Control Logic simulation for Distribution Control System (DCS) used in Power Generation

Major Project Report

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Master of Technology in Electrical Engineering

Submitted By

Nimesh Pagi

(17MEEE06)

By

Prof.Akhilesh Panwar

DEPARTMENT OF ELECTRICAL ENGINEERING

INSTITUTE OF TECHNOLOGY

NIRMA UNIVERSITY

AHMEDABAD-382481

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Certificate

This is to certify that the major project entitled **"Control Logic simulation for distribution Control system (DCS) used in Power Generation"** submitted by **Nimesh Pagi (Roll No: 17MEEE06)**, towards the partial fulfillment of the requirements for Semester-III of Master of Technology (Electrical Engineering) in the field of Electrical Power Systems of Nirma University is the record of work carried out by him/her under our supervision and guidance. In my opinion, the submitted work has reached a level required for being accepted for examination. The results embodied in this major project part-I, to the best of my knowledge, haven't been submitted to any other university or institution for award of any degree or diploma.

Date:

Mr.Biju P.K
Industrial Guide,
Principal Engineer, IAPG Department.
Project Manager,
ABB GISPL,Bangalore

Prof.Akhilesh Panwar
Guide & Assistant Professor,
Department Of Electrical Engineering,
Institute of Technology,
Nirma University, Ahmedabad.

Dr. S.C.Vora
Head of Department,
Department of Electrical Engineering,
Institute of Technology,
Nirma University, Ahmedabad.

Dr.Alka Mahajan
School of Engineering,
Department of Electrical Engineering,
Institute of Technology
Nirma University, Ahmedabad.

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-Nimesh Pagi
17MEEE06

Abstract

Over the last decade, Automation technologies give important changes in the power generation process. These changes have led to significant advances in instrumentation, protection, controllers, I/O modules and other plant automation components.The Distributed Control System (DCS) plays a role of brain for Automated power generation process. The control of large scale generating units is very complicated andit includes the estimation and control of no. of parameters so as to build the general plant efficiency.DCS is in charge of overseeing basic frameworks working in these condition.

When the power generation process is large and the control aspects are complex, it is difficult to install DCS directly in real system. For this reason direct implementation on real systems requires big efforts and time investments. Sometime system implementation failure would result in the high asset, time and economical loss. It is also necessary to update DCS because of changes in plant requirement to improve system efficiency and stability.Till now we directly test the real system by trial and error for satisfactory result. Major disadvantage of this method is to shut down the plant process and it will also result in to revenue loss. However, the Simulation of actual Distributed Control System(DCS) is still missing.

To overcome this problem, the work presented in this dissertation report describes the Control Logic simulation of the devices used in Distribution Control System (DCS) in Power Generation Simulation tools. It will be helpful to installing / Updating the Distributed Control System(DCS) system in actual application without any problem. So , after satisfactory results we can apply it in actual system. The results for these simulations will be embedded and discussed in the thesis.

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Abbreviations

Dcs	Distributed control system
I/O Module	Input/output module
PGP	Power Generation Portal
PGIM	Power Generation Information Management
PID	Proportional integral derivative
MPC	Model predictive control
DMC	Dynamic Matrix Control
MHTGR	Modular high temperature gas-cooled reactor
GPC	Generalized Predictive Control
SC	Supercritical
NSSS	Nuclear steam supplying system
OTSG	Once-through steam generator
T.F	Transfer Function

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Chapter 1

Introduction

1.1 Distributed control system

A D.C.S is an automatic control System for plant.It includes Huge no.of Circles.In this automatic controllers are divided into the system.And one admin Control unit.The DCS idea expands smooth control and diminishes Device Installation Prize by localize the controll works near to the Industrial Plants or other. It is Remote Observing and it can be with smart Supervision.

Distributed management systems originally developed in huge industries.It were Intelligent because the Distributed Control System manufacturer would provide small Control level.It also provide to the central supervisory Components.

Nowadays, the Function of supervisory control and data acquisition is similar like DCS system. The Distributed control systems Is to be used in tremendous power plant.Because it Provides Faster,Relaible and accurate result at the end.

The quality of Distributed control system Is it's management Process around hubes in system.In case of any failure of processor,it will only affects one Part of the processing plant.If one Central PC Fails then it will affects the overall plants. The distribution of Computers from local to end field I/O modules connection. This type of connection with the controller consumes less time and and faster in operations.

