gauge)				ELECTRICAL CURRENT (A)			PRESSURE (Bar Absolut)			
NO	HOUR	PG1	PG2	PG3	PG4	R	S	T	PA1	PA2	PA3	PA4
1	13:05	0.34	6.12	5.78	1.02	3.50	3.50	3.50	1.353	7.133	6.793	2.033
2	13.15	0.34	6.12	5.78	1.02	3.70	3.70	3.70	1.353	7.133	6.793	2.033
3	13.25	0.306	6.12	5.78	0.986	3.70	3.70	3.70	1.319	7.133	6.793	1.999
4	13.35	0.306	6.12	5.78	0.986	3.65	3.65	3.65	1.319	7.133	6.793	1.999
5	13.45	0.306	6.12	5.78	0.986	3.70	3.70	3.70	1.319	7.133	6.793	1.999
6	13.55	0.306	6.12	5.78	0.986	3.67	3.67	3.67	1.319	7.133	6.793	1.999
Average		0.317	'6.12	5.78	0.997	3.65	3.65	3.65	1.330	7.133	6.793	2.010

Table 6 Enthalpy R-134a With Mass Refrigerant 90 gr

Enthalpy (kJ / kg)			
h1	h2	h3	h4
427.70	458.52	244.49	244.49

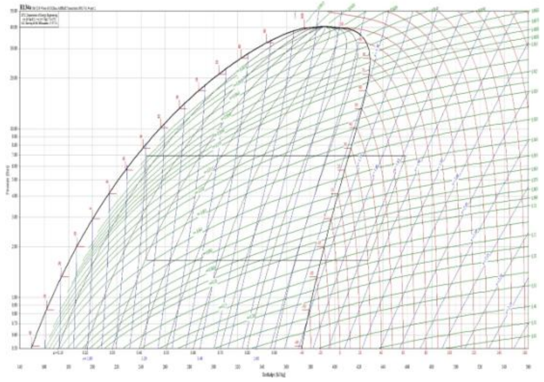

Figure 6: p-h Diagram with Mass Refrigerant 90 gr

R-134A Test Result with Mass Refrigerant 110 Gram

Table 7 Temperature Results Test Of Mass Refrigerant 110 gr

TIME		TEMPERATURE (° C)						
NO	HOUR	TL	T1	T2	T3	T4	TOE	TOC
1	14:00	32	31	68	33	24	31	32
2	14:10	32	30	73	33	20	29	32
3	14:20	32	30	73	33	20	29	33
4	14:30	32	30	73	33	20	29	33
5	14:40	31	30	73	33	20	29	33
6	14:50	31	30	73	33	18	29	32
Average		31.667	30.167	72.167	33	20.333	29.333	32.500

Table 8: Pressure and Electric Current Result Test of Mass Refrigerant 110 gr

TIME		PRESSURE (Bar Gauge)				ELECTRICAL CURRENT (A)			PRESSURE (Bar Absolut)			
NO	HOUR	PG1	PG2	PG3	PG4	R	S	T	PA1	PA2	PA3	PA4
1	14:00	0.544	7.14	6.46	1.224	4 19	4 19	4 19	1.557	8.153	7.473	2.237
2	14:10	0.544	7.14	6.8	1.292	4.26	4.26	4.26	1.557	8.153	7.813	2.305
3	14:20	0.51	7.14	6.8	1.292	4.26	4.26	4.26	1.523	8.153	7.813	2.305
4	14:30	0.544	7.14	6.8	1.292	4.2	4.2	4.2	1.557	8.153	7.813	2.305
5	14:40	0.51	7.14	6.8	1.292	4.2	4.2	4.2	1.523	8.153	7.813	2.305
6	14:50	0.544	7.14	6.8	1.292	4.14	4.14	4.14	1.557	8.153	7.813	2.305
Average		0.533	7.140	6.743	1.281	4.208	4.208	4.208	1.546	8.153	7.756	2.294

