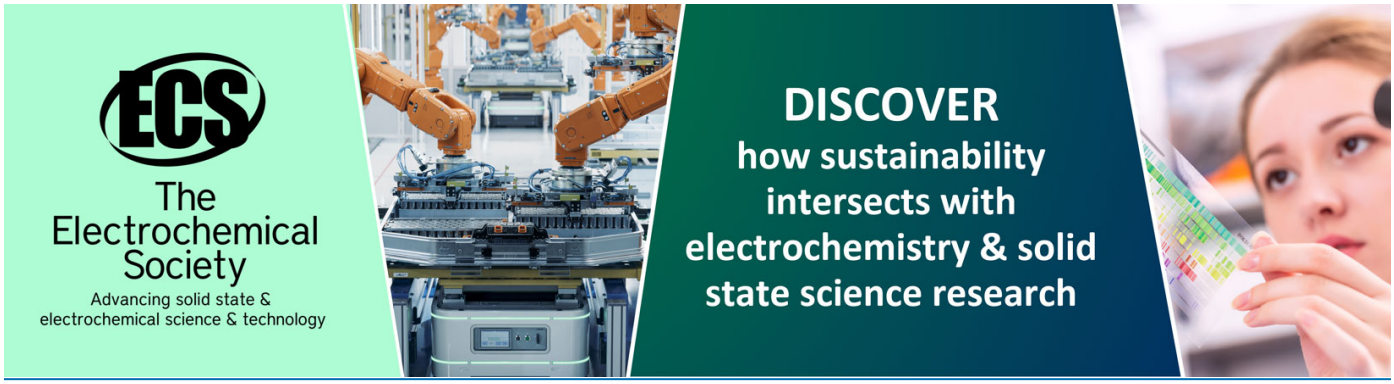
Exergy Analysis of Air Conditioning (AC) System in Suite Room Santika Hotel Yogyakarta



Exergy Analysis of Air Conditioning (AC) System in Suite Room Santika Hotel Yogyakarta

Isnan Yusrian Syas[1], Mohammad Kholid Ridwan[2]

[1] Master Student in Department of Nuclear Engineering and Engineering Physics, Faculty of Engineering, Gadjah Mada University, Grafika 2 Street, Bulaksumur, Yogyakarta, Indonesia
[2] Department of Nuclear Engineering and Engineering Physics, Faculty of Engineering, Gadjah Mada University, Grafika 2 Street, Bulaksumur, Yogyakarta, Indonesia

Email: isnanyusrian95@mail.ugm.ac.id

Abstract. Air Conditioning are major contributors to energy consumption in-suite room Santika Hotel Yogyakarta. A suite room is a choice of rooms with the best facilities compared to other rooms, so comfort is one of the services that must be optimized. The ain is to determine the conduction heat load of various components in the room. Heat conduction load calculation includes heat load through the glass on the east 1253.18 BTU/hr, conduction heat load through the wall to the south 606.14 BTU/hr, solar radiation through glass 1268.48 BTU/hr, heat gain from people 1980 BTU/hr, electrical equipment/lights 2193 BTU/hr and heat gain from ventilation 13053.6 BTU/hr. The total amount of heat gain used in exergy analysis calculation with a value of 3053.16 BTU/hr.

1. Introduction

Energy in the era of globalization is increasing along with the development of technology, industry, and population growth. Growing energy needs encourage every country to innovate and make various efforts to supply energy while maintaining the balance of the existing environmental ecosystem. Air conditioning is significant contributor to energy consumption in residential and commercial buildings in many regions [1]. Most people spend up to 90% of their time indoors, and many spend most of their working hours in an office environment [2]. To reduce energy consumption, air conditioning systems are not used to bring in adequate amounts of outdoor air, and CO_2 concentration will increase if the quantity of fresh air supply per person [3]. The function of the air conditioning system is to condition or regulate the air, both temperature, humidity, circulation and to purify or clean the air. Santika Hotel is one of the hotels in Yogyakarta that applies the air conditioning system design in buildings to provide a comfortable environment for its residents by conditioning the variables in the room air, which include temperature, humidity, airspeed, and cleanliness, so that they can spread throughout the room.

The energy performance of air conditioning systems is usually evaluated based on the first law of thermodynamics. However, compared to energy analysis, exergy analysis be better and more accurate [4]. Exergy analysis of a complex system can be performed by analyzing the components of the system separately. Identifying the main sites of exergy destruction shows the direction for potential improvements [5]. A thermodynamic system based on the principles of the first law of thermodynamics, namely the amount of energy that is constant during the energy transfer process and

based on the principles of the second law of thermodynamics, shows that exergy is a cross between the I and II laws of thermodynamics, that there is no change in the amount of energy, but a difference in the quality of energy [6]. Hotel Santika Yogyakarta is one of the buildings that play an essential role in the mobility of foreign and domestic visitors. Therefore, to support all activities in it, air circulation in the hotel building must be made so that visitors feel comfortable inside.

