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Air conditioning system analysis for two floors electronic industrial building size 40 X 25 X 10 meters at PT. CI. in Jakarta

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ABSTRACT

Air fresheners or AC (Air Conditioning) systems are increasingly becoming a necessity for urban communities and the industrial world in Jakarta. AC functions to cool industrial rooms, offices and homes. The PT CI Electronic Industry Building, has not yet installed an air conditioning system so that the production room is not comfortable for its employees. The purpose of installing air conditioning in the industrial building is to increase employee comfort and productivity. In installing an air conditioning (AC) system in the industrial building, design data and cooling load analysis are required. Therefore it is necessary to study the design of industrial air conditioners at PT CI by calculating the cooling load, calculating the required electrical power in order to determine the size and type of air conditioner needed. The research methodology starts from determining industrial building data, such as what tools and machines are in the room, the area of the room and the room wall materials, then analyzing the cooling load, determining the power of the cooling machine and determining the cooling system used. From the results of the cooling load analysis in the Electronics Industry building at PT CI, the total load on floors 1 and 2 was 709 kW, or 201,6 TR, including sensible load: 705.83 kW and Latin load: 3.03 kW. The refrigerant used by the AC R 134a engine. The compressor power is 356 HP. Medium large COP 2.8. The cooling system chosen is the central air conditioning system.

Keywords: industry; load; cooler; power; air conditioning.

INTRODUCTION

In accordance with the natural conditions in the Jakarta area, it is very hot or the temperature is between 27 and 34 degrees Celsius, so that in residential rooms, offices, hotels, hospitals and industries it is less comfortable and in the end the work ethic decreases. For this reason, a room air conditioning system or Air Conditioner (AC) is needed which functions to reduce indoor air. So the room air conditioning system is a system consisting of several components that function to condition the room air so that the air in the room is cool and comfortable for the occupants. The problem is the building of PT. CI, which has two floors, has not yet installed an air conditioning system, so the room for the electronics industry is too hot and uncomfortable for employees to work in. So it is necessary to install an air conditioning system (AC) in the room so that the room is cool, comfortable so that it can improve the work ethic of its employees. The number of PT.DI employees working on the 1st floor of the building is 15 people and 9 production machines, while on the 2nd floor there are 20 people and 3 production machines. It is planned that the indoor temperature is 23 degrees Celsius and the RH (Relative Humidity) humidity is around 50-60%. (Sumanto, 2020) The purpose of analyzing PT CI's room air conditioning system is to determine the amount of cooling load on the first floor and second floor and then to determine the amount of electrical power required for the refrigeration machine and the selection of the type of refrigeration machine used. The heat load that must be cooled by Air Conditioning (AC) is grouped into two parts, namely latent heat load and sensible heat load. (Moran, Michael J.2004) Loads come from various sources (humans, food products, equipment, building structures, and so on) through convection, conduction, and radiation heat transfer processes so that the air experiences an increase in temperature and humidity.(J.P. Hopman, 2010) The heat load that causes an increase in room air temperature is called the heat load. Sensible heat load and latent heat load can be determined by measuring changes in the state of the air before and after the cooling process passes through the cooling coil (indoor). In the analysis of the cooling load, it is grouped into two areas, namely the verimeter area and the internal area. (Wiranto Arismunandar, Heizo Saito, 2005): In general, room air conditioning uses a cooling machine, which is a machine consisting of various components that work according to their function to cool the room temperature so that the room becomes cool and comfortable. (*Egsean.com*, 2021). Meanwhile, to determine the compressor power using a refrigeration system diagram or standard vapor compression cycle according to the reference. (William C. Reynolds Henry C. Perkins, Filino Harahap, 1991)

The following is a schematic diagram of the cooling machine:

