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Procedia Computer Science 86 (2016) 361 – 364

Procedia Computer Science

2016 International Electrical Engineering Congress, iEECON2016, 2-4 March 2016, Chiang Mai, Thailand

A Simplified Air-conditioning Systems Model with Energy Management

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Abstract

This research is a study of a split type air conditioner system demand response modelling. Air conditioners are commonly used in home and other buildings. Such systems mainly rely on air–cooled compressor for heat rejection process. Since air conditioners consume high electrical energy therefore, the management of their electrical energy consumption is also important. The main objectives of this research are to study and simulate an air conditioning system with electrical energy management by adjusting the temperature set point inside the building. The studies also include the factors that involved in air conditioner energy consumption such as the temperature inside the building, the temperature outside the building, insulation of the building and air flow etc., These studies are analysed and then applied to the air conditioners in a specific room to reduce their energy consumption without affecting people comfort in the building. The air conditioner model is simulated using MATLAB. The simulation results are compared with the results from measuring instrument. It can be concluded from the experiment that the results from MATLAB model and the results from the measuring instrument are consistent.

Peer-review under responsibility of the Organizing Committee of iEECON2016

Keywords: Air-conditioner; Energy management

1. Introduction

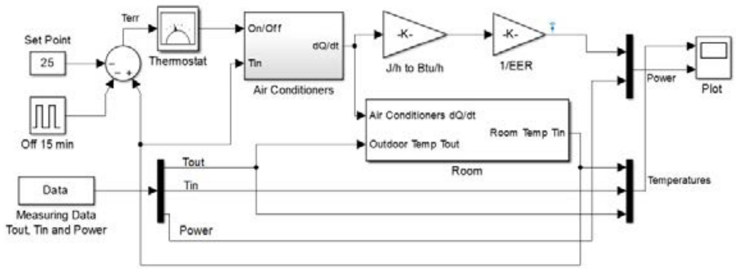
Air conditioners are electric appliances that consume high energy in Thailand. In the past few years, Thai government launched a campaign to decrease air conditioners energy consumption in offices buildings by setting indoor temperature set-point at 25°C. Further increasing indoor temperature set-point will affect people comfort but more energy saving. The research challenge is to investigate how to save air conditioner energy consumption without affecting people comfort in the building by adjusting a higher temperature set point inside the building than 25°C for a short duration.

Peer-review under responsibility of the Organizing Committee of iEECON2016
doi:10.1016/j.procs.2016.05.099

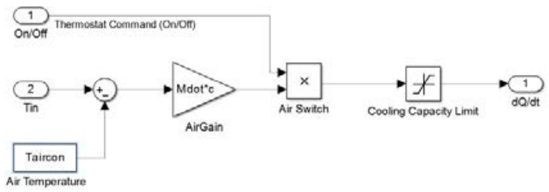
Air conditioner transfer heat from indoor to outdoor through a compression-expansion cycle involving a refrigerant or working fluid. This heat moves against the spontaneous heat flow direction (warm to cold) [1]. The refrigerant must be heated up by compressing it through an electric compressor to a temperature higher than the medium into which the heat is transferred, so that it can release heat to the energy carrier medium through a condenser. The refrigerant must be cooled through an expansion valve to a temperature lower than the interior temperature, so that it can absorb heat from the internal through an evaporator. Then the refrigerant vapor is routed back into the compressor.

2. Air-conditioner System Modelling

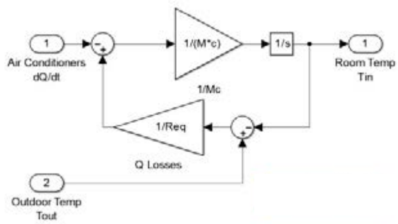
The thermal characteristics of a building resulting from the basic heat transfer equation can be represented in terms of network of resistances and capacitances [2, 3]. The capacitance is related to the air volume in the building as well as to the thermal inertia of the material; the resistances are related to the building envelope insulation materials (i.e. roof, wall, windows) and to the heat patterns through internal walls. The building mass used to quantify these parameters includes floors, interior partitions, furniture etc. It is straightforward to see that temperatures and heat in the thermal model are respectively the analogous of voltage and current in an electrical circuit. For simplicity, an air conditioning system in this research is modelled by a thermal resistance in Simulink as shown in fig 1. The model is modified from thermal model of a house for heating system [4]



(a) Air-Conditioner system



(b) Air-Conditioner subsystem



(c) Room subsystem

Fig.1 Model in Simulink

The model can be described by the following equations

$$\frac{dQ}{dt} = \left(T_{in} - T_{aircon}\right) \cdot Mdot \cdot c \quad (1)$$

$$\left(\frac{dQ}{dt}\right)_{losses} = \frac{T_{out} - T_{in}}{R_{eq}} \quad (2)$$

$$\frac{dT_{in}}{dt} = \frac{1}{M_{air}.c}\left(\frac{dQ_{losses}}{dt} - \frac{dQ_{aircon}}{dt}\right) \quad (3)$$

where

$\frac{dQ}{dt}$	heat flow from air-conditioner out of a room (J/h)	M_{air}	air mass inside the room (kg)
c	heat capacity of air at constant pressure (J/kg.K)	T_{in}	room temperature (^{o}C)