Nomenclature

Q	Heat Gain (BTU/hr)
E	Exergy
SHGF	maximum solar heat gain factor (BTU/hr.ft^2)
A	area of glass (ft^2)
SC	shading coefficient
CLF	cooling load factor for glass
Q_s, Q_l	sensible and latent heat gain (BTU/hr)
$q_{s,} q_l$	sensible and latent heat gain per person
n	Number of people
CLF	cooling load factor for people
W	lighting capacity (watt)
BF	ballast factor
CLF	cooling load factor for lighting
Q_s, Q_l	sensible and latent cooling load from ventilation (BTU/hr)
TC	temperature change between outdoor and inside (F)
CFM	air ventilation rate (ft^3/min)
$W_0^{'} - W_i^{'}$	outdoor and inside humidity ratio (gr/lb)

2. System Analysis

2.1. Air Conditioning

Air Conditioner is a tool that can condition the air. Air conditioning serves as the desired air conditioner (cool or cold) and is comfortable for the body. To ensure the effective functioning of the air conditioning and air filtration systems, the exhaust air from the clean rooms [7]. Interacting systems between room air temperature of a single zone space and supply air temperature controls are considered. In air conditioning systems, the control loop can quickly get into huntings [8]. In general, there are two types of cooling systems based on the heat transfer medium, namely, air conditioning, heat transfer system through air media, and water cooling, heat transfer system using water or coolant media.

2.2. Heat Gain

Glass and walls are analyzed in the same way. In winter, the heat loss is simple transmission based on the inside and outside temperature, and U-value of composite structure,

2.2.1. Conduction through the glass and wall. Solar radiation affects the outside surface of walls and glass. It depends on the properties of wall and glass structure, outer character material and color, and intensity component perpendicular to the outer character. The solar radiation amount depends on the orientation of the character, solar azimuth angle, and solar altitude angle.

$$Q = U \times A \times \Delta T \quad (1)$$

2.2.2. Solar radiation through glass. The maximum solar heat gain factor (SHGF) is the ultimate solar heat gain through a single clear glass at a given month, orientation, and latitude [9].

$$Q = \text{SHGF x A x SC x CLF} \quad (2)$$

2.2.3. Heat Gain from People. Sensible heat gains per person are heat gain from persons in air-conditioned spaces, number of people is the count of people responsible for heat gain in space and cooling load, the temperature. Difference between indoor and outdoor air with the inclusion of heating effect of solar radiation [10]. The equations for cooling loads from sensible and latent heat gains from people are

$$Q_s = q_s \times \text{n} \times \text{CLF} \quad (3)$$

$$Q_l = q_l \times \text{n} \quad (4)$$

2.2.4. Electrical equipment/lights. The factor BF accounts for heat losses in the ballast in fluorescent lamps, or other special losses. A typical value of BF is 1.25 for fluorescent lighting. For incandescent lighting, there is no extra loss, and BF = 1.0. The factor CLF accounts for the storage of part of the lighting heat gain. The storage effect depends on how long the lights and cooling system are operating, as well as the building construction, type of lighting fixture, and ventilation rate.

$$Q = 3.4 \text{ x W x BF x CLF} \quad (5)$$

2.2.5. Heat Gain from Ventilation. The outside air temperature used for calculating the sensible ventilation load is corrected for the time of day. There will be no diversity of bags, because all lights are on at all times, and the people occupancy occurs simultaneously [9]. Outdoor air enters a structure using both infiltration and ventilation**.** The heat gain produced by the entering air will be expressed in terms of its sensible heat gain and its latent heat gain in Btu per hour.

$$Q_s = 1.1 \times \text{CFM} \times \text{TC} \quad (6)$$

$$Q_l = 0.68 \times \text{CFM} \times \left(W'_0 - W'_i\right) \quad (7)$$

2.3. Cooling Load

In designing an air freshener system, cooling load is the most important thing to get comfort. The calculated cooling load will determine the piping system and ducting size of the air freshener system. There are two types of cooling load sources in a room, namely sensible heat loads and latent heat loads. Sensible heat load is a load due to the heat released to change the temperature, while the latent heat load is a load because the heat released is needed to change phase. The general condition of a building differs depending on the location, area, and state of the building being reviewed. The optimal control model of the air-conditioning systems belongs to a multivariable nonlinear problem, on the basis of predicting air-conditioning system load [11]. The following is the cost of each room from the Santika Hotel Yogyakarta,

Table 1. Condition of the suite room at the Santika Hotel Yogyakarta

Floor Area	387,30 ft^2
Room Height	11,48 ft
Room Volume	4446,20 ft^3
Door and Windows	86,07 ft^2

Table 2. The power used or generated in the room

Tubular Lamp	40 Watt
Television	100 Watt
Refrigerator	45 Watt
Visitor	6 Person

Santika Hotel Yogyakarta has several rooms on each floor, such as standard rooms, deluxe rooms, and suite rooms. The area under review is in the first floor with room conditions such as table 1. The power used in the room depends on several components of table 2. Each part has a power that affects the amount of heat generated.