1.2 Functional levels of a DCS control operation

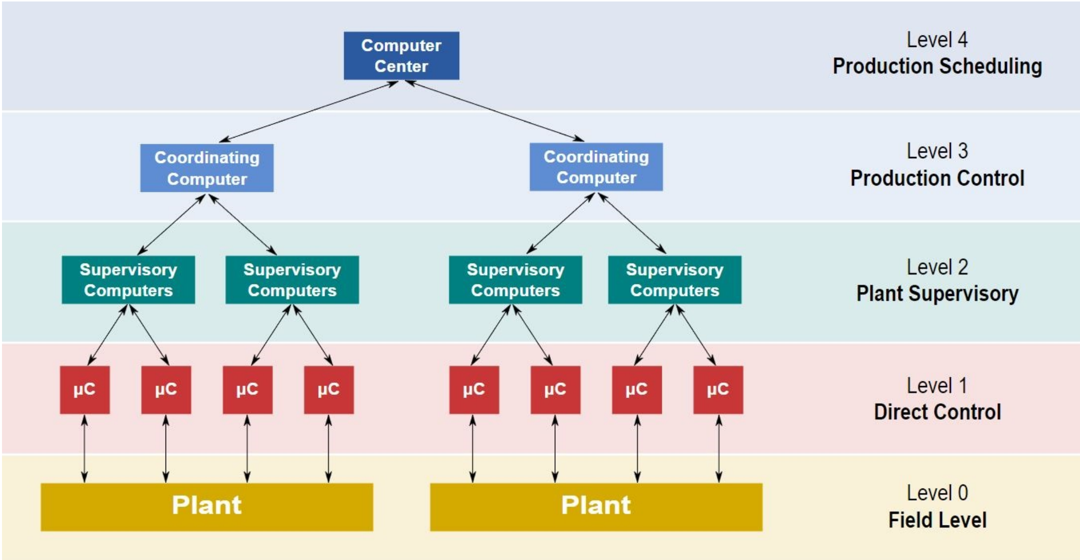

Figure 1.1: operational diagram

The accompanying diagram is a general model which shows functional manufacturing levels using computerized control.Referring to the diagram;

1.2.1 Level 0

This is the level which contains the plant field gadgets.if we take an example of it could be Pressure sensors, Temp. sensors.These Devices works as an input signal and is connected with the direct control.

1.2.2 Level 1

It includes the industrial I/O Smart Devices.It also Co-related Processor.It can also called as Direct Control method.

1.2.3 Level 2

This level Includes the control room PC.This level is also called as Plant supervisory Control.In this Computers collects data from processor in systems.It includes data collection process and Supply the Control rooms person who control screens.

1.2.4 Level 3

Level 3 Is the coordinating Computers.It connects between the computer center and Supervisory Computers.It doesn't explicitly control the method, yet is stressed over checking age and watching targets.

1.2.5 Level 4

This is the generation planning level.It incorporates the PC focus.

Levels one and two are the helpful components of a standard Distribution Control System.In this all apparatus are a bit of connected system from Manufacturer.

Level three and four aren't so much control in the customary Means.The Level three and four don't seem to be entirely method management within the standard sense, but instead where age control and arranging occurs.

1.3 Architecture of Distributed Control System

Distribution Control Systems consists of three major qualities.

1. Different control capacities can be dispersed into little arrangements of subsystems that are of semi autonomous. These are interconnected by a rapid correspondence transport and their capacities incorporate information introduction, information securing, process control, process su-pervision, announcing data, putting away and recovery of data.

2. The second trademark is the computerization of assembling process by incorporating propelled control techniques.

3. The third trademark is organizing the things as a framework.

Figure 1.2: structure of Architechture

The Distributed control system composes the whole structure as a solitary mechanization framework where different subsystems are build together to an appropriate direction structure and data stream. These qualities of DCS can be seen in its design appeared in the graph beneath. The essential components involved in a Distributed Control System incorporate working station,Smart devices,and correspondence framework.

Applications:

Distributed control systems (DCS) are majorly used in power generation plant.

1.3.1 Engineering PC,Controller or work area

In this area controllers are distributed in this distributed control system.we can consider computer and a laptop that has Involved code for that if we take an example for management of Control station.There are numerous tools availbale in a engineering Station.So these tools allow the Engineer to perform, test and analyze the things.In this engineer can do various input and output connection ,develop new-new loop for system to make easier,and also develop logic for that.

1.3.2 HMI or Operating Process Station

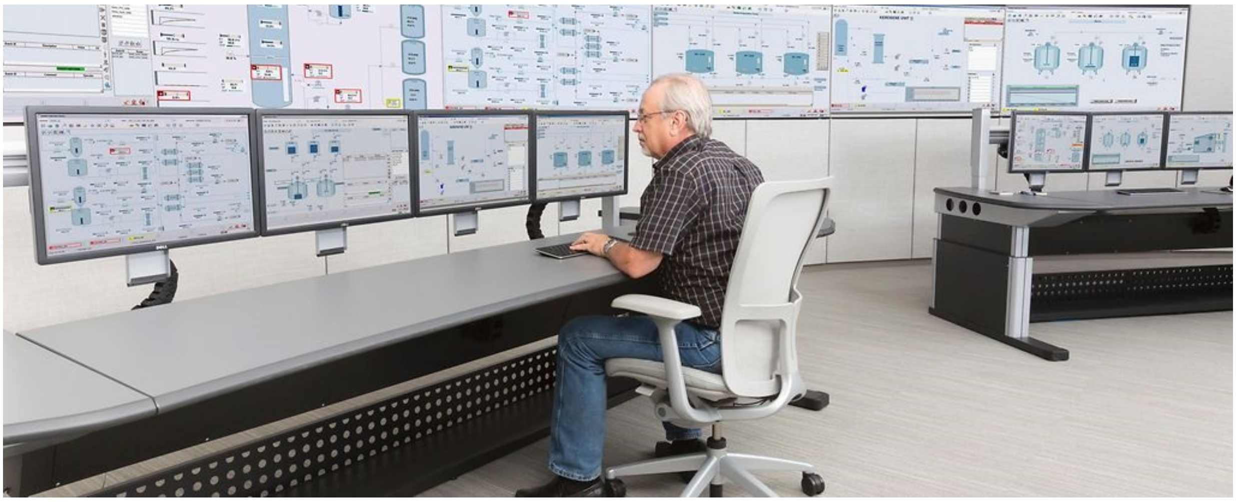

Figure 1.3: operating Station

An engineer who sets in a working area.he can read or show all the things like number of parameter values and various tools constantly and according to he can manages all these things.If we take an example of that There are some package tool which run straightforward just like DCS system of ABB . This is accustomed operate, monitor and management plant parameters.There are various units available in an operation station.so in that unit runs functions alarm function,Price show,whereas Function like display shows various parameters,few for knowledge work are being run by Multiple amount of units or we cam say by number of laptops or displays.

