

Development of Cooling Load Demand Program for Building in Malaysia

Zamri Noranai, Dayang Siti Zainab Abang Bujang, Rosli Asmawi, Hamidon Salleh, Mohammad Zainal Md Yusof

Abstract—Air conditioning is mainly to be used as human comfort medium. It has been use more often in country in which the daily temperatures are high. In scientific, air conditioning is defined as a process of controlling the moisture, cooling, heating and cleaning air. Without proper estimation of cooling load, big amount of waste energy been used because of unsuitable of air conditioning system are not considering to overcoming heat gains from surrounding. This is due to the size of the room is too big and the air conditioning has to use more energy to cool the room and the air conditioning is too small for the room. The studies are basically to develop a program to calculate cooling load. Through this study it is easy to calculate cooling load estimation. Furthermore it's help to compare the cooling load estimation by hourly and yearly. Base on the last study that been done, the developed software are not user-friendly. For individual without proper knowledge of calculating cooling load estimation might be problem. Easy excess and user-friendly should be the main objective to design something. This program will allow cooling load able to estimate by any users rather than estimation by using rule of thumb. Several of limitation of case study is judged to sure it's meeting to Malaysia building specification. Finally validation is done by comparison manual calculation and by developed program.

Keywords—Building, Energy and Coaling Load

I. INTRODUCTION

AIR conditioning is mainly to be used as human comfort medium. It has been use more often in country in which the daily temperatures are high. In scientific, air conditioning is defined as a process of controlling the moisture, cooling, heating and cleaning air. In other term, it is a process to manipulate the air system to changes. Air conditioning can be also referred in all form of cooling heating ventilation or disinfection. As in generally air conditioning is define as a system to cooling and dehumidification air in surrounding system to achieve thermal comfort. Air conditioning usually often referred as an appliance that using AC current.

Zamri Noranai is phd candidate at Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Malaysia. (e-mail : zamrin@uthm.edu.my)

Dayang Siti Zainab Abang Bujang is graduated at Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Malaysia.

Rosli Asmawi is lecturer at Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Malaysia (e-mail : roslias@uthm.edu.my)

Hamidon Salleh is senior lecturer at Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Malaysia. (e-mail hamidon@uthm.edu.my)

Mohammad Zainal Md Yusof is professor at Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia, 86400 Parit Raja, Batu Pahat, Malaysia (e-mail : mdzainal@uthm.edu.my)

In four season counties, air conditioning usually come with heating element to heat during cold season and cooling during summer season. As in country with one season like Malaysia, air conditioning system only comes with cooling system to overcome heat gain. In Malaysia, air conditioning for building consume more than haft total electric energy. Heat gain refers to all heat, from all sources, that is introduced to a room or building .Heat gain is the increase of heat within a given space as a result of direct heating. Cooling load is the total amount of heat energy that must be removed from a system. In order to maintain user comfortable in the building, total heat gain of the building should be estimated.

The total capacity cooling load that produces by air conditioning that overcomes the heat gain will affect the building temperature and comfortable. If the cooling load is higher than the heat gain of the building the temperature will lower. However cooling load for building is varying, it depends on building specification, whether, location, user trend and surrounding condition. Over load of cooling load may affect energy consumption and cost. Most of this air conditioning always over size, in which it will causes efficiency problem and high cost. If the designs are underestimated, the effected will produce to equipment and system operation. With proper estimations, the amount of cooling load and heat gain should be appropriate to the air conditioning system unit[1]. More energy to operate system can be deduced and suitable air conditioning can be applying base on the proper estimation of heat gain and cooling load.

II. COOLING LOAD ESTIMATION

Cooling load and heat gain are interrelated to each other and it very important to the air conditioning system. When the system is higher in space, from the cooling load, the space will be warmer. The situation is difference when the cooling load is higher, than the heat gain. The temperature and the humidity of the room are low. It very depending on those two items, if the heat gain and cooling load are same then there is no changes in temperature. The estimation of the cooling load would be helpful to this kind of situation, to determine the total capacity of the air conditioning to cope with the cooling demand.