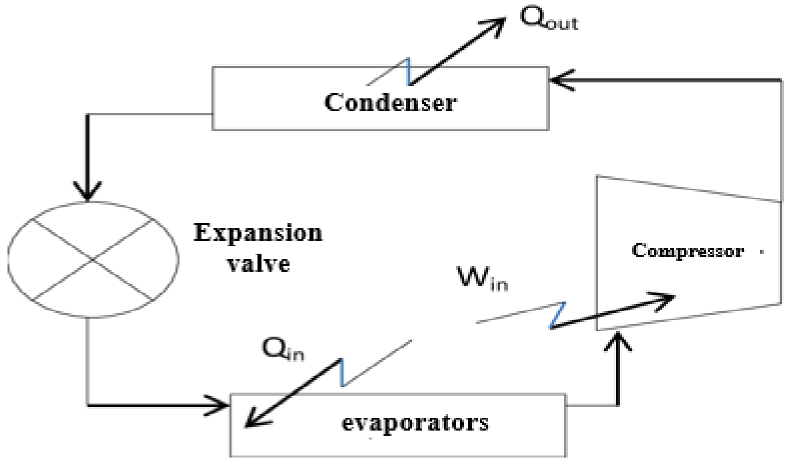

Figure 1. Schematic Diagram of the Cooling System and Figure Source: up load by Imam Taukhid, Tampubolon dan Samosir, 2005 https://www.researchgate.net/figure/Gambar-1-Siklus-refrigerasi-kompresi-uap-standar di unduh 18 Nopember 2022)

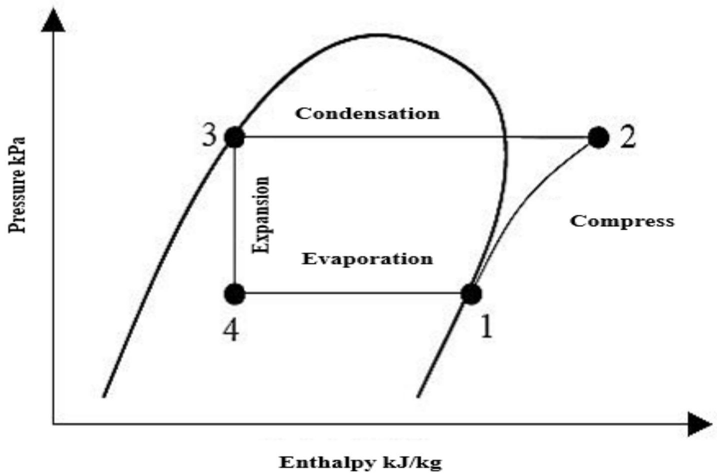

Figure 2. Standard Vapor Compression Refrigeration Cycle Source: https://gregoriusagung.wordpress.com/2010/12/11/mesin-pendingin-siklus-kompresi-uap/ di down Load 18 Nopember 2022)

Standard Vapor Compression Cycle Explanation:

a). Process 1-2. Compression process: namely the refrigerant gas process is sucked from the evaporator by the compressor and pressed to the condenser.

b). Process 2-3. Condensation process: the refrigerant gas is cooled so that the refrigerant becomes liquid.

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c). Process 3-4. Expansion process: the liquid refrigerant is misted from the evaporator and its phase becomes mist/gas.

d). Process 4-1. Evaporation process: namely the low temperature refrigerant absorbs the heat of the room in the evaporator, then the refrigerant is sucked in by the compressor again, thus continuously so that it becomes a cycle called standard vapor compression. (Richard C Jordan Gailey B.P. 1981)

The comfort factor in a room is generally determined by the following parameters:

Dry bulb temperature and wet bulb air temperature, Average radiation temperature, Air flow, Air cleanliness, Odor, Air quality, Noise level. (Wilbert F Stoecker & Jerold W ,Jones, Supratman Hara.1996)

There are several types of air fresheners according to cooling load, namely:

Cooling Load 1 - 4TR Type of Room Air Freshener, namely Split or Casset type. The load is 2-10 TR Type of Air Conditioning (AC) Package. Moderate 10 -30 TR Type AC Split Duck. And 50 – 1000 TR Central AC. (Daikin, 2022)

RESEARCH METHODS

The research methodology is a mindset or depiction of thinking in carrying out a research activity from the initial preparation of data collection, analyzing data until the writing of the research report is complete. This mindset is described in the form of a flowchart as shown in Figure 3.