Table 9 Enthalpy R-134a With Mass Refrigerant 110 gr

Enthalpy (kJ / kg)			
h1	h2	h3	h4
427.04	457.85	245.85	245.85

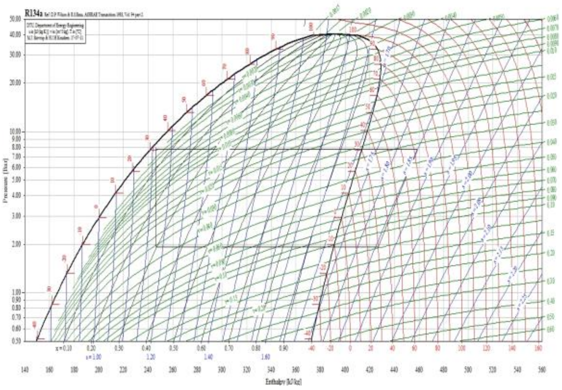

Figure 7: p-h Diagram with Mass Refrigerant 110 gr

R-134A Test Result with Mass Refrigerant 130 Gram

Table 10: Temperature Results Test Of Mass Refrigerant 130 gr

TIME		TEMPERATURE (° C)						
NO	HOUR	TL	T1	T2	T3	T4	TOE	TOC
1	14.55	31	30	69	34	17	26	33
2	15.05	31	30	71	34	16	26	33
3	15.15	31	30	72	34	17	26	33
4	15.25	31	30	72	34	16	26	33
5	15.35	31	30	72	34	15	26	33
6	15.45	31	30	73	34	14	26	33
Average		31	30	71.5	34	15.83	26	33

Table 11: Pressure and Electric Current Result Test of Mass Refrigerant 130 gr

TIME		PRESSURE (Bar Gauge)				ELECTRICAL CURRENT (A)			PRESSURE (Bar Absolut)			
NO	HOUR	PG1	PG2	PG3	PG4	R	S	T	PA1	PA2	PA3	PA4
1	15:05	0.884	7.616	7.14	1.496	4.63	4.63	4.63	1.897	8.629	8.153	2.509
2	15:15	0.816	7.48	7.14	1.496	4.61	4.61	4.61	1.829	8.493	8.153	2.509
3	15:25	0.816	7.616	7.14	1.496	4.66	4.66	4.66	1.829	8.629	8.153	2.509
4	15:35	0.816	7.616	7.14	1.496	4.63	4.63	4.63	1.829	8.629	8.153	2.509
5	15:45	0.816	7.48	7.14	1.496	4.54	4.54	4.54	1.829	8.493	8.153	2.509
6	15:55	0.816	7.48	7.14	1.496	4.53	4.53	4.53	1.829	8.493	8.153	2.509
Average		0.827	7.548	7.14	1.496	4.6	4.6	4.6	1.840	8.561	8.153	2.509

Table 12: Enthalpy R-134a With Mass Refrigerant 130 gr

Enthalpy (kJ / kg)			
h1	h2	h3	h4
426.43	456.62	247.51	247.51

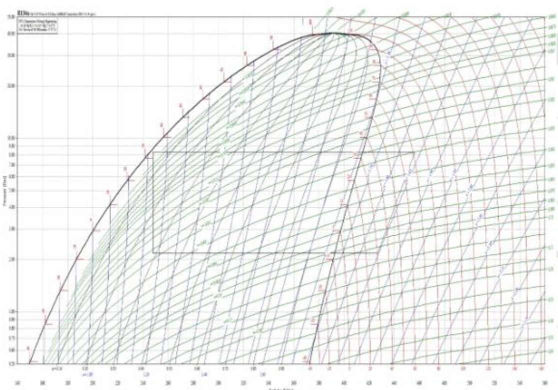

Figure 8: p-h Diagram with Mass Refrigerant 130 gr

R-134A Test Result With Mass Refrigerant 150 Gram

Table 13: Temperature Results Test Of Mass Refrigerant 150 gr

TIME		TEMPERATURE (° C)						
NO	HOUR	TL	T1	T2	T3	T4	TOE	TOC
1	10:10	31	29	68	35	18	22	32
2	10:20	31	29	69	35	17	21	33
3	10:30	32	29	70	36	16	22	33
4	10:40	32	29	70	35	15	22	34
5	10:50	32	29	71	36	15	22	33
6	11:00	32	29	71	36	15	22	34
Average		31.667	29	69.833	35.5	16	21.833	33.167

