

AIR-CONDITIONING SYSTEM WITH SIMULTANEOUS CONTROL OF SENSIBLE AND LATENT HEAT FOR BUILDING ENERGY CONSERVATION IN MALAYSIA

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論 文 内 容 の 要 旨

As one of the leading developing countries in Asia, Malaysia's urban growth is on the rise and could be physically seen by the rapid increase of rural buildings and premises in the cities across the nation. However, the nation's economy development has resulted in the increase of energy consumption of the whole country as well. As the air-conditioning system is the main energy consumer of office buildings, it is important to find new methods to reduce its energy consumption. The task is indeed challenging due to the fact that Malaysia is having the environment of tropical climate. Buildings in the country are exposed to substantial amount of solar heat and constant slightly high temperature during daytime occupancy. In addition to that, the outdoor air contains excessive humidity, more so with the requirement of the full 12 months cooling period in the country. Due to the high humidity condition, it is a customary practice for the air-conditioning temperature to be set at a relatively low value in order to increase the dehumidification rate. As a result, cold indoor condition occurs which causes the occupants to feel thermally uncomfortable inside the buildings. The use of the outdoor air treatment system is an option to treat the incoming fresh air into the room. However, high equipment cost renders the system unfavorable in Malaysia.

The objective of the research is to propose a new air-conditioning system for energy reduction and to overcome the problems typically associated with tropical climate. The design criteria of the new air-conditioning system include humidity control feature, low energy consumption and minimum equipment cost. The new system should improve the thermal comfort of the occupants and can be retrofitted as an add-on configuration to the existing air-conditioning. In order to vindicate the capability of the new system, its performance is justified through a simulation exercise. On the other hand, the design method of the new system is clarified with the use of manual calculation and psychrometric chart.

This dissertation consists of six chapters. Chapter 1 contains the background of problems related to buildings in hot and humid environment of Malaysia. The purpose of the research is explained and the solution to overcome the problems is described. Some reviews are made on past research. The relationship of other chapters with the main objective is also clarified.

Chapter 2 contains the initial phase of the study to grasp the current situation in Malaysia in

terms of the effort towards building sustainability. It is observed that the guidelines and standard on energy efficient buildings have been established with clear instructions. The support from the government of Malaysia is evidence through the incentives offered to building owners and buyers of a certified green building. However, the current practice tends to design a system with a low temperature set-point. The priority factor in choosing the type of air-conditioning system to be installed was purely due to the equipment initial cost, as energy cost was not in consideration.

Chapter 3 contains a field study to comprehend the current situation of room condition and air-conditioning system in Malaysia. In the exercise, the measurement of indoor temperature and relative humidity was performed inside 3 different buildings in the suburban area. The types of chiller and air handling units commonly being used also being studied during the walk through. The thermal measurement device recorded the data round-the-clock for several days of observation. The data are eventually compared with existing comfort zones defined by recognized standards in Malaysia. It is observed that most of the occupants were not thermally comfortable in the measured rooms. Therefore, it is necessary to realize a new room condition which is more suitable for buildings in hot and humid environment.

Chapter 4 contains the research solution by proposing a new air-conditioning system to resolve the problems faced by Malaysian buildings. As the first step, a new room condition (26°C,50%) is defined to improve thermal comfort and achieve less energy consumption. It is relatively high temperature but low humidity compared with current situation. The design requirements in terms of humidity control, simple control setup and low equipment cost are also explained to justify the necessity to use two air handling units (AHU) in the system. The first AHU is given the task to control the room temperature while the second AHU is meant for maintaining indoor humidity level. Design configuration of control-air-volume (CAV) and variable-air-volume (VAV) air conditioning system is also being clarified in this chapter.

Chapter 5 contains the performance analysis of the proposed air-conditioning system. In the study, simulation approach is adopted in order to confirm that the control method is able to operate under the tropical climate. Since there are two AHUs in the new system, the analysis for the combination of size percentage or ratio between the AHUs is also covered. It is observed from the simulation results that the new system is able to run under CAV and VAV configuration. It is observed that the range of acceptable AHU size ratios is a function of indoor latent heat. In addition, VAV system is capable in providing a wider range of acceptable AHU size ratio compared to CAV system. It is also observed that the proposed air-conditioning system could offer energy savings between 10.2 - 13.6% for CAV and between 10.7 - 13.2% for VAV compared to normal air-conditioning system.

Chapter 6 contains the design method of the new air-conditioning system using manual calculation and psychrometric chart. It is observed that the chart of acceptable size ratio from Chapter 5 is required to determine the AHU capacity. For existing building, the new system can be designed as an add-on configuration to retrofit the existing air-conditioning system.

Chapter 7 concludes the whole research and provides some recommendations for future works.