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STUDY THERMAL OF COMPRESSOR POWER REDUCTION ON USING SOLID DRY PAD PRE-AIR COOLING SYSTEM

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Abstrak

The aim of the research is uses of compressor based air conditioning system has rapidly increased the consumption of fossil fuel energy resources and the degradation of environment quality. Massive study has been done worldwide to reduce energy consumption for compressor based air conditioning (AC) system. This study is subjected to investigate the use of solid dry pad as pre-air cooling for AC system. In this study, solid dry pad would be placed in the evaporator and condenser inlet air side. This placement was objected to give a pre-cooling effect for evaporator and condenser inlet air, so then the compressor could be operated with a lower power consumption. The experiment would be carried out within three level air mass flowrate of 0.293 kg/s; 0.319 kg/s; and 0.359 kg/s, for air velocity of 2.2; 2.4; and 2.7 m/s respectively, the cooling cabin is set into 30^{o}C using a heater as a cooling load. As a results, it could be revealed that at the highest air mass flowrate of 0.359 kg/s, it could achieved the lowest compressor power consumption of 0.44 kW, within a higher cooling capacity of 2.625 kW, a higher condenser heat rejection of 3.622 kW and also higher COP of 5.9. Referring to those results, it can be concluded that when employing solid dry pad pre-air cooling for evaporator and condenser AC system, it could reduced compressor power consumption by 12.2%; 21.9% and 20% for air velocity of 2.2; 2.4; and 2.7 m/s respectively.

Kata kunci : *solid dry pad, pre-air cooling, compressor power reduction.*

BACKGROUND

The aim of the research is uses of compressor based air conditioning (AC) system has been caused a massive fossil fuel energy input required and also it could severe the environment damages. Many effort has been conducted to develop method in minimizing the use of fossil fuel energy input for AC system. Tay Cher Seng and Thazin Soe, (2017) has been developed study in the application of passive displacement ventilation (PDV) which distributes cooled air into the room without using mechanical fan, as typically fan would consumed 15% of total energy used in a building. As a result the PDV system can reduce energy consumption from air side equipment from 0.25 kW/RT to 0.00 kW/RT.[1]. X. Cui et.al.(2017) has been develop a study to introduce an air treatment system (ATS) for reducing energy consumption for AC system and improving indoor air quality. The ATS system could lowering outdoor air intake rate in turn would reduced cooling load. As a results, the ATS could reduce total energy required from 52.18 W/m2 to 41.26 W/m2 by adjusting air intake rate from 10 L/s per person to 4 L/s per person.[2]. Wei-Han Chen et.al.,(2018) has investigated the uses of an energy saving device (ESD) on the split –type air conditioning (SAC) system. This ESD was equipped by several absorber component that can absorb and distribute expelled condensate for evaporative cooling the compressor. The ESD system has been proving that it could obtain the compressor shell temperature, high-side pressure, and power consumption for SAC system of 15.1^{o}C, 2.7% and 9.2% lower than those without the ESD system.[3]. Dae Kyu Lim et.al.,(2018) has develop study on the application of an evaporator pressure control reading (EPCR) compare to the current evaporator outlet pressure reading (EPCP) for air conditioning system. It has been found that after 100 min operation, EPCP system under sensible heat load of 3 kW, dry bulb temperature of 23.2^{o}C and relative humidity of 51%, while EPCR system within the same dry bulb temperature and relative humidity of 58.9%. As a results, it found that the average power consumption of 2500 W for EPCP and 1850 W for EPCR.[4]. Jun Mei et.al.,(2018) has investigate a control method for direct expansion air conditioning system that control thermal comfort and indoor air quality and simultaneously reduce energy consumption and cost. It conclude that the control system could reduce power consumption about 31.38% and for cost about 33.85%.[5] Furthermore Weihua et.al.,(2017) investigated the influence of a pipe-planted cooling system with ventilation, in which the pipe-embedded cooling system were integrated with ground source heat exchanger (GSHX). The results showed that the pipe-embedded cooling system has been obtained 80% energy saving, while the mechanical ventilation alone has reached 48% energy saving. This combination cooling system has provided an additional increase of 13% energy saving in hot summer and warm winter region. [6]. Refer to those study, there were various method to reduce power consumption on air conditioning system. This purposed work would investigate the uses of dry ice based solid dry pad which is placed in the inlet side of evaporator and condenser as a pre-air cooling system. This placement was aimed to provide a pre-cooling process for the room air that would pass through to the evaporator and provide air pre-cooling for the condenser to release heat into the surrounding. The air pre-cooling process before evaporator and condenser is expected to lighten the cooling load of evaporator and reject more heat in condenser, in turn it would reduce the compressor power consumption. The compressor power consumption can be lowered as some amount of the evaporator cooling load has been taken over by the solid dry pad. This would lowering compressor work as it only provide a less refrigerant mass flow rate and a slightly higher refrigerant temperature into the evaporator than as it should be, when the solid dry pad were not installed.