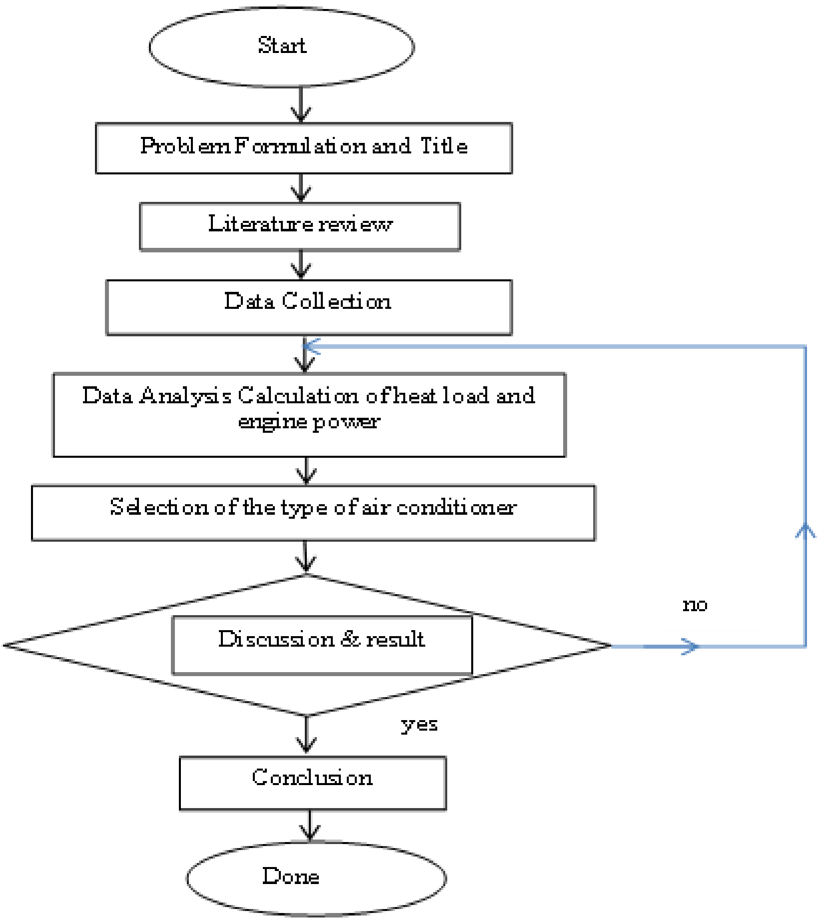

Figure 3. Research Flowchart

The building to be air conditioned is a 2-storey electronics industrial building located in Jakarta at 107° east longitude and 6° south latitude and an elevation of 8 meters above sea level. (Mochamad Sugiri, Srihanto 2020) The observations made were direct interviews from PT CI sources, both face to face and by means of communication.
The data obtained from the Industrial Building are:

Building Name = PT. COVAC INDONESIA. (PT.CI)

Activity = Electronic Industry
Building Type = Industrial Building Electronic
Location = Jakarta
Size = 25 x 40 x 10 m
Number of floors = 2 floors

Floor Data I:

a) Amount of lamps = 8 units (55 Watt/unit), b) Amount of Doors = 2.unit (size 1500 X 2000 mm), c) Amount of glass windows = 8 units (size 400 X 500 mm), d) Amount of people = 15 people, e) number of machines = 9 units. (5.5 kW, 30 kW, 15 kW, 30 kW, 15 kW, 5.5kW, 30 kW, 15 kW, 15 kW)

Floor Data II:

a) Amount of lamps = 6 units (55 Watt/unit), b) Amount of Doors = 2. unit (size 1500 X 2000 mm), c) Amount of glass windows = 6.unit (size 400 X 500 mm), d) Amount of people = 20 people, e) Amount of machines = 3 units (30 kW, 15 kW, 5.5 kW)

Room Temperature Planning Data:

a). Planned room temperature = 23 o C,
b). Outdoor temperature = 32o C,
c). Planned RH = 55 %, d). Outdoor RH = 80 %

The cooling load on refrigerasi eguipmentseldom result from any one single source of heat. rather , it is the summation of the heat which usually evolves from several different source (Roy J Dossat,1961).