There are few methods to calculate and estimate building cooling load. Initially calculate method is done by manually calculation where a number of parameter and tables need to consider during the calculation. This method is simple method but took long time and required more intention. Small mistake and careless will cause wrong result and wrong judgement of

air condition capacity. As alternative calculation methods, cooling load estimation is done by software estimation. There are many software's are available in the market, but it costly to building owner and required high level of knowledge. In practise almost cooling load estimation is done by rule of thumb. It can give wrong loads on both the high and low side, but the tendency is to be conservative with high loads. In past year using the same rules-of-thumb method, can be consider as being conservative was safe, and also a competitive way to bid. Basically there are many factors influence to calculated building cooling load such as windows, doors, skylights, walls, partitions, ceilings, roofs, floors, open crawl space, air infiltration, people, equipment, process and appliances [2-3]. Equation (1~8) are the formula to calculated building heat gain and building cooling load.

Conduction through Walls & Roofs

$$Q_{\theta} = UA (CLTD)\theta. \quad (1)$$

Where;

U: Overall heat transfer coefficient BTU/hr-ft²-F

A: area, m²

CLTD: Temperature difference, cooling load at time θ , (F,C)

Conduction through Glass

$$Q_g = UA CLTD \text{ or } Q_g = UA CLTD_c \quad (2)$$

Where;

U: Overall heat transfer coefficient BTU/hr-ft²-F

A: area, m²

CLTD: Temperature difference, cooling load at time θ , (F,C)

Conduction through Interior Structure

$$Q_{p/f/c} = U \times A \times TD \quad (3)$$

Where

TD : Temperature difference, space (F)

Solar Radiation through Glass

$$Q_s = SHGF \times A \times SC \times CLF \quad (4)$$

Where

SHGF : Solar Heat Gain Factor

A : Area of Glass

SC : Shading Coefficient

CLF: Cooling Load Factor

The heat gain from lighting

$$QL = 3.4 \times W \times BF \times CLF \quad (5)$$

Where:

W: lighting capacity, Watts

BF : ballast factor

CLF : Cooling Load Factor for Lighting

The heat gain from people

$$Q_p = Q_s + Q_L \quad (6)$$

$$Q_s = q_s \times N \times CLF \quad (7)$$

$$Q_L = q_L \times N \quad (8)$$

Where:

q_s: sensible heat gain per person

q_L : latent heat gains per person

N : number of people

CLF: Cooling Load Factor for people

III. MATLAB

MATLAB has many advantages for technical problem solving such as ease of use, platform independence, predefined functions, device independent plotting, graphical user interface and compiler. However MATLAB has two principal disadvantages. The first is that it is an interpreted language, and therefore can execute more slowly than compiled languages. The second disadvantage is cost; it is more expensive than the conventional C or FORTRAN compiler. But this might offset by the reduced time required for an engineer or scientist to create a working program. Therefore it is cost effective for businesses. In addition, MATLAB can display other windows that provide help and that allow the user to examine the values of variables defined in memory. Graphical User Interface (GUI) is a program interface that takes advantages of the computer's graphics capabilities to make the program easier to use. Well-designed graphical user interfaces can free the user from learning complex command languages. On the other hand, many users find that they work more effectively with a command driven interface, especially if they already know the command language. The main reason GUIs are used is because it makes things simple for the end-users of the program. If GUIs were not used, people would have to work from the command line interface, which can be extremely difficult to understand.

IV. METHODOLOGY

In order to achieve the objectives and scopes of this project, several step of method have been suggested to develop cooling load calculation program, which are: Selecting the appropriate building, Estimation of the cooling loads, Develop the calculation of cooling loads using MATLAB software, Simulation of the calculation of cooling loads demand. Process flow to describe the methodology of the study and program flowchart is shown in Fig 1 and Fig 2.

