Sustainability, Agri, Food and Environmental Research, (ISSN: 0719-3726), 10(X), 2022:
http://dx.doi.org/

A review and analysis of control techniques in HVAC systems
Una revision y análisis de técnicas de control en sistemas HVAC

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ABSTRACT

Heating Ventilating and Air Conditioning (HVAC) systems are the core energy-absorbing equipment in buildings. Building HVAC system with effective control technique can greatly reduce energy consumption. The high demand for HVAC system Placing in buildings, using an effective control technique to decrease the energy absorbing of the equipment while meeting the thermal comfort demands in buildings are the most important goals of control designers. The different control methods for HVAC systems. This paper defines control techniques used in HVAC systems, MATLAB/simulation design and implementation of controller's technique with the transfer function for the HVAC system.
Keywords-HVAC, PID controller, MPC Controller, Adaptive Controller, Fuzzy Controller.

RESUMEN

Los sistemas de calefacción, ventilación y aire acondicionado (HVAC) son el equipo principal de absorción de energía en los edificios. La construcción de un sistema HVAC con una técnica de control eficaz puede reducir en gran medida el consumo de energía. La alta demanda del sistema HVAC La colocación en edificios, utilizando una técnica de control efectiva para disminuir la absorción de energía del equipo mientras se satisfacen las demandas de confort térmico en los edificios, son los objetivos más importantes de los diseñadores de control. Los diferentes métodos de control para sistemas HVAC. Este artículo define las técnicas de control utilizadas en los sistemas HVAC, MATLAB / diseño de simulación e implementación de la técnica del controlador con la función de transferencia para el sistema HVAC.
Palabras clave: HVAC, controlador PID, controlador MPC, controlador adaptativo, controlador difuso.

INTRODUCTION

Simple application of Proportional integral derivative (PID) controller is given where explained design of mechanism for auto tuning of PID controllers used in HVAC system. They give theoretical background for tuning PID controllers and explain how it can be done based on process data (Wemhoff, 2010). The implementation of a complete monitoring and control distributed architecture is being done, in parallel with the modelling and simulation development. The design of the system is being done flexible, scalable, and with the intention to be easily implemented in other office buildings. Modern control methods such as PID controllers are mostly used in the industry; their benefit is often limited because of poor tuning; on the other hand, they can be easily designed due to low cost and reliable in field conditions. The PID control techniques can be used on model-free and model-based control systems (Teeter and Chow, 1998; Wang et al. 2008; Fong et al. 2008; Wemhoff, 2010). A review of papers discuss with intelligent control method in HVAC systems is Intelligent authors mean fuzzy-logic-based. First, a basic introduction to fuzzy control is given, after which authors continue with modified fuzzy techniques. Most of reviewed papers deal with control of HVAC systems in various forms, but part of them deal with improving of results of classical PID controllers (by developing methods for auto-tuning) (Mirinejad et al. 2010). Model Predictive Control (MPC) is highly described in paper. Authors explain actual application of MPC strategy for control of HVAC system. They explain various topic, from modelling of HVAC system, its elements and building, to control on several levels of complexity. Many practicable and expert details are released, with review of current research, which makes this a very good starting point for researching Model Predictive Control (Kelman et al. 2012). HVAC systems is given in paper (Quina et al. 2003). Authors discuss introduction of HVAC systems and their model (which is integral part of MPC). Then discuss MPC and its specification. They give a review of current research, comparing them on according to type of model and controller, stage (computer simulation and special features. Rehrl and Horn, 2011 gives very detailed description of creating a Model Predictive Controller for test plant, where MPC is combined with feedback linearization. PID controller is mostly used in many industrial control systems for various stage (Ziegler and Nichols, 1942) propose their first PID tuning method. This is because the PID controller model is simple and its probity is easier to recognize than most other advanced controllers. Still much research has been going on in tuning the PID controllers.

STATE OF ART.

Traditional control strategies: Proportional controller controls how fast an output reacts to a system variation. For HVAC system air and water is change position proportional to the deviation of the value of the controlled variable from the set point. Integral controller controls a reaction based on a sum of variation and reset response; Target value will be unable to reach without Integral controller. Derivative controller controls reaction to the rates at which system process change and is use for measure noise. Traditional control category are two types: On/Off control methods and PID control method HVAC system of the building. The traditional control technique used for controlling the system with some limiting condition. This method is easy for tuning single input single output systems but tuning multi input multi output system is not easy.