2.4. Exergy Analysis

From energy equilibrium and entropy, the change in exergy is the result of the reduction of the transfer of exergy that accompanies the heat and energy that accompanies it with the destruction of exergy from energy equilibrium and entropy, the change in exergy is the result of the reduction of the transfer of exergy that accompanies the heat and energy that accompanies it with the destruction of exergy. Exergy equation form,

$$\frac{dE}{dt} = \sum_j \left(1 - \frac{T_o}{T_j}\right) Q_j - \left(W - p_o \frac{dV}{dT}\right) - E_d \quad (8)$$

$$\frac{dE}{dt} = \sum_j \left(1 - \frac{T_o}{T_j}\right) Q_b \quad (9)$$

If the temperature at the heat transfer location is lower than the ambient temperature, then the exergy displacement will have the opposite direction.

3. Result and Discussion

The room being reviewed is a suite room first floor with one room per floor because the suite room specifications are the same foot. Suite room is a choice of rooms with the best facilities compared to other rooms. Visitor comfort is one of the services that must be optimized, especially about air conditioning.

3.1. The calculation results Suite Room Heat Gains

The suite room has several components that are used in calculating the heat load, such as the use of electronic equipment, the position of the ventilation, the number of people, and the position of the windows and doors. Table 3 shows the calculation of the heat gain consumption in the suite room.

Table 3. Suite Room Heat Gains

No	Heat Gain Component	Q (BTU/hr)
1	Conduction through the glass	1253.18
2	Conduction through the wall	606.14
3	Solar radiation through glass	1268.48
4	Heat Gain from People	1980
5	Electrical equipment/lights	2193
6	Heat Gain from Ventilation	13053.6

In calculating the cooling load of the suite room, the air conditions and materials used for the glass, walls, and doors are the same as in other rooms, so the overall heat transfer coefficient is the same as for the other rooms. For suite rooms, the position of the window faces east while the wall faces south. The results of the heat gain calculation in the suite rooms are shown in table 3, where the heat load through the window is much greater than the heat load through the wall. In the suite room, 10 tubular lamps have a capacity of 40 watts, so the total capacity is 400 watts. The ballast Factor for tubular lamps is assumed to be 1.25, while other equipment such as televisions and refrigerators is considered to be 1. The lamps are only turned on during working time, so that the length of time the light is on is equal to the time of use of air conditioning, so CLF = 1.

Radiant energy from the sun passes through transparent materials such as glass and becomes a heat gain to the room. Its value varies with time, orientation, shading, and storage effect [10]. All glass is assumed to absorb some heat and light from the sun, and there is interior shading by Venetian Blinds or Roller Shades. From Edward G's book using Venetian Blinds obtained the value of SC = 0.29. CLF values at 13.00 p.m, N = 0.88, E = 0.22, W = 0.31, and S = 0.79.

The rate of heat gain from people depends on their physical activity. Assuming the CLF = 1 and there are six people seated at rest, the sensible heat value is 225 BTU/hr, and the latent heat value is 105 BTU/hr. Each person in the room requires 30 CFM of fresh air, so the heat load from the ventilation obtained is 13053.6 BTU/hr.

3.2. Exergy analysis

Exergy analysis is used to determine the maximum amount of work obtained when the heat gain flows through a process that involves interaction with the environment [12]. The amount of exergy is obtained from equation nine by applying all the heat gain in the suite room. The calculation results received a total heat gain of 20354.4 BTU/hr with an indoor temperature of 92 °F and an outdoor temperature of 78 °F. The data obtained are used to determine the exergy value of the suite room. The exergy value obtained is 3053.16 BTU/hr.

4. Conclusion

Calculation of heat gain consumption in-suite rooms is influenced by conduction through the glass and wall, solar radiation, People, Electrical equipment/lights, and ventilation. Each component obtained a value of BTU /hr of 1253.18 BTU /hr, 606.14 BTU /hr, 1268.48 BTU /hr, 1980 BTU /hr, 2193 BTU /hr, and 13053.6 BTU /hr. The most significant heat gain value comes from ventilation, while the smallest heat gain comes from the wall. The total amount of heat gain used in exergy analysis calculation with a value of 3053.16 BTU/hr.

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