The Basics for Calculation of Cooling Loads for rooms on the 1st floor and 2nd floor are:

a) Radiation Load through Window glass. (Wilbert F Stoecker & Jerold W, Jones, Supratm Hara, 1996) :

Qjr = A . sc . SHGF. CLF …………………………………………………………...(1)

where : Qjr = Window Radiation Sensible Heat,
A = Area of window glass.
Sc = Shading coefficient (0.59).
SHGF = Solar Heat Gain Factor :162 Btu/h ft2 = 510.98 Watts/m2,
CLF = Cooling Load Factor. (0.39)

b) Conduction load through window glass. Wilbert F Stoecker & Jerold W, Jones, Supratman Hara, 1996) :

Qjk = U . A . CLTD ……………………………………………………………...(2)

where : A = Window Glass Area (m^2),
U = Coef. heat transfer, (U) = 1.10Btu/h ft2 = 3.47 Watts /m^2,
CLTD = Differential Temperature Cooling Load $(32\text{-}23)^0C = 9^0$ C

c) Calculation of the heat load of the East Wall Floor 1 (Qdt) (Wilbert F Stoecker & Jerold W,Jones, Supratman Hara, 1996) :

Qdt = U x A x CLTDcor. ………………………………………………………….(3)

where : A = Area of the east wall (m^2.),
U = 1 / Rtot = Heat transfer coefficientRU = 1/(Rt) (W/m2K),
CLTDco = {(CLTD+(25–ti)+(to–29)} ……………………………………………..(4)

d) Cooling Heat Load through the Door. :

Qp =U x A XCLTDCor………………………………………………………….....(5)

where : A = door area (m^2),

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U = 1/Rt = Heat transfer coefficient (10 mm thick aluminum R = 0.32 m^2/ kW)

e) Heat Load Through the roof and floors (from corsemen concrete and sand):

Q lt = U x A x (to-ti) ………………………………………………………………..…(6)

where : A = roof or floor area (m^2),U = 1/R Heat transfer coefficient (1.94 m^2 /kW), ti = planned indoor temperature (ºC), to = outdoor temperature (oC)

f) Caloric Load Analysis of Lights in Buildings. (ASHRAE, 2020):

Qlp = n x Fu x Fb x CLF…………………………………………………………..…(7)

where : n = many lights,
Fb = florence ballast factor (1,2),
Fu = usage factor (0.85)

g) Calculation of heat for Office or Industrial Equipment (ASHRAE, 2020)

Qal = N x HG X CLF ……………………………………………………….…..(8)

where : N = number of equipment in (Watts),
HG = Cooling load factor issued by Equipment (kW),
CLP = Cooling Load Factor by usage time (0.85)

h) Person or Employee Sensible Expenses indoors (Wilbert F Stoecker & Jerold W, Jones, Supratman Hara, 1996):

Qos = n x SHG x CLF ……………………………………………………………..(9)

where : n = many people in the room,
SHG = Sensible heat factor emitted by people (0.555% of 150 Watts: 82.5 Watts),
CLF =: Coolant load factor which is affected by working time (0.80)

i) Calculation of Latin Heat Indoors:

Qol = n x LHG x CLF ………………………………………………………...…….(10)

where : LHG = Latin heat factor that is released by people 150 – 82.5 Watt: (67.5 Watts)

j) Heat Load of Ventilated Air and Sensible infiltration ((ASHRAE, 2020)

Qvs = (1.23) (Q”) (to-ti)………………………………………………………...(11)

where : Q” = Volume flow rate from outside (2,5 l/s per person),

k) Latent Infiltration and Ventilation Load:

Qvl = 30 Q” (Wo-Wi) ……………………………………………………………..(12)

where : Wo = outdoor air humidity (77%),
Wi = Room air humidity (55%)

RESULTS AND DISCUSSION

Calculation of the cooling load is calculated during the hottest month and hour, at that time, namely June 25, 2022 between 12.00 and 14.00 WIB, with a planned indoor temperature of 23ºC and 55% humidity. The calculation of the air conditioning load is carried out based on the data that has been obtained as mentioned above (Srihanto. Moch, Sugiri 2021).

Table 1. Results of Heat Cooling Load Analysis of 1st and 2nd Floor Buildings.