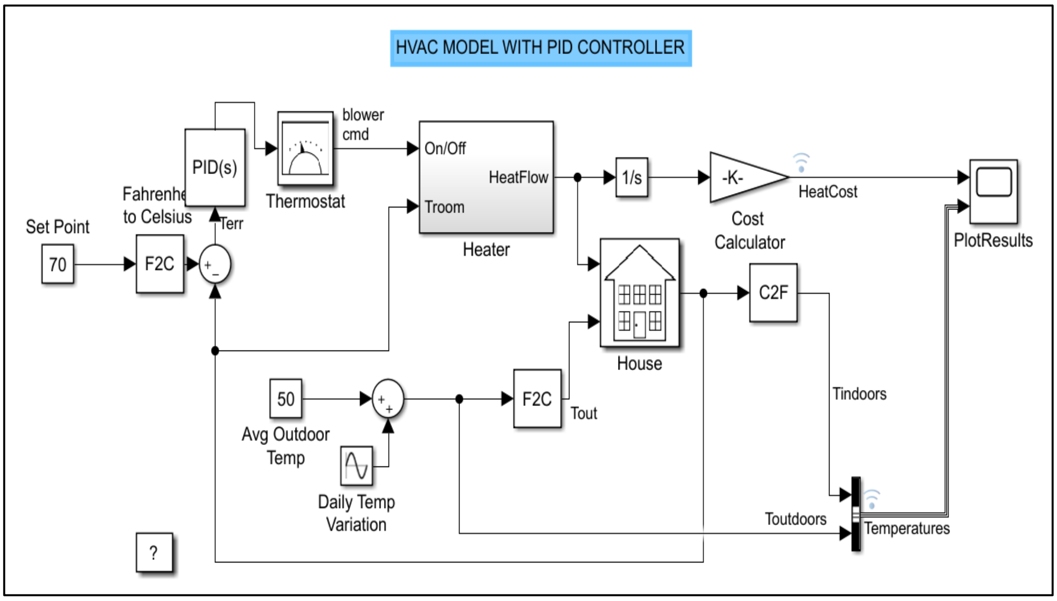

Fig. 1 Simulink model of PID controller with HVAC System

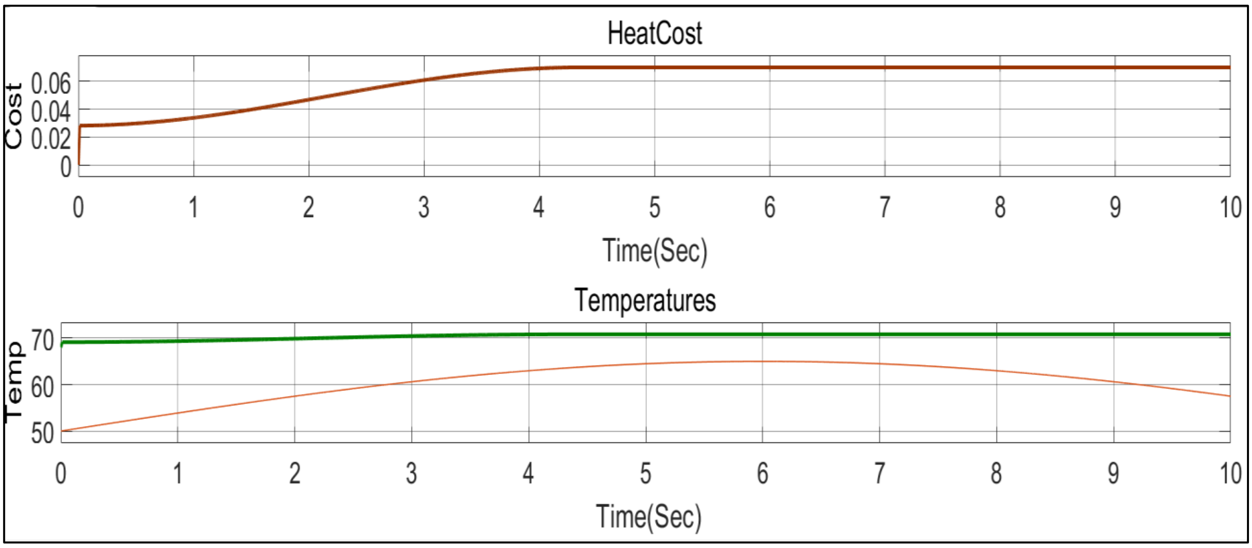

Fig. 2 Simulink result of PID controller

Figure 2 shows the output came from HVAC system with PID controllers here simulation run for 10Sec in that heat cost 0 to 3Sec is