



Energy Efficient Building: HVAC Control

Surjit Lahiri attempts to throw light on the technologies involved in sensing and adaptively controlling the HVAC throughout the year to meet two core objectives – thermal comfort to building residents and optimized consumption of energy/ operating costs.

INTRODUCTION

Usually the heating, ventilation, and air-conditioning (HVAC) in buildings is thermostat controlled at a prefixed temperature set point. Researchers in the area of thermal comfort have learned that the required indoor temperature of a building is not a fixed value. Attaining and maintaining certain range of temperatures is sufficient to bring comfort to its residents. From an economic point of view this means that it is preferable to

operate the HVAC in such temperature region, representing the lowest operating costs of the HVAC installation.

NEED FOR PREDICTIVE TEMPERATURE CONTROL:

Best of breed green and eco friendly building architectures promote the concept of passive climate system to the hilt in their designs. A passive climate system is a building that tries to utilize the outdoor

climate as much as possible to reduce the energy consumption of the building. The outdoor climate is used, besides the heating and cooling device, for indoor temperature control. It is also used for fresh air supply and lighting. To be able to regulate the contribution of the outdoor climate, the facade of the building is equipped with ventilation windows and shading devices. It is obvious that the outdoor climate is not always capable of providing the energy to maintain a required level of comfort in a building. However, it might be possible to use the outdoor climate in an advantageous way by storage of energy in the walls. This would require a control system, which is able to predict the future thermal behavior of the building and use this prediction to maximize the outdoor climate contribution to the indoor comfort, simultaneously minimizing the energy consumption.

FIGURE: PREDICTIVE TEMPERATURE BASED HVAC CONTROL SYSTEM

The predictive temperature based HVAC control system must be able to determine control actions in advance (such as ventilation with cold outdoor air or heating just before the occupied period of the building starts) by using prediction of the indoor temperature. This prediction of the indoor temperature will also include prediction of the outdoor climate, especially solar radiation and temperature. Research has shown that energy can be saved by intermittent conditioning of the building. It is also possible to save energy by allowing a certain deviation from the temperature set-point. The control system can try to maintain the indoor temperature between an upper and a lower temperature boundary, which leads to a minimum energy consumption. Acceptable temperature boundaries can be deduced from the theory of thermal comfort. During the unoccupied night period of an office building, the temperature may float freely between certain safe temperature boundaries (e.g., 12° C and 30° C). Thus the average heat loss is as low as possible, and the required energy is minimal.

Often it is not possible to maintain the indoor temperature within a required temperature range instantaneously, because the capacity of the HVAC installation is not sufficient to accomplish this. This happens, for instance, in the morning, in a European City building scenario, when the building must be heated from the temperature that has established after cooling down at night, to the required temperature during the day, when people occupy the building. Another possibility might occur in summer, when outdoor temperatures are high and solar radiation heats up the building too much, while the capacity of the cooling installation is not adequate to maintain the indoor temperature within the required temperature range. To be able to deal with these types of problems a predictive control system is required that can assess the effects of the HVAC installation on the indoor temperature correctly. The control of the heating or cooling process allows the temperature to be kept between two predefined limits, instead of a strict set-point. These limits may, however, be selected or altered by the user. It is also required that the process operate between these

limits at an economic optimum. Besides these two main requirements, many additional conditions may exist, such as input and output constraints, stability requirements, and rate constraints.

HOW WELL DOES IT WORK:

The crucial question is, how well suited is the estimated model for usage with the predictive control system? There are the several operating situations where the control system uses the estimated model. In a European city building scenario for example - the first situation is to control the indoor temperature with the heater or by cooling with natural ventilation by the windows. The second situation occurs when the heater has to start in advance to reach the required indoor temperature. The estimated model is required to determine the point of time to start. The third and fourth situations that require the usage of the estimated model occur when cooling with natural ventilation by the windows is not adequate to keep the indoor temperature below the required limit. The estimated model is used to determine whether night ventilation is necessary, or pre-cooling is necessary during the day. The occurrence of these situations depends largely on the weather conditions and the thermal behavior of the building. By observing the indoor temperature responses of the building, it can be seen that night ventilation is rarely possible because even without ventilation at night the indoor temperature drops low enough to start the heater in the morning. By contrast in an Indian city building scenario night ventilation would be an effective way for pre-cooling. The model is well-suited to predict the point of time to start the heater. Research shows that predictive control system saves about 15 per cent in terms of energy consumption annually (over and above benefits of passive climate systems), which is basically caused by the effect that stricter control at the required limits is possible and no overshoot and oscillations occur. It also leads to a better indoor climate, because fewer hours of excessive temperature exceeding of the required temperature limits occur.

CONCLUSION

Adopting passive climate systems is the need of the hour to conserve energy and reduce greenhouse gas emissions. They form key prerequisites for US Green building council's LEED - green building certification system. Having a predictive temperature based HVAC cooling system designed upon a passive climate system meets two core objectives - thermal comfort to building residents and optimized consumption of energy/ operating costs throughout the year. By and large such a predictive temperature based HVAC control system was less conceivable about 2 decades earlier than now due to exponential increase in computational resources at relatively low cost and an imperative need to conserve energy and save our earth from GHG emissions. ■

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