Table 14: Pressure and Electric Current Result Test of Mass Refrigerant 150 gr

TIME		PRESSURE (Bar Gauge)				ELECTRICAL CURRENT (A)			PRESSURE (Bar Absolut)			
NO	HOUR	PG1	PG2	PG3	PG4	R	S	T	PA1	PA2	PA3	PA4
1	10:10	0.952	8.16	7.48	1.904	5.23	5.23	5.23	1.965	9.173	8.493	2.917
2	10:20	0.952	8.16	7.48	1.904	5.38	5.38	5.38	1.965	9.173	8.493	2.917
3	10:30	0.952	8.16	7.48	1.836	5.3	5.3	5.3	1.965	9.173	8.493	2.849
4	10:40	0.952	8.16	7.48	1.768	5.33	5.33	5.33	1.965	9.173	8.493	2.781
5	10:50	0.952	8.16	7.48	1.768	5.22	5.22	5.22	1.965	9.173	8.493	2.781
6	11:00	0.952	8.16	7.82	1.836	5.41	5.41	5.41	1.965	9.173	8.833	2.849
Average		0.952	8.16	7.53	1.836	5.31	5.31	5.31	1.965	9.173	8.549	2.849

Table 15: Enthalpy R-134a With Mass Refrigerant 150 gr

Enthalpy (kJ / kg)			
h1	h2	h3	h4
425.01	453.97	249.67	249.67

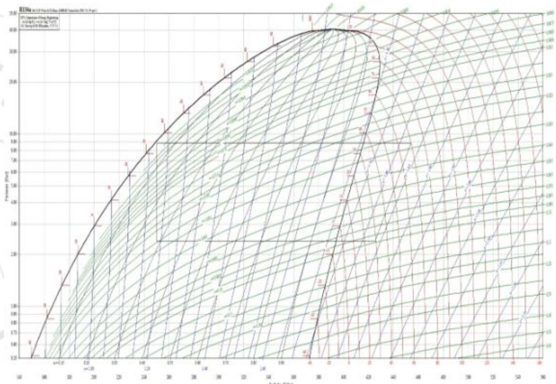

Figure 9: p-h Diagram with Mass Refrigerant 150 gr

R-134A Test Result with Mass Refrigerant 170 Gram

Table 16: Temperature Results Test Of Mass Refrigerant 170 gr

TIME		TEMPERATURE (° C)						
NO	HOUR	TL	T1	T2	T3	T4	TOE	TOC
1	10.10	32	28	65	38	18	18	35
2	10.20	32	28	65	38	18	17	35
3	10.30	32	28	66	38	18	18	35
4	10.40	32	29	67	39	18	18	35
5	10.50	32	29	67	39	18	18	36
6	11.00	32	29	67	39	18	18	36
Average		32	28.5	66.167	38.5	18	17.833	35.333

Table 17: Pressure and Electric Current Result Test of Mass Refrigerant 170 gr

TIME		PRESSURE (Bar Gauge)				ELECTRICAL CURRENT (A)			PRESSURE (Bar Absolut)			
NO	HOUR	PG1	PG2	PG3	PG4	R	S	T	PA1	PA2	PA3	PA4
1	10:10	1.36	8.84	8.5	2.312	6.61	6.61	6.61	2.373	9.853	9.513	3.325
2	10:20	1.36	9.18	8.5	2.312	6.65	6.65	6.65	2.373	1.0193	9.513	3.325
3	10:30	1.36	9.18	8.5	2.312	6.78	6.78	6.78	2.373	1.0193	9.513	3.325
4	10:40	1.292	9.18	8.84	2.312	6.88	6.88	6.88	2.305	1.0193	9.853	3.325
5	10:50	1.292	9.18	8.84	2.312	6.97	6.97	6.97	2.305	1.0193	9.853	3.325
6	11:00	1.292	9.18	8.84	2.312	6.88	6.88	6.88	2.305	1.0193	9.853	3.325
Average		1.326	9.123	8.67	2.312	6.788	6.788	6.788	2.339	1.0136	9.683	3.325