1.3.3 The Process Control Unit

This is control processing unit.It contains different control and I/O modules.The Sensors which is located at end of the Station or we can say that field devices is Connected to I/O Modules.This control unit collect the data from sensors and process it based on logic.

Figure 1.4: Process Unit

1.3.4 Connected Communication System

In a whole distributed Control System design ,we can assume that a communication way or a medium play a vital role. It is a combination of various things like station design,and then process will take place and the Digital gadgets will also connected to each other.It also conveys a data or info. starting with one station then onto the next. The normal conventions utilized in Distributed control system incorporate Ethernet, Profibus, Modbus and DeviceNet.

1.3.5 Field Control Devices

A smart field gadgets innovation are propelled highlights of Distribution control system development that replaces S.T.D I/O Modules. These type of smart or digital Devices insert the insight required for direct detecting and it can also control strategies into the essential impelling gadgets.apart from this, it replaces the prerequisite for a Distribution control system controller to control the whole process.

Now,End devices or field Devices play a major role in this system.These devices connected to the field transport. so that sourcing of different estimations to the following The larger no. of control station is conceivable by means of computerized line.

Figure 1.5: Field devices

1.4 Feature of DCS

- Energy conversation
- System security
- Scalable platform
- Longest equipment life
- Maximum efficiency
- High System security

1.5 Advantages of DCS

- Flexible and Relatively easy to expand
- High response time
- High reliability
- Overall lower installation cost
- Historical storage and Retrieval system
- Improve operator interface to plant

1.6 Disadvantages of DCS

- Failure diagnosis is more complex
- High software development cost
- Overall process is dependent on DCS
- More skills required by the operator

1.7 Symphony Plus (DCS System)

1.7.1 Introduction

ABB Symphony Plus is a distributed control system .It is basically designed to take maximum plant efficiency .The reliability and efficiency can be done through through automation and optimization of the plant.The all types of power generation are need of symphony plus for better performance.

For power generation, Automation is available via ABB - Power Generation Care, offering a complete service that raises the performance of the plants automation and electrical assets, its operations, maintenance staff, and the production process during the life cycle of the facility.

1.8 System Architecture

1.8.1 S+ Operations

To provide users to the most relaible, advances and efficient operation of system the S+ Operations is to be designed.Arragement of all plant data ,include the real time data are provided by S+ Operations management .

1.8.2 S+ Engineering

S+ Engineering offers all the necessary functionality needed to engineer, configure, administrate, secure, commission and maintain every component in your Symphony Plus Control System.

As shown in figure 1.7, S+ Engineering offers all the necessary functionality needed to engineer, configure, administrate, commission, security and maintain every component in your Symphony Plus Control System - from control I/O, field instrumentation and electrical devices to network architecture, operation, engineering, and advanced system application.

1.8.3 S+ Controllers

The S+ controller is a high-performance, high-capacity process controller that is used to support the plants total control requirements. S+ Operations, S+ Engineering and other applications communicate with controllers over the system. In our project work mainly

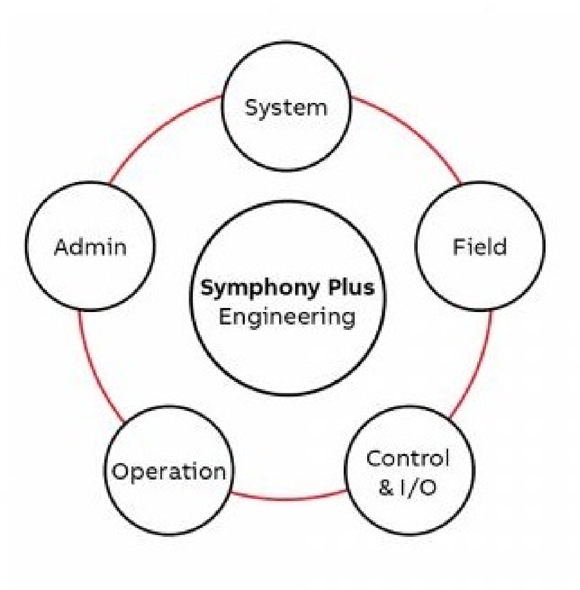

Figure 1.6: operation of DCS

we work with controllers listed below,

- SPC 700
- HPC 800

1.9 Working of DCS system

The action of DCS along these way; Sensors distinguishes the methodology information and send it to the neighborhood I/O modules, to which actuators are also related all together to control the technique parameters. The data or information from these remote modules is accumulated to the procedure control unit by means of field transport. In the event that savvy field gadgets are utilized, the detected data specifically exchanged to process control unit through field transport.

