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Fuzzy logic based energy saving technique for a central air conditioning system

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Abstract

In this paper a scheme has been proposed to maintain the temperature and the humidity, in each of the rooms served by a central Air Conditioner (AC) unit, close to the targeted values, and reduce the electrical energy intake of the AC compressor. The upper limits of the comfort zone, typically marked at a temperature of 25 °C and a relative humidity of 70%, are used as the targets. It should be noted that a conventional AC system controls humidity in its own way without giving the users any scope for changing the set point for the targeted humidity unlike the scope it offers to change the set point for the targeted temperature through a thermostat. But in this work this limitation has been taken into cognizance and overcome to a great extent using fuzzy logic to represent the intricate influences of temperature on the humidity of the space being cooled and correct the thermostat setting. In the developed scheme, the sensor captured temperature and humidity readings for each room are compared against the targets at the selected intervals of time, and the corresponding differences are fuzzified. These differences are used to decide the fuzzy qualifier, which is decoded into a crisp value that is the change required in the setting of the thermostat of the AC. As a result, each room will maintain a temperature near 25 °C and a relative humidity near 70% while the compressor will remain off for an appreciable period leading to a saving of energy. Though a thermostat with programmable setting for an AC unit dedicated to a single room has been reported in the literature, the same for a central AC unit that serves more than one room appears to have not yet been presented. The advantages of the scheme proposed for programming a thermostat under central air conditioning system are that it (i) requires for each room only a pair of input data i.e. the sensor captured temperature and humidity readings for each room, (ii) controls humidity indirectly and (iii) leads to a saving in energy consumption while maintaining a comfortable level of cooling in each of the rooms though their occupancy, size and the thermal conditions are different from one another.

Keywords: Central air conditioning; Energy saving; Fuzzy logic

1. Introduction

The importance of saving electricity in the present energy-starved world can hardly be exaggerated. Cooling loads, more specifically the AC units, contribute a major share to electricity consumption in the tropical and equatorial countries. A central air conditioning system is typical of the large non-residential complexes such as shopping, administrative, institutional buildings, etc. As the central AC is installed from the energy efficiency point of view, the owners hardly give any post-installation thought to find if there is further scope for saving the energy. Regarding this, an electrical engineering option worth investigation is a programmable thermostat.

Implementation of a programmable thermostat for a central AC differs in many ways from that for a single room or a dedicated AC unit for which the thermostat is placed in the room itself. In the central system only a common pair of return and supply air ducts (e.g. similar to the system diagram shown in Fig. 1) originate from the air handling (AHU) unit and run through all the rooms being served by the same unit. The AHU components

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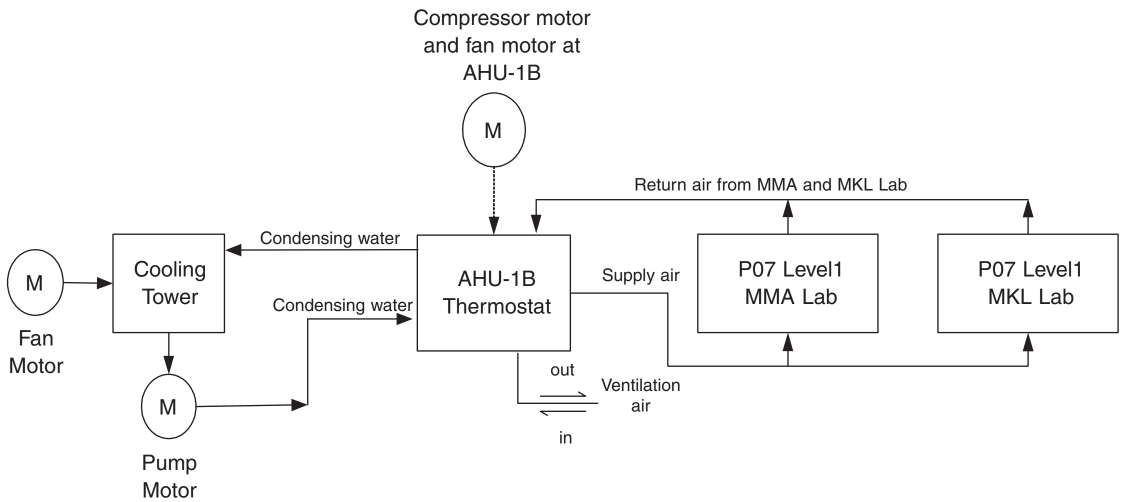

Fig. 1. Schematic diagram of the studied central AC system.

(e.g. compressor, motor, blower, etc.) and other control gears of a central AC unit are located in a separate and remote location often termed AHU room. Since for central air conditioning the common thermostat is placed in the AHU room (but not inside the AHU) instead of any of the rooms being served it does not sense the temperature of the rooms but the temperature prevailing in the AHU room. As a result, unless supported by additional mechanism the thermostat attempts to control the temperature of the AHU room only but not the rooms being served. Notably the AHU room is not as much insulated as the served rooms. The thermostat is also not an ideal or strict "on-off" controller [1] so that it does not turn off the compressor whenever the attained temperature becomes just less than or equal to the set point. Rather it has an inherent positive error band [1] so that it turns a compressor off only if the difference between the set point of the thermostat and the AHU room temperature is more than a limit i.e. outside the band. The width of the error band varies from thermostat to thermostat and may typically be around 1.5 °C. If the AHU room temperature exceeds the set point or the difference decreases to lie within the band i.e. the AHU room temperature becomes 1.5 °C or further less than the set point the compressor will be turned on again. So, in general, the compressor keeps running throughout the business hours producing a cumulative cooling effect in the served rooms i.e. as the time progresses the coolness in the rooms increases even when the outside weather does not change appreciably. This usually leads to overcooling of the served rooms to different degrees depending upon their respective physical dimensions, thermal insulation quality, and occupancy size (the number of persons staying in the room). Programming the thermostat in a way that would result in frequent change between 'on' and 'off' states of the compressor is also detrimental. So apart from the restriction in frequent switching of the compressor, another difficulty in programming the thermostat of a central AC is taking into account the cooling conditions of different rooms.

A review of literature [2–6] shows that a good deal of research effort has been put on developing programmable thermostat for a dedicated room AC unit. Some of those have considered fuzzy logic programming. However, those work are too difficult to be extended for fuzzy programming of the thermostat of a central AC that serves more than one room. This is because those work require a huge number of input data even for a single room and would give rise to complications in the fuzzy decision making process. Until now, it appears that little research effort has been put on developing programmable thermostat for a central AC unit. In this paper, a fuzzy programming scheme has been proposed that would decide the correction needed in the thermostat setting using only a pair of input data from each of the rooms served by a central AC unit, and maintain the temperature and humidity in each room at a comfortable level that can suit most of the people under any ambient weather condition, and reduce the electrical energy intake of the AC. For capturing the input data a pair of sensors (i.e. one for temperature and the other for relative humidity) is to be installed in each of the rooms being served while the thermostat need not be shifted from the AHU room.

2. Proposed methodology

The concept of "comfort zone" is established in the literature on air conditioning [7,8]. Its boundaries in terms of temperature have been defined within 20–25 °C, and in terms of relative humidity within 40–70%. However, a room temperature just above the lower boundary gives a feeling of overcooling to the majority of people in tropical countries. The proposed scheme has used the upper boundary of the comfort zone i.e. 25 °C and 70% respectively as the target temperature and the relative