increasing from 0 to 0.05 and from 0.06 its constant. Temperature is always constant that is 70.

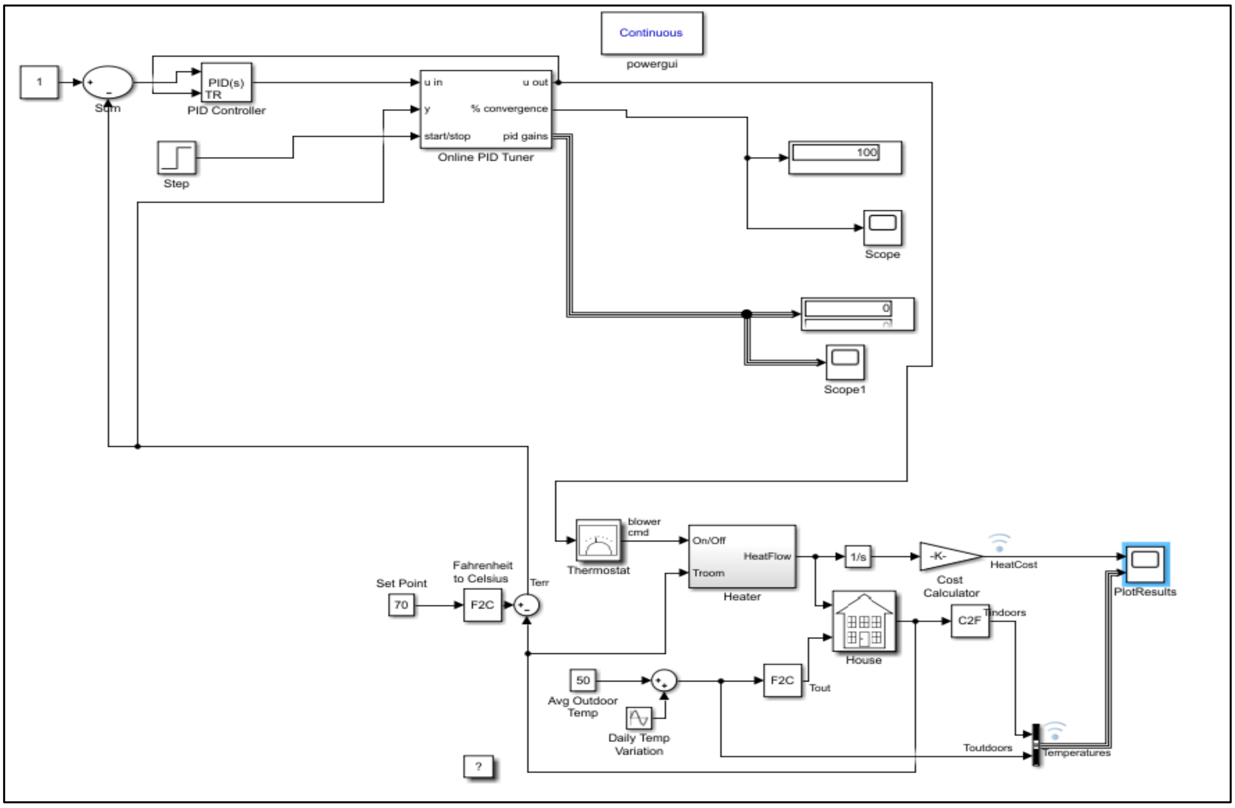

Fig. 3 Simulink model of PID Auto tuner with HVAC

In Fig 3 developed simulation model of close loop PID autotune controller in that PID controller value sets automatically.