The gathered facts is further processed, analyzed and produces the output results primarily based at the control logic implemented within the controller. The consequences or manipulate moves are then carried to the actuator devices through area bus. The DCS configuring, commissioning and manage common sense implementation are carried on the engineering station as cited earlier. The operator able to view and ship control moves manually at operation stations

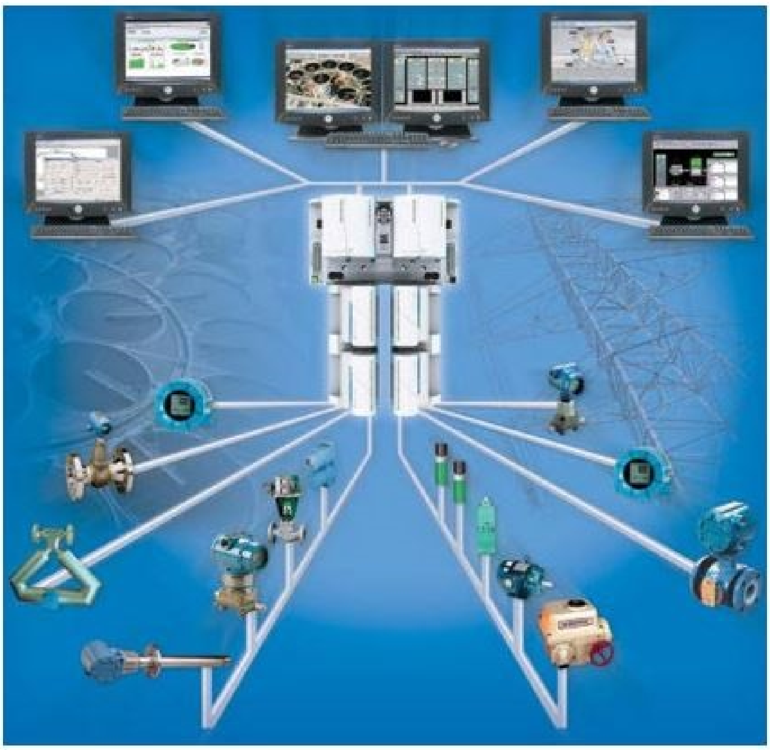

Figure 1.7: operation of DCS

Chapter 2

Literature Survey

1. ”Controller Design for Temperature Control of Heat Exchanger System: Simulation Studies” - By Subhransu Padhee - in WSEAS TRANSACTIONS on SYSTEMS and CONTROL, E-ISSN: 2224-2856,Volume 9, 2014.

Comparison of different controllers performance such as feedback, feedback plus feed-forward and internal model controller for tube heat exchange at certain reference value to maintain the temperature of outlet uid placed in shell.For finding best controller error rate amd performance are being measured. Internal model control performs better than feedback PID and feedback plus feed-forward controller as per simulation results.

2.BOILER FIRING CONTROL DESIGN USING MODELPREDICTIVE TECHNIQUES”, By Wen Tan,Tongwen Chen,Horacio J. Marquez - in IFAC Proceedings Volume 35, Issue 1, 2002, Pages 197-202.

PI controllers are used at Syncrude Canadas northern Alberta plant because they are easy to use and simple to access for boiler firing rate control. Whenever large load is there instability occurs ,because of firing rate limit. Considering Canadas utility boiler as a reference , we tried to redesign the controller. We can say that performance can be improved by desiging PID controllers properly. For further improvement, we adopt a model predictive control (MPC) scheme which is capable of handling the firing rate constraints directly; a simple MPC algorithm is implemented on a nonlinear simulation package, and significantly better results are achieved.

In this paper, they studied PID and MPC controllers for firing rate control of an industrial boiler in Alberta.Ex-tensive testing showed that both controllers can improve plant stability and performance due to sudden change in steam demand;but finally they concluded that the MPC controller has superior performance and stability and handles controller constraints effectively.

3.Step-Response of Model Development for Dynamic Matrix Control of a Drum-Type BoilerTurbine System" , By Un-Chul Moon and Kwang. Y. Lee - in IEEE Transactions On Energy Conversion, VOL. 24, NO. 2, JUNE 2009. This paper presents the application of dynamic ma-trix control (DMC) to a drum-type boilerturbine system. Twotypes of step-response models for DMC are investigated in de-signing the DMC; one is developed with the linearization of the nonlinear plant model and the other is developed with the process step-response data. Then, the control performances of the DMC based on both types of models are evaluated. Because of severe non linearity of drum water-level dynamics, it is observed that the simulation with the step-response model based on the test data shows satisfactory results, while the linearized model is not suit-able for controller design of the drum-type boilerturbine system.

This paper presents the application of DMC to a drum-type boilerturbine system. Two possible step-response models are investigated in designing the DMC; one developed by linearizing the mathematical model and the other developed with the process test data. Because of the high nonlinearity of the drum water-level dynamics, the linearized model is not accurate for relatively large changes in step inputs. On the other hand, the model based on the test data has already reflected the nonlinearity of the model, thus exhibits better responses. Consequently,DMC designed with the process test data model shows satis-factory results while with the linearized model it shows poor results. The DMC shows robust performances for different size of input signals, and prediction and control windows. It also shows good tracking performance and has benefit when considering the input/output constraints, which is often the case in real industrial systems.

The novel contribution of this paper is as follows: First, it has been shown that the wide-range operation of drum-type boilerturbine system can be effectively controlled by a direct application of DMC. Until now, the direct application of DMC to drum-type boiler-turbine system was found to be difficult due to the drum-level dynamics with instability and the non minimum phase. Second, the linearized model of drum-type boilerturbine system is shown not to be valid for a long-range prediction of DMC, main reason being the poor quality of linearized drum water-level dynamics. Therefore, a careful validation of the step-response model is necessary in designing the DMC, although a valid mathematical model is used in this paper. These results can provide a good practical guidance in implementing the DMC.

4.Fuzzy control method for Heat-Exchanger ,By Adrian-Vasile Duka,Duka, Stelian-Emilian Oltean 2013,20,

In this Paper the designing of fuzzy control system is disccued.By using Ziegler-Nichols method,a PI controller is tuned and To develop the fuzzy-logic -controller, it will provide starting point.By using matlab simulink we will verify the effect of design.