MATERIAL DAN METHOD

Material

This experiment was equipped by an air conditioning unit, isolated air channel, two solid dry pad unit. Two solid dry pad is made of 20 cube pipes each, in staggered and in-line arrangement, and it is fully filled with local dry ice. The geometric size of solid dry pad was 40 mm x 40 mm x 380 mm (length x width x height). Some digital thermocouple was placed in inlet and outlet side of evaporator and condenser respectively. A conditioned cabin 200 cm x 120 cm x 120 cm size was set up on 30^{o}C using a heater as a cooling load. It is used a mechanical fan within three air velocity level of 2.2 m/s, 2.4 m/s and 2.7 m/s for air circulation between cabin and evaporator. A clamp meter was used to measure the input electric current of compressor.

Method

a. Experimental Set Up and Procedures

The experiment was set up in three air velocity level of 2.2 m/s, 2.4 m/s, 2.7 m/s. The conditioned cabin air temperature was adjusted on 30°C.

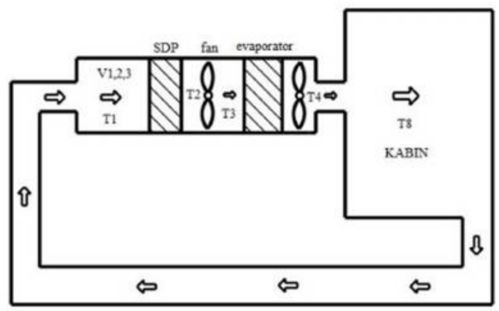

Figure 1. Experiment Schematic Diagram

As it can be seen from Fig.1, the air is forced circulated from conditioned cabin to the evaporator using mechanical fan. The air would pass through the solid dry pad first for pre-cooling before it come to the evaporator for another cooling process and flowing to the conditioned cabin. The experiment would be conducted in two repetition for each air velocity level of 2.2 m/s, 2.4 m/s and 2.7 m/s, and the air temperature would be recorded every 15 minutes for one hour time, as T1 solid dry pad inlet air temperature, T2 mechanical fan inlet air temperature, T3 and T4 evaporator inlet and outlet air temperature respectively, T8 is conditioned cabin air temperature. Along with the temperature measurement, the input electric current for the compressor is measured as well.

b. Experiment Formula

As it required to determine the compressor power reduction, it would then to be used the formula as follow

P=V.I...(1)

Where P denotes compressor power consumption (Watt), V is the existing electric voltage (Volt) and I is input electric current of compressor (Ampere).

RESULT

After the assessment, it would then to be resulted data for the experiment with and without solid dry pad (SDP) as follow

Table 1 *Compressor electric current without SDP*

Air Velocity (m/s)	Electric Current Average (Ampere)
2.2 m/s	2.55
2.4 m/s	2.50
2.7 m/s	2.40

Table 2 *Compressor electric current with SDP*

Air Velocity (m/s)	Electric Current Average (Ampere)
2.2 m/s	2.275
2.4 m/s	2.125
2.7 m/s	2.000

Those compressor electric current data is taken at 220 V electric voltage. It represent the average compressor electric current for three air velocity level of 2.2 m/s, 2.4 m/s, and 2.7 m/s, which is recorded every 15 minutes in 60 minutes assessment time**.**

DISCUSSION

As a result, it could be developed the relation graphic between compressor power consumption and air velocity without/with Solid Dry Pad as it showed in **Fig.1**

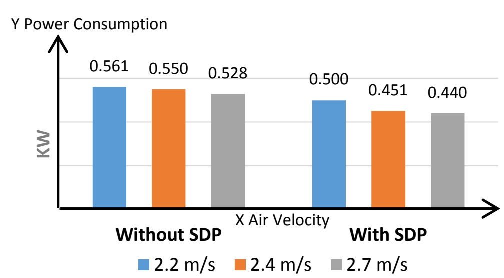

Figure 1. Relation Graphic Between Compressor Power Consumption and Air Velocity without and with Solid Dry Pad

Referred to the **Fig.1**, it could be explained that at condition without SDP the highest power consumption of 0.561 kW has been occurred at the lowest air velocity of 2.2 m/s, as same as with the SDP, the highest power consumption of 0.50 kW has been reached at 2.2 m/s air velocity. This described that there would be a higher compressor power consumption on the lower air velocity either for the system without or with SDP. This was occurred due to at the lower air velocity, the SDP has a lower pre-cooling capacity by then it only absorbed less heat and more heat should be absorbed by the evaporator.

The higher the cooling load of the evaporator, the higher the compressor power consumption. On the other hand, generally it can be showed that the use of the SDP on the condition without SDP would consumed more energy input for compressor compared to that with SDP. Furthermore the average of compressor power reduction can be obtained by installing the SDP is about 18%..

CONCLUSSION

It can be concluded that within the use of solid dry pad, the higher air velocity would result a higher reduction of compressor power consumption and in average it can reduce the compressor power consumption about 18%.

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