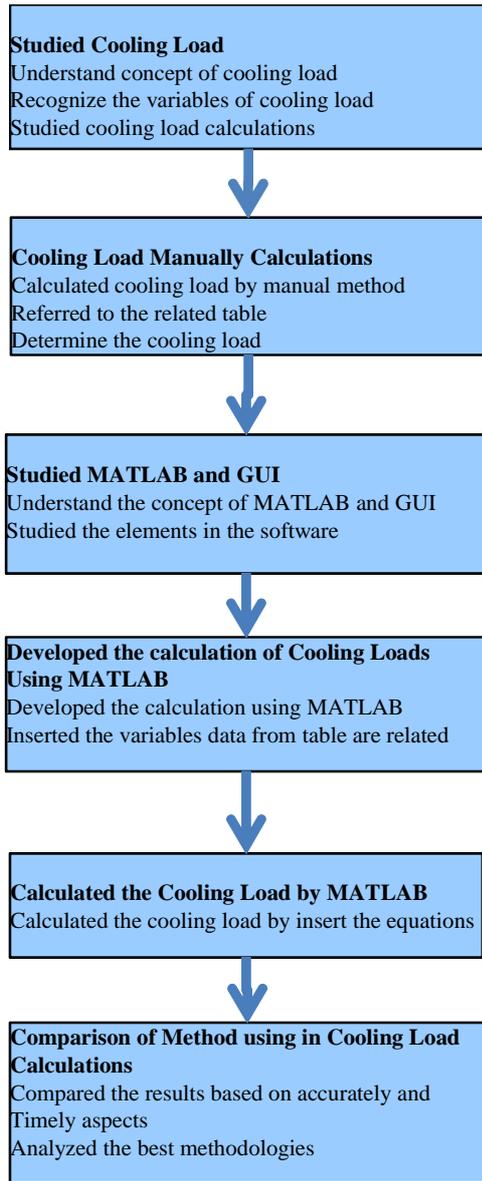


Fig. 1 Process Flow of Study

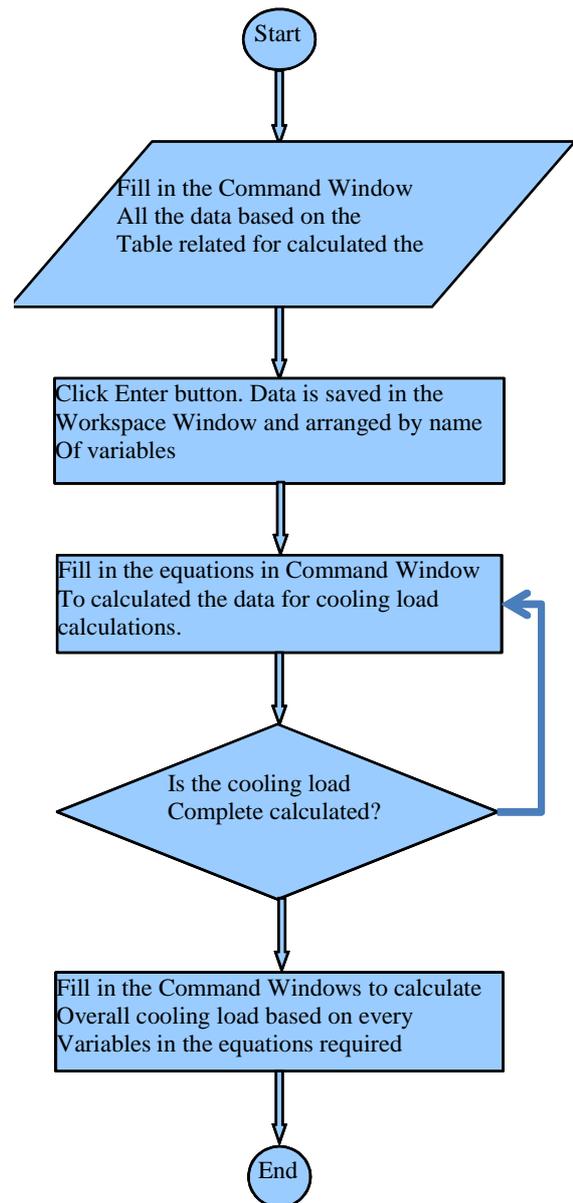


Fig. 2 Process Flow of Program

V. CASE STUDY

Block C15, C16 and C17 at UTHM are the office for academicians. This building houses 210 staff who works for 8 hours a day, from 8.00 am. to 5.00 pm, and staff does not always stay in their rooms during the day. In addition, the building also is equipped with equipment like personal computers, small printers, lamps and indoor split unit air conditioner. A software using MATLAB is developed to perform cooling load calculation automatically. Computerized calculation of the cooling load by Using MATLAB software will save time and energy and it also can be used by anyone without any knowledge of the cooling load calculation of the air conditioning system. The cooling load was determined by using MATLAB software where inserted equations related in

Command Window and it automatically read the data variable from Workspace Browser. Both methods was compared in order to determined the accurate value of cooling load and from this result the better method which is MATLAB was proven[4].

TABLE I

COOLING LOAD THROUGH WALL CONDUCTION AT 0800, DECEMBER			
Direction	MATLAB (BTU)	Manual (BTU)	% Error
NE	12421	12309.4	0.898
SE	18379	18214.2	0.897
SW	27018	26773.7	0.904
NW	12615	12500.7	0.906
Average of Error			0.901

The calculation of cooling load through the wall conduction is calculated with different method which is by using MATLAB and manual calculations at 8 am in month of December. For North East (NE) direction the cooling load obtained from the MATLAB calculation is 12421 BTU while by the manual calculation, the value is 13256.3 BTU and the difference in the percentage of error is 0.898%. For the direction of South West (SW), cooling load obtained from MATLAB calculation is 27018 BTU while by the manual calculation the value is 26773.7 BTU. Meanwhile for the difference in the percentage of error is 0.904%. Next, for the North West direction, the cooling load obtained from MATLAB calculation is 12615 BTU while by the manual calculation