5.Dynamic Matrix Control for the Thermal Power of MHTGR-Based Nuclear Steam Supply System", By Di Jiang, Zhe Dong, Miao Liu and Xiaojin Huang - in Energies 2018, 11, 2651 The modular high temperature gas-cooled reactor (MHTGR) based nuclear steam supplying system (NSSS) is constituted by an MHTGR, a once-through steam generator (OTSG) and can generate superheated steam for industrial heat or electric power generation. The wide range closed-loop stability is achieved by the recently proposed coordinated control law, in which the neutron ux and the temperatures of both main steam and primary coolant are chosen as controlled variables, and the owrates of both primary and secondary loop and the control rod speed are chosen as manipulated variables. However, the thermal power is only controlled in open loop manner and hence could be further optimized through feedback. Motivated by this, a dynamic matrix control (DMC) is proposed for optimizing the thermal power of MHTGR based NSSS. A simple step-response model with the thermal power response data is utilized in designing the DMC. The design objective of DMC is to optimize the deviation of the thermal power from its reference under its rate constraint. Then, by the virtue of strong stability of existing control law and optimization ability of DMC, a cascade control structure is implemented for the thermal power optimization, with the coordinated control law in the inner loop and DMC in the outer loop. Numerical simulation results show the satisfactory improvement of thermal power response. This cascade control structure inherits the advantages of both proportional-integral-differential (PID) control and DMC, by which the zeros offset and the short settling time of thermal power are realized.

Chapter 3

BFP Control system Diagram

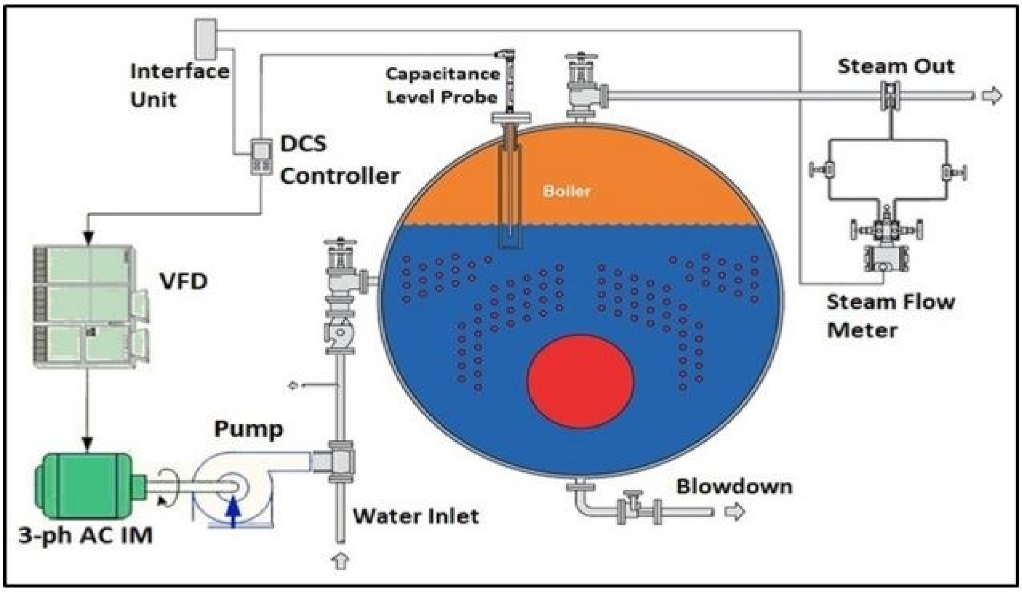

Figure 3.1: Control System Diagram

Operating Mechanism:-

- The Controller will check the reading from flow-meter. If the flow is 100 percent then the motor need not to be control.

- But, if flow is reduced below the max. level than gradually the motor speed is to be reduced.

- So, that energy will be saved accordingly.

- The Controller will instruct the VFD drive to function accordingly and motor speed will be reduced.

- This data will be displayed on user screen.

3.0.1 Steps to control to be used.

- Sense steam flow from Steam Flow Meter. Sense water level from Capacitance Level Probe.
- Connect sensed data with I/O Modules..
- The data is continuously supervised by DCS controller.
- Based on control requirement DCS control the VFD frequency o/p.
- AC Induction Motor speed will change because of change in freq.
- So, Pump output also change with change in rotor speed.
- Finally, Quantity of Water feeded in the boiler will change as per requirement.

So, Above process continuously controlled by DCS Controller and we get desired control.