No	Component	Load of Sensibility(kW)		Latent Load(kW)	
		Lantai 1	Lantai 2	Lantai 1	Lantai 2
1	Heat Load of Windows (Ql)	0,24	0,119	-	-
2	Heat Load of Wall (Qd)	110,37	110,4	-	-
3	Heat Load of Doors (Qp)	0,57	0,57	-	-
4	Heat Load of Roofs (Qa)	56,7	56,7	-	-
5	Heat Load of Floors (Qla)	78,5	78,5	-	-
	Internal Heat Loads:			-	-
6	Lighting (Qlp)	0,44	0,33	-	-
7	Equipments (Qal)	1,19	1,7	-	-
8	Machines (Qm)	137,7	47,8	-	-
9	Man or Peoples(Qol)	1,1	1,65	1,01	1,35
10	Ventilation	0,15	0,55	0,25	0,33

11	Total Heat Loads	386,96	298,32	1,26	1,68
12	Safety factors 3 %	11,61	8,94	0,03	0,06
13	Total Heat plus safety+ 3%	398,57	307,26	1,29	1,74
14	Heat of Sensibel dan latent	705,83 kW		3,03 kW	
15	Heat sensible & latent (Qt)		Qt = **709 kW.**		
16	Total Heat Latent & Sensible at first floor		399,86 kW		
17	Total Heat Latent & Sensible at second floor		309 kW		

Analysis:

From the results of the analysis of the planned cooling system for the electronics industry building, the load is sensible and Latin as well as the 1st floor = 399.86 kW and the 2nd floor = 309 kW. while the total sensible and latin load is = 709 kW. Then the type of machine that is selected is the central cooling system. Cooling capacity in units of TR (tons of refrigerant is (Wilbert F Stoecker & Jerold W, Jones, Supratman Hara, 1996) :
Qt = 709000 Watt/3517 = 201,6 TR (. (Tons of Refrigerant)

The P-H diagram is a diagram of enthalpy and refrigerant pressure which is useful for determining the size of the compressor power and the amount of COP. According to the working temperature with the refrigerant used, namely: (Srihanto, Moch. Sugiri, Bagaskoro Dwi Kurniawan, 2021)

The cooling machine uses R 134a. with specifications working at the temperature :
Refrigerant enters the compressor at 20^0C, enthalpy h1 = 390 kJ/kg,
Refrigerant leaving the compressor at 62^0C, enthalpy h2 = 445 kJ/kg,
Refrigerant Exit Condenser temperature 35^0C, enthalpy h3 = 240 kJ/kg.
Where h3= h4 is 240 kJ/kg.

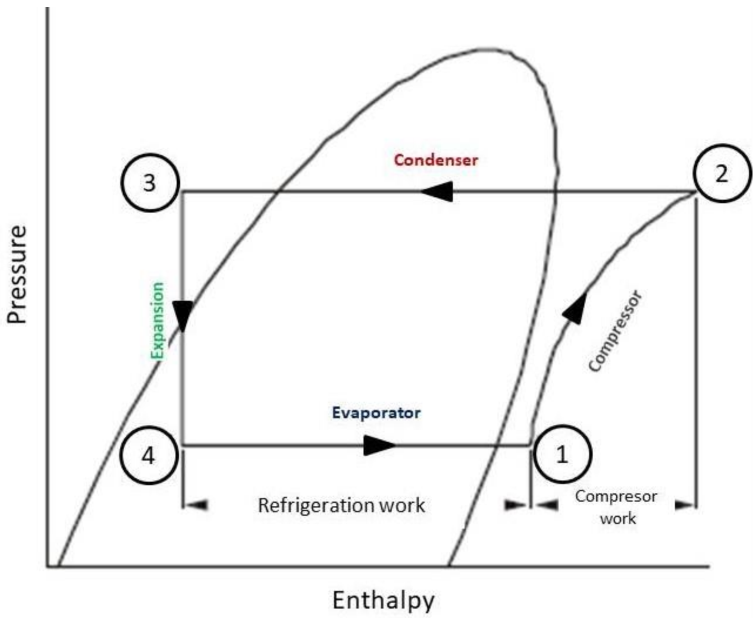

Figure 4. P-H Diagram of Actual Refrigeration Cycle Source: Word Press com. https://chillerstory.id/2020/10/08/sistem-refrigeration-dalam-p-h- diagram/download 18 November 2022)

Refrigerant mass flow rate Qt = m(h1-h4) ,

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(m)= Qt/(h1-h4) = (709 kW)/(150 kJ/kg) = 4.75 kg/s.
Obtained Compressor Power (W) = m (h2-h1)= 261.25 kJ/s = 261 kW, or in HP = = 356 HP.
Determine the price of COP (Coefficient Off Performance) (Roy J Dossat 1961)
COP = (m (h1-h4))/(m(h2-h1))= (709 kJ/s)/(261 kJ/s) = 2.8 .