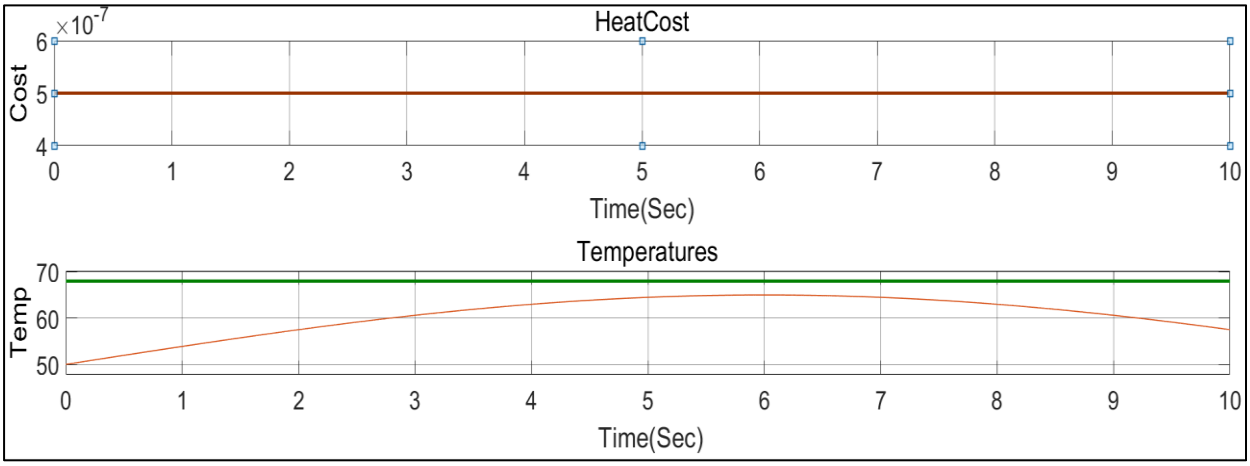

Fig. 1 Simulink result of PID Auto tuner

Figure 4 shows output came from HVAC system with PID autotune controllers here simulation run for 10Sec in that heat cost is 5 and always constant. Temperature is always constant that is 70.

Model predictive control (mpc): The future states of system can be predicting by Model Predictive control technique. The MPC method provides practical solution in HVAC system. The

HVAC systems are time-varying, and time delays, disorder act on the system, more energy absorb, and wide operation range of system. The MPC method can be able to handle many problems. MPC is a multi-control technique which is based on a prediction method. The past behaviour of the system and future inputs are used for prediction of the future output of the HVAC system. For the process control applications MPC technique is mostly used. To minimize the cost and energy consumption, the system is used to generate a proper control technique. The MPC control method mostly applied on the solar power HVAC system. Predictive control techniques rely on predicting the dynamic behaviour of system in future and adjusting response of controller accordingly. Generally, this means some variant of MPC, where projection is performed based on explicit model of building. These kinds of methods can achieve very good results, but often have problems with complex implementation. Setpoints, predictions and inputs that are adjusted based on these predictions.