3.1 Systems Modeling and Verification added to the Altair software

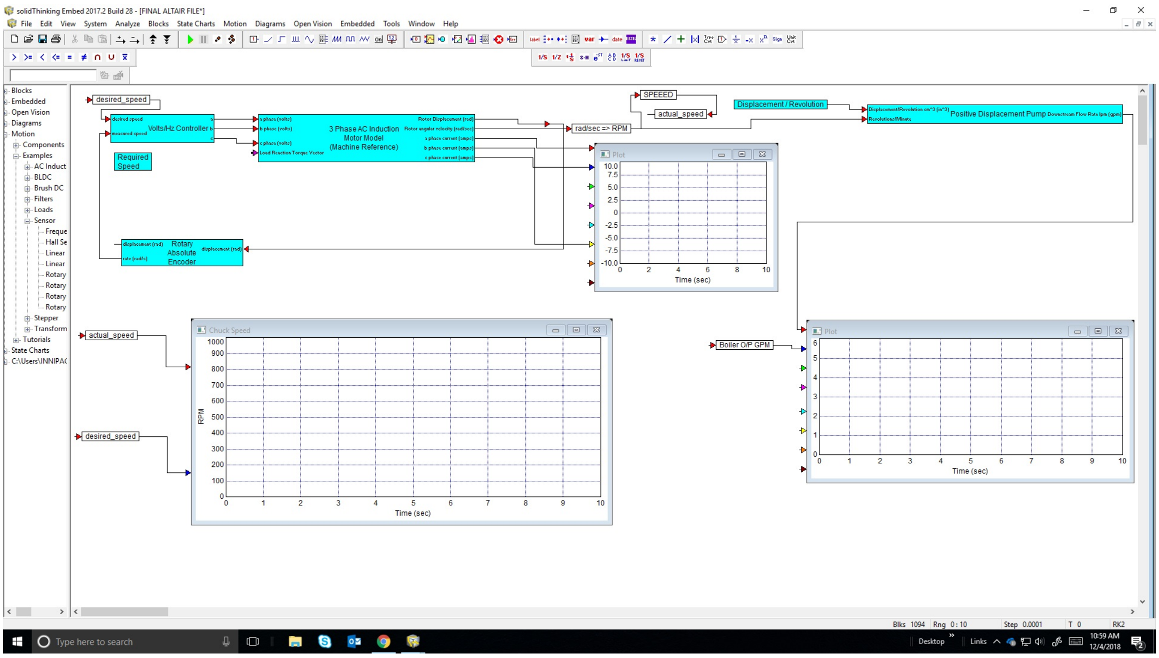

Figure 3.2: System Simulation

1. Pick the desired stream rate:- First of all just choose the essential d stream rate of fluid from the Pump. Compose this incentive in Gallons per minute every moment.

2. Calculate the height of the water:- Here,the vertical area covered from the most noteworthy purpose of the water to the last objective of the water. If the water level of this changes after some time,then just use the most extraordinary distance.This pump requires to generate this much amount of pumping head.

3. Calculate Losses in the pipes.:- Other than the base Pressure Required to push the water at specific Physical Length, our Pump needs to eliminate the force of friction in the pipes.These losses happens due to usage of material of pipes and various Parameters length of pipe,diameter of pipe etc.

4. Include or add the pumping lift plus friction loss:- Here,the vertical distance water needs to flow plus there are some losses from the pipe both make the add up dynamic head.It is the aggregate total pressure load that the pump requires to survive.

5. Calculate or find the specific gravity of water:-If you are pumping other or some different liquids like oil from the pump system,then check the gravity of that particular liquid or take it from some books. Here, For Water the particular gravity is to be decided as equal to one.

6. Now add these values into the formula of water horsepower and check for it.:- As shown from the below figure of Water H.P Equations we can calculate it. here,Q is the stream rate in Gallons per minute. SG is the explicit gravity.And we consider one for water.Now,Put the all values in equation and Calculate the water horsepower.

3.2 Systems Verification in the Altair software

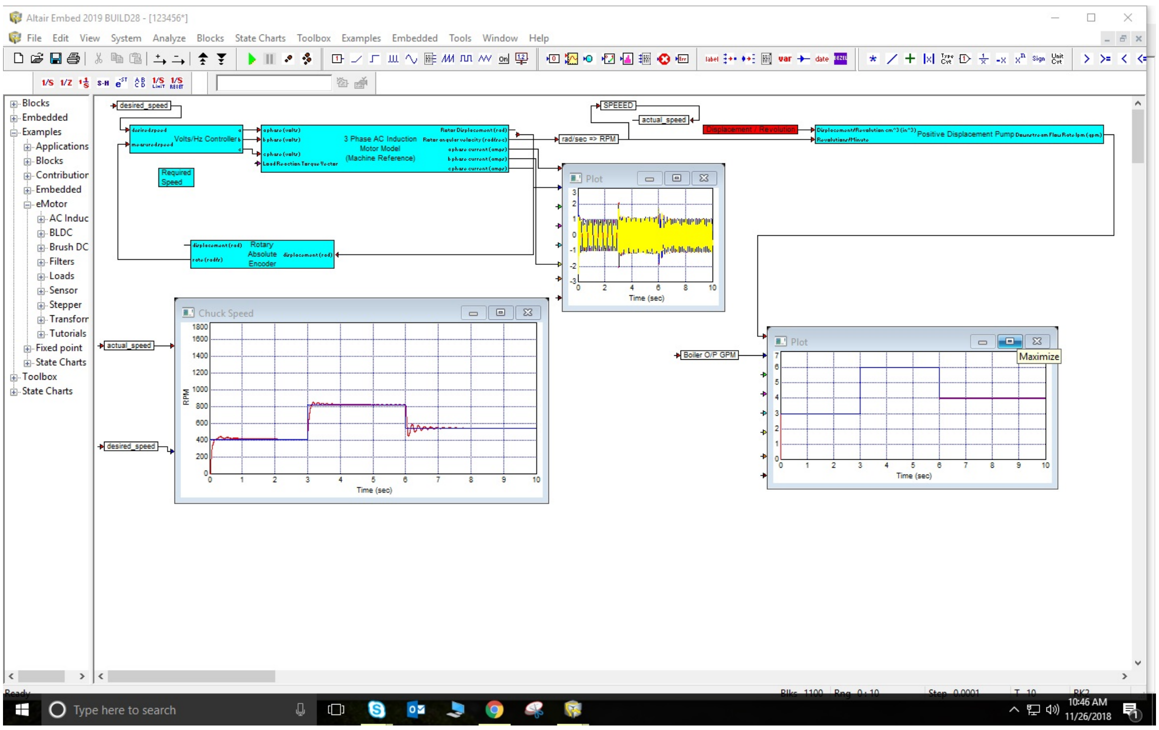

Figure 3.3: System Simulation

After running the simulation we can get desired speed control of motor.And From this we get a required output from it.