the value is 12500.7 BTU and for the difference in the percentage of error is 0.906%. The least percentage of error is the South East direction of 0.897%, result of calculation cooling load by MATLAB is 18379 BTU compared by manual calculation of 18214.2 BTU. The average percentage error for all directions is 0.901% [4].

VI. CONCLUSION

The overall comparison of cooling load calculation By MATLAB and manual was discussed. Based on table, all the results tabulated by MATLAB have been rounded to non decimal numbers compared with manual calculation. Based on the result, the errors between the MATLAB and manual calculation is slightly less than 1%. This is means that the MSTLAB calculation more accurate rather than manual calculation. Even though the methods are different the result obtained by MATLAB calculations are faster, efficient and precise compared to the manual tabulation method. Furthermore, it save user time and possible error s that occur in manual can be eliminated. Besides, all the recent calculations automatically save in the Command History Window which means users can recall the recent calculation data, thus time saving as compared to the manual method of calculation. This software development also can be applied in certain parties or individuals to determine the rate of cooling load required. Furthermore this program also can be used by unskilled individuals.

ACKNOWLEDGMENT

The author gratefully acknowledges the financial support of this work by Universiti Tun Huseein Onn Malaysia under Short Grant vote number 0630 and Fundamental Research Grant Scheme vote number 0721.

REFERENCES

- [1] I. Dincer, (2004), Thermal Energy Storage, Encyclopedia of Energy, vol. Volume 6, p. 14,
- [2] Z. Noranai and M. Z. Md Yusof, (2011), Study of energy efficiency opportunities in UTHM, Proceedings of World Academy of Science, Engineering and Technology, vol. 77, pp. 745-751,
- [3] M. Zainal, (2003), Air Condition System Design Manual, UTHM., Unpublished. ,
- [4] D. S. Z. A. Bujang, (2012), Calculation Of Cooling Load For Lecture's Room At C16 By Using Matlab Software, Final Project Thesis,