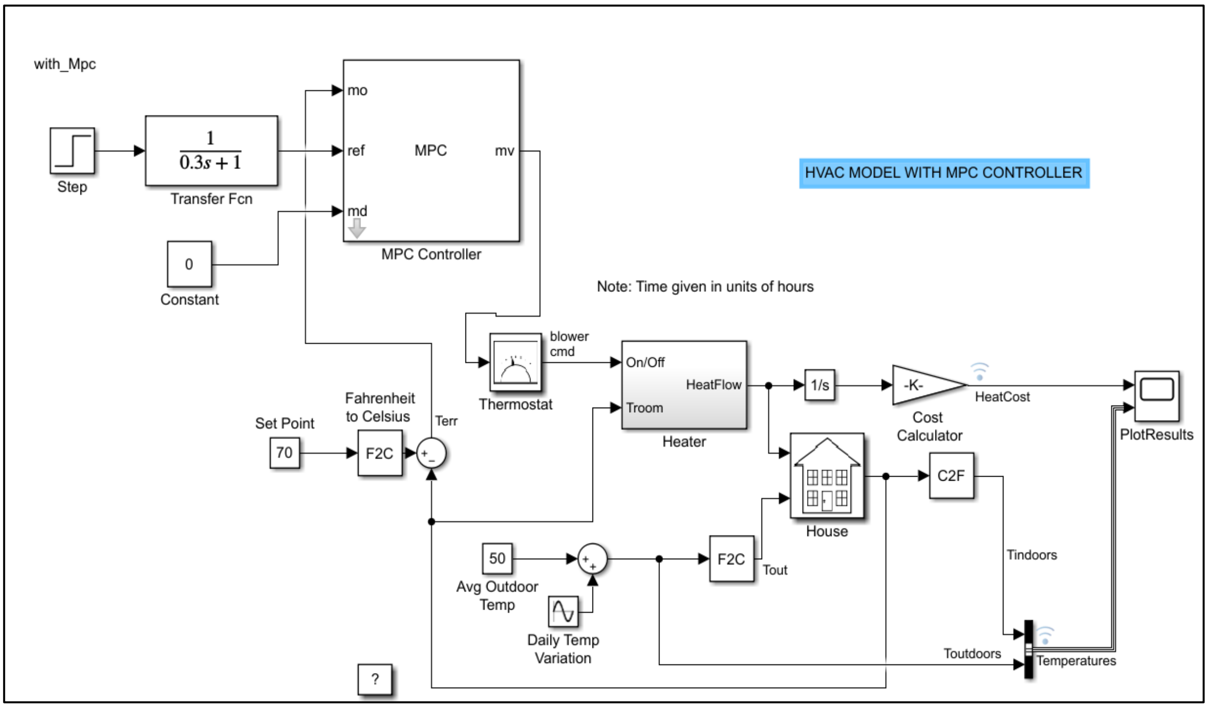

Fig. 2 Simulation model of MPC controller with HVAC

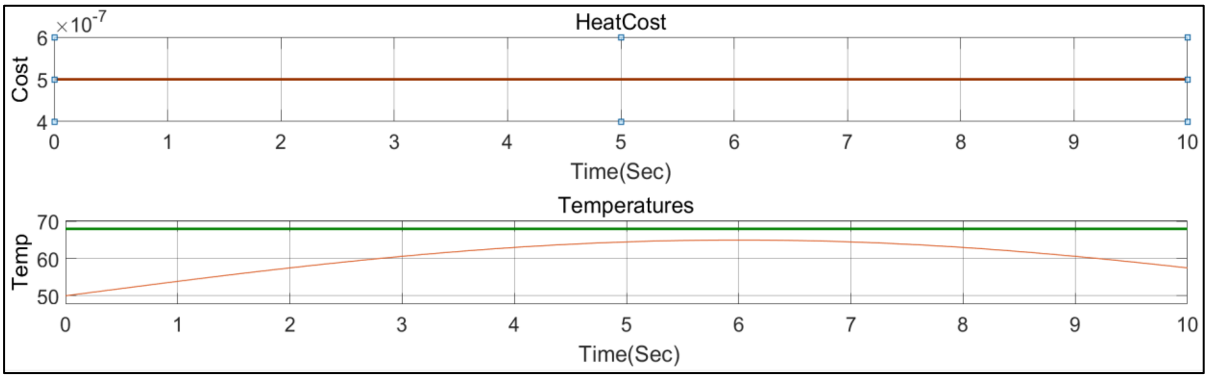

Fig. 3 Simulink result of MPC Controller

Figure 6 shows output came from HVAC system with MPC controllers here simulation run for 10Sec in that heat cost is 5 and always constant. Temperature is always constant that is 70.

Adaptive control: Adaptive control deals with complex system that have incalculable parameter deviation and unreliability. Its basic objective is to maintain consistent performance of a system in the presence of uncertainty and variations in plant parameters and adaptive control is superior to robust control in dealing with uncertainties in constant or slow-varying parameters. Disadvantage of this method is difficulty for stability, and they need bilinear observer. Model of the system is necessary for design of this controller. Adaptive controller able to self-regulate, they are applied in several types of buildings in different climate conditions. The energy efficient control of HVAC system and to determine an Adaptive control strategy.