- **Motor Speed Graph**:-This Time(sec) VS rpm graph shows motor speed after controlled by v/hz controller. Here,Desired speed of motor is indicated as Blue Line. And the actual speed of motor is by Red Line that we get at output side. Here both the speed actual and desired one will follow the same path. In this graph I gave steps to the signal that shows after 3 sec it will goes high and then at 6 sec it will remain original. This graph follows the steps properties As Shown below whatever we feed in it and we will get desired speed.

- **Output Current from Motor**:-In this current plot of motor shows that in between 3 sec to 6 sec there is a spike will happen in specific time period.

- **Boiler Output Plot**:-As shown from the diagram of boiler output plot,output from the pump will follow the same path as boiler output in gpm.

Chapter 4

Study of PID and Fuzzy-PID Controllers in Boiler Heat Exchanger

The Power plants which uses the steam-driven turbines.The main purpose of heat exchange is to boil water and convert into steam in a proper way. A Heat exchangers to produce a steam from water are called as boilers.

The heat-exchanger is a mechanical gadget,which is used to exchange heat and this heat can exchange between at least 2 liquids or energy from hot fluid to cold fluid. There is a strong wall available which separates the fluids to avoid mixing. For both cooling and Heating Process . So many types of heat exchanger is used in various types of industries.Although shell and tube type heat exchanger system is most commonly type of Heat Exchanger. Heat Exchangers are commonly used in Evaporator,cooling towers ,condensers and various genarating plants. The use of heat exchanger is in cooling systems,air conditioning systems,various power stations,Different types of chemical plants, petroleum industries, and sewage Plants.[1]. If we take a example of a heat exchanger then it is found in an internal combustion engine.In this a Flowing liquid flows through radiator coils.And basically it heats the incoming Air in a system.

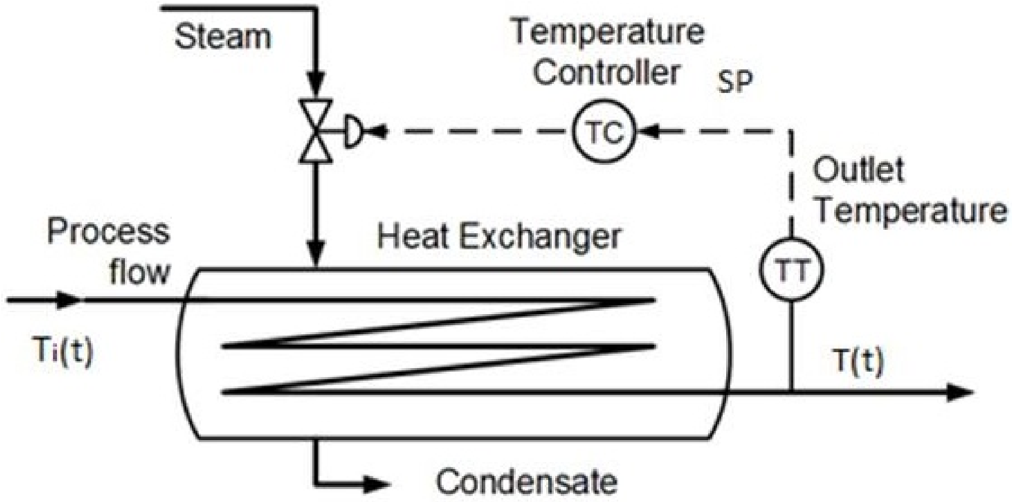

Figure 4.1: Diagram of shell - tube heat exchanger

The heat exchangers in various Power industries and their system have to follow the external load Changes and their are some rules and Guidelines which have to follow.There are various mechanical procedures and tasks, for example, Different power plants and various chemical process plants simulations of the reaction of heat exchangers are need to be required[2].

The Working principle of heat exchanger is shown in Fig.

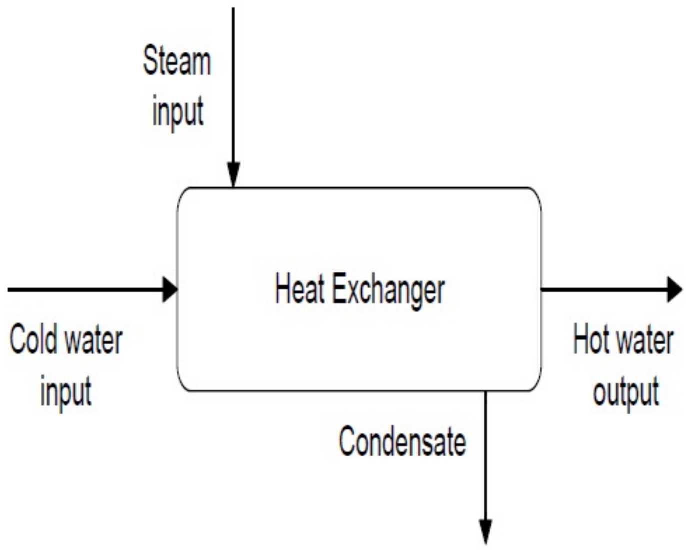

Figure 4.2: Working Principle of heat exchanger

There are different types of heat exchanger in Power plants and they are Sorted considering Various Process and Construction wise.[3]. and below as shown in fig .is different types of heat exchanger.