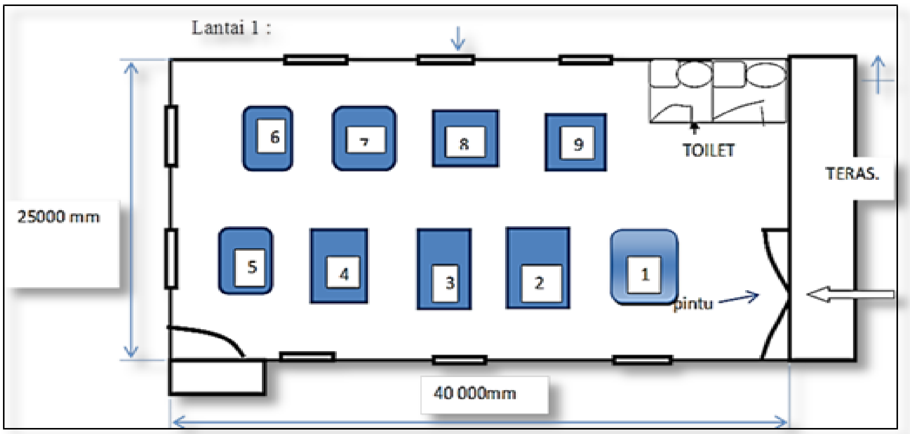

Figure 5. Lay out Building first floor of PT.CI.

Attachment 2

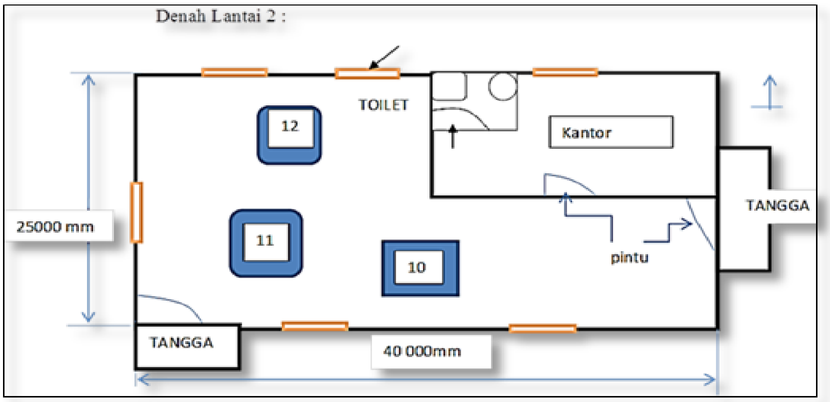

Figure 6. Lay out Building second floor of PT.CI.

CONCLUSION

With the height of the two-storey electronics industry building Size = 25 x 40 x 10 m with a floor area of 1000 square meters, the room temperature is maintained at a temperature of 23 to 25°C and a humidity level (RH) of 50-80%, then from the planning calculation results obtained of the load analysis of the 2-storey electronic building, the sensible and Latin is Number of Latin & sensible load 1st floor load is 399,86 kW, Sensible and Latent Expenses Lt 2 load is 309 kW. So the total sensible and Latin heat load on floors 1 and 2 of the electronics building is what is cooled 709 kW. The ratio of Cooling Load per square meter is: Total cooling load / room area. The magnitude of the ratio = 709 kWatt/ 2000 m^2 = 354 W/m^2. The ratio is due to the height of the building which is 10 meters. Or converted to 201,6 TR. So choose the type of central air conditioner. It is planned that the engine will use R 134a, and the analysis results of the planned compressor power calculation are of recommended: 261 kW, or 356 HP, and the value of the coefficient of performance (COP) of the cooling machine is 2,8.

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