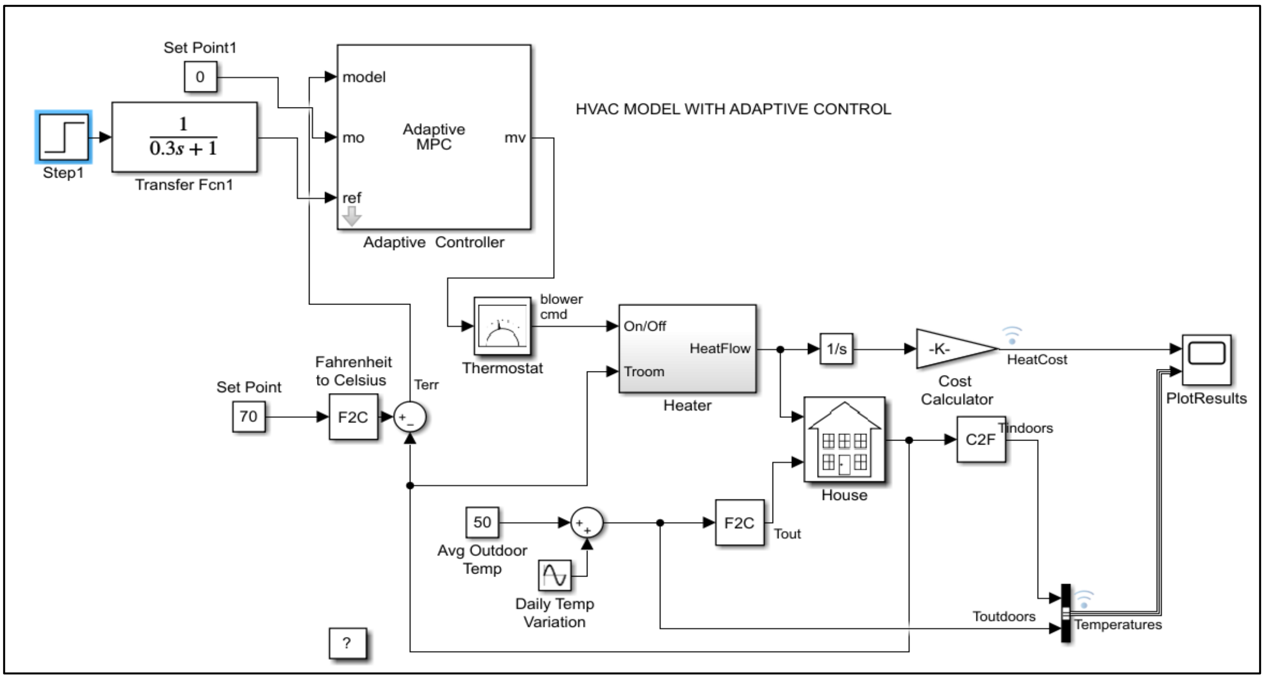

Fig. 4 Simulation model of Adaptive controller with HVAC

Fuzzy controller: Fuzzy Logic Control are used quite often in HVAC control, one of reasons being very simple implementation of controller. Very simple example of Fuzzy Logic in HVAC control is shown in paper (Al-Ali et al. 2012). Fuzzy controller to turn on and off HVAC units in rooms of one building, in scenario where there is not enough energy to keep them all turned on. Fuzzy Controller must maintain the thermal comfort inside the house, while avoiding situation where HVAC power load is greater than available power (peak-load reduction). Authors implement their controller in laboratory conditions. Similar approach is used in Viller et al. 2009. The energy efficient control of HVAC system and to determine a fuzzy control strategy.

