International Journal of Mechanical, Industrial and Aerospace Sciences
ISSN: 2517-9950
Vol:6, No:8, 2012

Development of Split Air-Conditioning System using Chill Water as the Cooling Medium

Faezzan Madli, Zamri Noranai, Md. Norrizam Mohamad Jaat, Hamidon Salleh, Mohammad Zainal Md Yusof

***Abstract*—**Current air conditioning system is using refrigerant as the cooling medium. The main purpose of this study is to develop an air conditioning system using chill water as the cooling medium. In this system, chill water used to replace refrigerant as the cooling medium. This study is focus on the split type unit air conditioning system only. It will be involving some renovation on the indoor unit and freezer. The cooling capability of this system was validate by few series of testing, which conducted at standard 36m^3 office room. Result of the testing found that 0.1 m^3 of chill water is able to maintain the room temperature within standard up to 4 ~ 8 hours. It expected able to maintain room temperature up to 10 hour with some improvement.

***Keywords*—**Chill water, air-condition, office room.

I. Introduction

MALAYSIA is one of the countries on the equator that has the tropical rainforest climate or equator climate. Therefore, in order to do our daily life in a much more comfortable way, the uses of air condition system seem to be very important nowadays [1]. Air conditioning system is the process removal of heat from indoor air to outdoor air for the thermal comfort design temperature. In another expression, air-conditioner is a tool, a device, a appliance, system, or machine designed to lower the air temperature and humidity within an area, commonly for human comfort cooling in buildings or vehicles. Air conditioners use refrigerant that easily convert from a gas to a liquid and back again. This refrigerant is use to transfer heat from the indoor air to the outdoor air [2].

Air condition has three main parts; they are a compressor, a condenser and an evaporator. The compressor and condenser are located outdoor while evaporator is located indoor. The refrigerant goes into the evaporator through a very tiny and narrow hole. This process cause pressure drops and refrigerant begins to evaporate into a gas. Finally, it extracts heat from the indoor space. As the heat is removing from the air, the indoor air is cool. This process continues repeatedly until the room reaches the design temperature. System operation will turns off when indoor temperature has reached the design temperature. As indoor temperature warms up, air conditioner back on until the room reaches the design temperature. The objective of this study is to develop an air conditioning system by using chill water as the cooling medium.

Zamri Noranai is with Universiti Tun Hussein Onn Malaysia, Malaysia e-mail:zamrin@uthm.edu.my

At present air conditioner unit using refrigerant as the cooling medium transfer, while this study will be using water as the cooling transfer medium.

II. Methodology

A scale down TES model was developed base to split type air-condition operation system. The indoor air condition unit was modifying by attaching cool storage freezer. Several additional parts and components were included into the system. The development process is including design, material selection, component selection, fabrication, assembly and experiment.

At design stage it is important to design how to transfer cool from storage tank through evaporator and finally to surrounding. Low temperature chill temperature in storage tank was transfer to evaporator by water pump. Water was use as transfer medium. Water acting as the medium to transfer cool from tank to evaporator. When the low temperature reaches indoor unit, a blower from air condition system wills blowout cool air from indoor unit to surrounding. This process will create a turbulent air condition around indoor unit and will help heat transfer process from surrounding to storage tank.

New piping design needs to replace split air condition piping system. The main important thing is the piping system must connect the water pump to enable water pump to pumping chill water from storage tank into indoor unit and then return to storage tank. No copper tube used in this new piping system[3,4]. Fig. 1, show the systematic diagram of TES model. A new wiring system needed to control water pump and air condition indoor unit. The operating system are controlled by using present air-conditions control system.

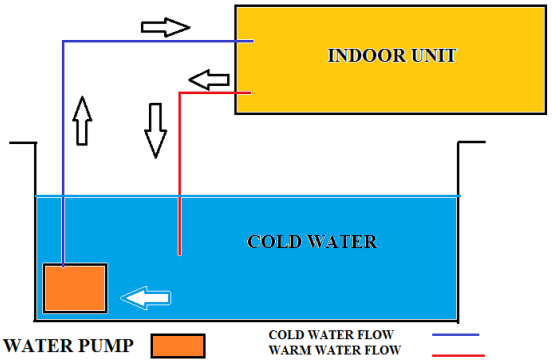

Fig. 1 Systematic diagram TES model

Chill water temperature is important thing in this study. Maintaining lower temperature of chill water is a main important to consider. Losses in chill water storage capacity will consider as a weakness in this studies. Therefore chill water storage tank cannot be just an ordinary water tank. It must capable to kept low temperature for a longer. For this reason, chest freezer seems to be one of the good choices as a storage tank. In additional it also will produce chill water by itself. Fig. 2, shown completed fabricates TES scale down model.