Table 18: Enthalpy R-134a With Mass Refrigerant 170 gr

Enthalpy (kJ / kg)			
h1	h2	h3	h4
423.66	449.66	253.92	253.92

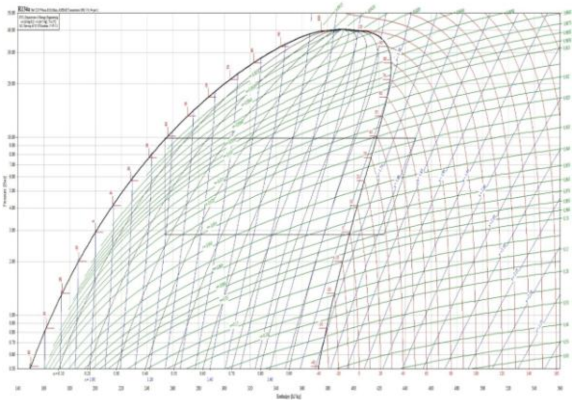

Figure 10: p-h Diagram with Mass Refrigerant 170 gr

R-134A Test Result with Mass Refrigerant 190 Gram

Table 19 Temperature Results Test Of Mass Refrigerant 190 gr

TIME		TEMPERATURE (° C)						
NO	HOUR	TL	T1	T2	T3	T4	TOE	TOC
1	12:10	32	27	63	40	18	17	37
2	12:20	32	27	64	40	18	17	36
3	12:30	32	27	63	40	18	17	36
4	12:40	32	27	65	40	18	17	37
5	12:50	32	27	64	40	18	17	37
6	13:00	32	27	64	40	18	17	37
Average		32	27	63.833	40	18	17	36.667

Table 20: Pressure and Electric Current Result Test of Mass Refrigerant 170 gr

TIME		PRESSURE (Bar Gauge)				ELECTRICAL CURRENT (A)			PRESSURE (Bar Absolut)			
NO	HOUR	PG1	PG2	PG3	PG4	R	S	T	PA1	PA2	PA3	PA4
1	12:10	1.564	9.52	9.18	2.584	7.58	7.58	7.58	2.577	10.533	10.193	3.597
2	12:20	1.564	9.52	9.18	2.584	7.60	7.60	7.60	2.577	10.533	10.193	3.597
3	12:30	1.564	9.86	9.18	2.584	7.86	7.86	7.86	2.577	10.873	10.193	3.597
4	12:40	1.564	9.86	9.18	2.584	7.94	7.94	7.94	2.577	10.873	10.193	3.597
5	12:50	1.564	9.86	9.18	2.584	7.86	7.86	7.86	2.577	10.873	10.193	3.597
6	13:00	1.564	9.86	9.18	2.584	7.93	7.93	7.93	2.577	10.873	10.193	3.597
Average		1.564	9.746	9.18	2.584	7.795	7.795	7.795	2.577	10.759	10.193	3.597

Table 21: Enthalpy R-134a With Mass Refrigerant 190 gr

Enthalpy (kJ / kg)			
h1	h2	h3	h4
421.75	444.73	256.26	256.26

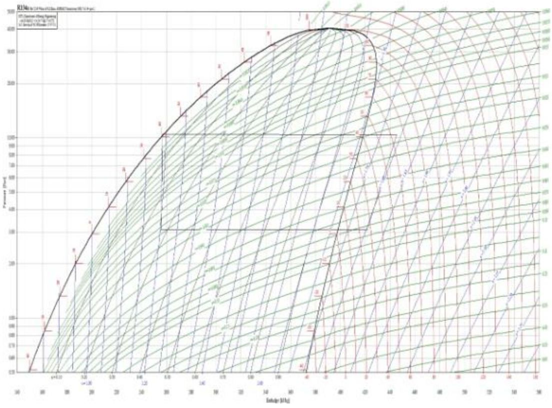

Figure 11: p-h Diagram with Mass Refrigerant 190 gr

5. Conclusion

Obtained from the discussion in Chapter IV, obtained the following conclusions:

1) The amount of COP of the air conditioning cars with R-134a which is best obtained at a mass weight of 190 grams with a value of COP at 7.20. AC electrical power consumption of a car that investigated using R-134a, the electric power consumption obtained with the greatest value is 1714.9 Watt.
2) With the rise in refrigerant mass weight, then the value of the refrigeration effect (RE) was decreased, in contrast to the electric power and the COP. But an increasing rate of refrigeration effect at a mass weight of 90 grams. The increasing weight of the mass of the refrigerant, increasing similarly the pressure on the car air conditioning machine. With increasing mass of refrigerant, then the rotation of the motor associated with the compressor will work harder.
3) Of all the mass of refrigerant that has been researched, refrigerant mass weight of 170 grams is the most appropriate refrigerant for car air conditioner which in research. This is because of the refrigerant mass of 170 grams, the electrical power produced is smaller than the refrigerant mass of 190 grams, and the resulting motor rotation is lighter than 190 grams. And the results at the point TOE and T4 is not too far.

6. Suggestion

For the development of further research, some suggestions to consider are as follows:

1) Adding a different type of variable refrigerant to compare a better COP for the same car air conditioner.
2) Researching further with different motor rpm rotation COP obtained if a higher or lower.
3) Researching further with mass amounts of refrigerant above 190 grams, are obtained COP value increasingly ascending or declining.

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