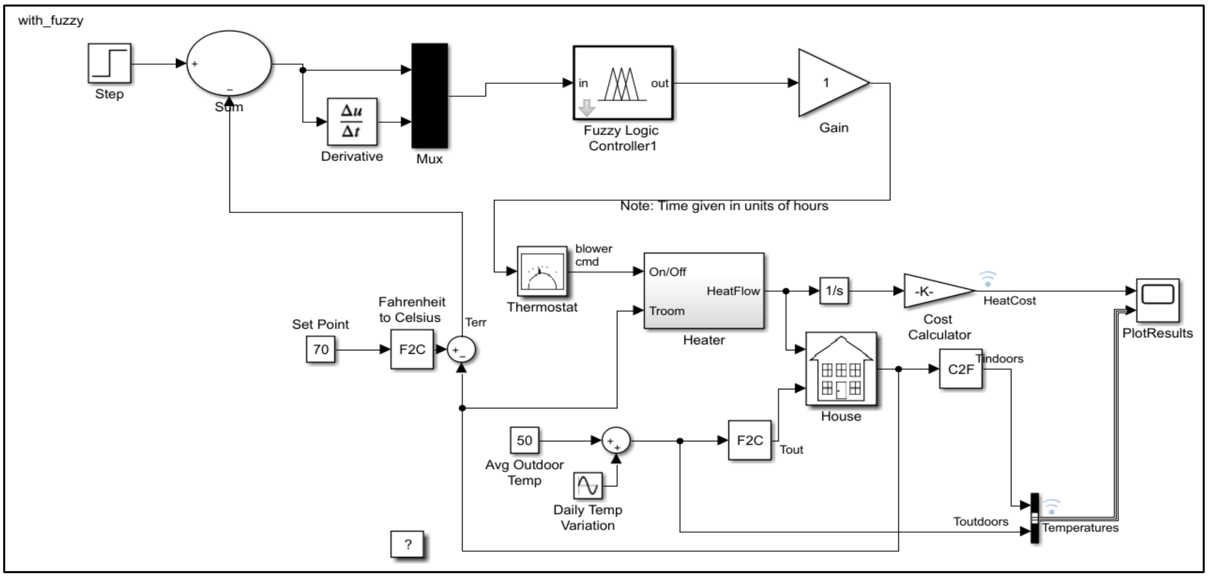

Fig. 5 Simulation model of Fuzzy controller with HVAC

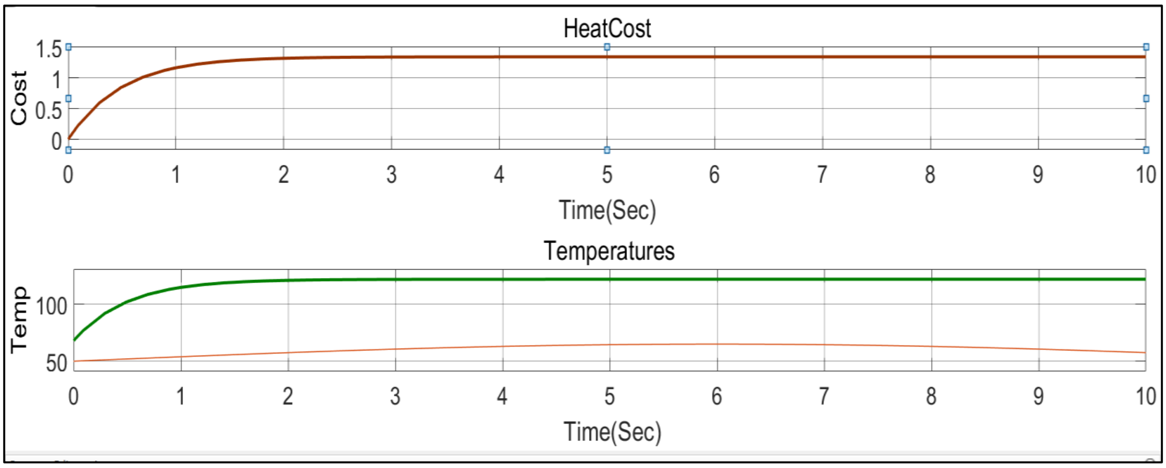

Fig. 6 Simulink result of Fuzzy Controller

Figure 9 shows the output came from HVAC system with Fuzzy controllers here simulation run for 10Sec in that heat cost 0 to 1Sec is increasing from 0 to 1.3 approx. and from 1.4 its always constant. Temperature at starting point increasing than it settles at 150.

As conclussions, different control methods explained and simulated for HVAC systems. Also, the nonlinear control method is maintained in general and particular in the case of HVAC systems. PID controllers, are still used in most applications, for domestic or commercial. Predictive and intelligent control technique gives good result for energy saving. This objective is to improve energy saving and less cost for the HVAC system, through simulation of controllers.

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Received: 15th February 2021; Accepted: 20th March 2021; First distributed: 29th March 2021.