(a)

(b)

(c)

(d)

Fig. 2 TES model (a) Front vien (b) Back view (c) Side view and (d) Front view

III. Result And Analysis

The developed TES scale down model is completed designed and fabricated process. The product consists of indoor, storage tank, water pump, piping system and power supply. Fig. 2, shown completed fabricates TES scale down model. Ordinary chess freezer was select as storage tank. The freezer will perform as ice or chill water maker and in same act as storage tank.

The indoor unit and storage tank is connecting by designed piping system. The indoor component consist condenser, blower and controller as common indoor units. Series of experiments had carried out to test the performance of the designed product to produce cooling effect inside a room during actual operation condition. Small office room selected as a case study.

CASE STUDY I

Date	:	4th Mei 2012
Time	:	11.30 am
Room Size	:	12 m²
Room Type	:	Small Office Room
Operation Mode	:	Open Loop
Cooling Medium	:	Chill Water
Volume	:	0.1 m³
Circulation Medium	:	Water
Storage Temp	:	6 ° C
Outdoor Temp	:	32 ° C

There are five thousand data was record in this case study 1. Data lodger recorded temperature reading every minute at eight-difference point. Experiment was start at 11.30 am until 5.00 pm. Detail of data result is show in table I.

TABLE I
CASE STUDY 1 COOLING TEMPERATURE READING BY DATA LODGER

Date	Time	Channel OUTDOOR TEMP °C	1- Channel ROOM (TOP) TEMP °C	2- Channel ROOM (BOT) TEMP °C	3- Channel AIR RETURN TEMP °C	4 - Channel AIR BLOW TEMP °C	5 - Channel WATER OUT TEMP °C	6 - Channel WATER IN TEMP °C	7- Channel CHILL WATER TEMP °C	8-
4/5/2012	11:30:40	32.55	27.42	20.32	23.77	18.57	18.28	9.43	5.97	
4/5/2012	11:40:40	34.20	28.08	20.97	24.16	19.23	19.02	10.59	7.20	
4/5/2012	11:50:40	34.11	28.80	21.36	24.64	19.75	19.53	11.24	8.06	
4/5/2012	12:00:40	33.68	28.86	21.62	24.79	19.95	19.89	11.65	8.52	
4/5/2012	12:10:40	34.38	29.00	21.76	24.93	20.17	20.09	11.93	7.51	
4/5/2012	12:20:40	34.68	29.45	21.99	25.33	20.41	20.31	12.14	6.96	
4/5/2012	12:30:40	35.32	29.85	22.17	25.41	20.62	20.54	12.31	6.96	
4/5/2012	12:40:40	35.33	30.19	22.45	25.60	20.92	20.89	12.56	7.11	
4/5/2012	12:50:40	35.80	30.52	22.73	25.98	21.21	21.18	12.79	7.18	
4/5/2012	13:00:40	36.37	30.73	23.05	26.27	21.52	21.46	12.96	7.30	
4/5/2012	13:10:40	37.76	31.25	23.30	26.56	21.79	21.78	13.19	7.44	
4/5/2012	13:20:40	35.52	31.07	23.42	26.64	21.93	22.02	13.62	7.77	
4/5/2012	13:30:40	34.59	30.53	23.43	26.47	21.83	22.01	14.03	8.16	
4/5/2012	13:40:40	34.47	30.33	23.45	26.43	22.01	22.06	14.43	8.58	
4/5/2012	13:50:40	34.37	30.31	23.59	26.44	22.12	22.21	15.09	9.02	
4/5/2012	14:00:40	34.56	30.30	23.76	26.55	22.39	22.53	15.98	9.44	
4/5/2012	14:10:40	35.16	30.51	24.14	26.82	22.79	22.94	17.03	9.60	
4/5/2012	14:20:40	35.90	30.70	24.53	27.01	23.27	23.42	17.98	10.02	
4/5/2012	14:30:40	38.14	31.06	24.94	27.46	23.79	23.93	18.87	10.67	
4/5/2012	14:40:40	38.08	31.49	25.40	27.83	24.30	24.45	19.65	11.61	
4/5/2012	14:50:40	42.16	31.95	25.80	28.25	24.73	24.87	20.31	12.64	
4/5/2012	15:00:40	39.75	32.57	26.23	28.58	25.22	25.43	21.00	13.63	
4/5/2012	15:10:40	39.02	32.66	26.55	28.72	25.59	25.53	21.51	14.57	
4/5/2012	15:20:40	38.13	32.51	26.89	29.08	25.90	26.01	22.12	15.45	
4/5/2012	15:30:40	38.59	32.79	27.30	29.38	26.36	26.40	22.61	16.32	
4/5/2012	15:40:40	39.09	32.87	27.59	29.58	26.71	26.70	23.12	17.19	
4/5/2012	15:50:40	37.54	32.72	27.88	29.96	27.07	27.16	23.70	18.05	
4/5/2012	16:00:40	37.15	32.51	28.11	30.02	27.32	27.35	24.14	18.97	
4/5/2012	16:10:40	36.91	32.41	28.30	30.22	27.58	27.64	24.56	19.83	
4/5/2012	16:20:40	36.51	32.27	28.54	30.37	27.86	27.93	25.05	20.68	
4/5/2012	16:30:40	35.87	32.40	28.66	30.01	27.95	28.04	25.37	21.61	

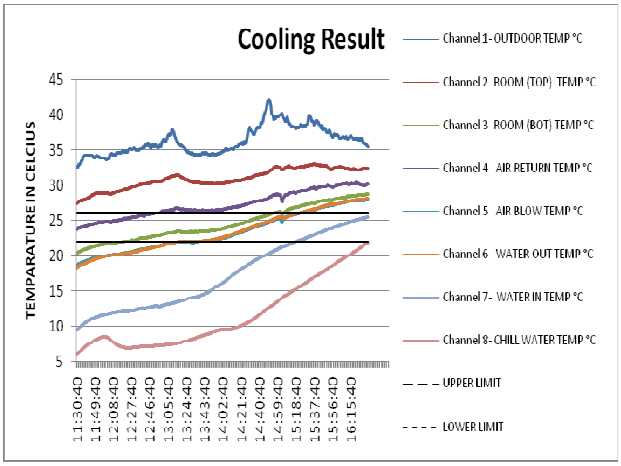

Fig. 3 Temperature distribution for case study I

At beginning of the experiment, normal office room temperature is 28°c. After TES scale down model start operating, office room temperatures reduce to 21°C. Fig. 3 shows graph of case study 1 result. The graph shows that office room maintained it temperature within specification. The model capable keeps room temperature to the desired thermally comfort temperature, which is 23 to 26 °C approximately about 210 minutes. In summaries, this experiment shows with 6°C of 0.1m² chill water successfully reduce room temperature from 28°C to desired temperature for three and half hours.

CASE STUDY II

Date	:	13th April 2012
Time	:	11.30 am
Room Size	:	12 m²
Room Type	:	Small Office Room
Operation Mode	:	Open Loop
Cooling Medium	:	0.1 m³
Volume	:	0.1 m³ of Chill Water
Circulation Medium	:	Water
Storage Temp	:	2 ° C
Surrounding Temp	:	36 ° C

From Fig. 4 shown at beginning of the experiment, normal office room temperature is 28 °c. After TES scale down model start operating, office room temperatures reduce to 20 °C. The graph shows that office room maintained it temperature within specification. The model capable keeps room temperature to the desired thermally comfort temperature, which is 23 to 26 °C approximately about 325 minutes. In summaries, this experiment shows with 6 °C of 0.1 m² chill water successfully reduce room temperature from 28 °C to desired temperature for more than five hours.

Fig. 4 Temperature distribution for experiment II

IV. CONCLUSION

From experiment conducted found that 0.1 m^3 of chill water is able to maintain the room temperature up to three hours. In conclusion, from the research be carried out found that chill water have a potential to be use as the air conditioning cooling medium. Further development for this study is essential.

ACKNOWLEDGMENT

The author gratefully acknowledges the support of this work by Faculty of Mechanical and Manufacturing Engineering, (FKMP), Office for Research, Innovation, Commercialization and Consultancy Management (ORICC) and Universiti Tun Huseein Onn Malaysia (UTHM) under Short Grant vote number 0630 and Fundamental Research Grant Scheme vote number 0721.

REFERENCES

[1] Z. Noranai and M. Z. Md Yusof, *Study of energy efficiency opportunities in UTHM*, *Proceedings of World Academy of Science, Engineering and Technology*, vol. 77 (2011) pp. 745-751.

[2] Prof Ir. Mohammad Zainal, "*Lecture Note – Air Condition System Design Manua*l", UTHM, Unpublished, 2003.

[3] Norfadzillah Binti Shamsidin. *Development of Auto Calculation of Cooling Load Rate Demand Using Matlab Software*. Bachelor Degree. Thesis. UniversitiTun Hussein Onn Malaysia. (2010)

[4] Dayang Siti Zainab Binti Abang Bujang. Calculation of Cooling Load for Lecture's Room at C16 By using Matlab Software. Bachelor Degree. Thesis. UniversitiTun Hussein Onn Malaysia. (2012)