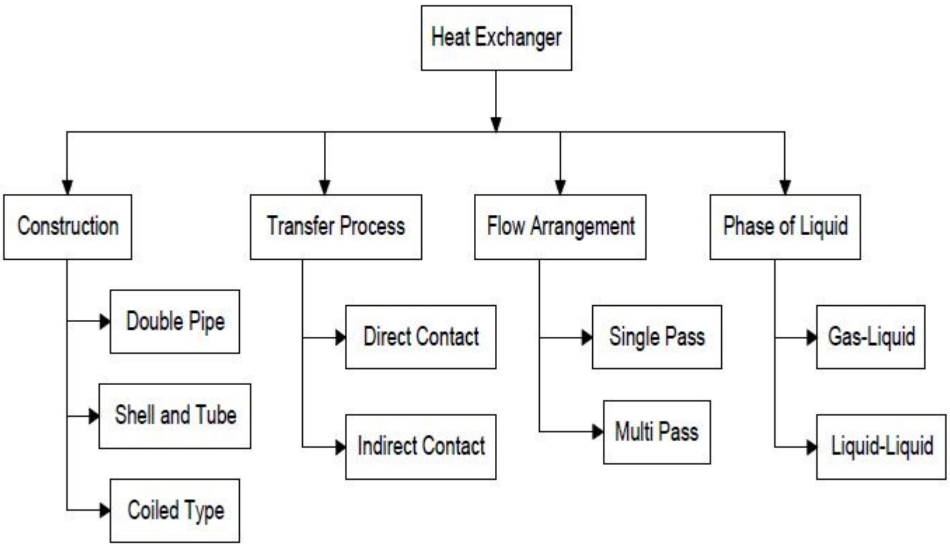

Figure 4.3: Classification of heat exchanger

Based on types of heat exchanger ,Shell and the Tube type Heat exchanger probably is the common type of heat exchangers which is apply for wide range of operating temperature as well as pressure. It has larger ratio of heat transfer surface to volume than double-pipe heat exchangers, and it is easy to manufacture in a large variety of size and configuration. Shell and tube heat exchanger can operate at high pressures, and its construction facilitates disassembly for periodic maintenance and cleaning.

Here,we can say that shell and tube type of heat exchanger is an modify version of the double-pipe type configuration. Disadvatage of single pipe over double pipe,a shell-and-tube heat exchanger made up of a number of pipes With Bundle type,and these tubes in a heat exchanger is covered with cylinder type of shell. The Process of shell - tube heat exchangers is one fluid flows inside the tubes. And the second Liquids or fluids flows inside the space ,In which flows through the null space between the tubes and the shell.The advantage of Shell-Tube Heat Exchangers consists of high performance,Good construction wise,Better life,best designed its function is very smooth. They can shoulder high of temperature, are energy efficient[4].

Chapter 5

Control Scheme of Heat Exchanger System

A main goal of heat exchanger system is to deliver hot heat from hot liquid to cold liquid.Now, in this the main or primary goal is to control the outlet liquid temperature.For that,here we are using different types of controllers for a heat exhanger system. Generally, It can be 2 types of Workflow available in disturbances.The disturbance is like that liquid flow variations available and a Input Liquid's Temperature Variations.If we show the actual plant process Temperature Variations is the most commonly shown types of variations than Liquid Variations in Pipes. There are two types of control mechanism like feed-forward and Feed-back control system.First,in feed forward control loop techniques, the input liquid flow is being measured in a system.There are several disturbance in the liquid flow process happen,which is controlled by feed forward controller. The result of the feedback and the feed forward controller is added and Whatever the output result we got, it is given to the control valve. The output is being calculated with the help of feed forward controller[5].

In industries, large heat exchanger networks are engaged to operate wasted heat energy. Actually heat transfer process is highly nonlinear in nature. In many cases conventional type of PID controllers arethere which is used in industry.The disadvantage is that thay are facing various Difficulties in non liner type of process.The changes in a input side that also we can not Predict earlier.So to avoid the problems like this in this we are using Fuzzy-PID type of controller.This updated controller is used in industries also.

The updated controllers controls the temperature of the outgoing liquid to a desired set point.This controls in a less possible time irrespective of load. also control process disturbances and non linearity[6].

5.1 Control Algorithms

In a heat exchanger's,the outlet temp. is to be control by the closed loop control. The control algorithm,which we have to apply to get a desired control objective.We are applying the Study of PID control and Fuzzy-PID Controllers in Boiler Heat Exchanger.

5.2 PID Controller :

As the name suggest PID the name of individual terms that consist the 3-term controller.In this P Stands for the proportional term and I stands for the integral term and D stands for the derivative term in a controller.This controller namely proportional, integral and derivative (PID) controllers are generally used industrial controller in various Parts. In a industrial control system may consist a control tree.whose Main control device is P.I.D Control Device[7].

A P.I.D controllers are widely used in generating and a control industry.It is due to the basic architecture and easy and reliable in implementation. Since last few times For tuning of P.I.D several methods are being used. Though, For different method there are few limitations.More than 90 percent of control loops uses PID Controller in several industries[8].

For design of controller and tuning of the controller to get the better performance it includes,

1. It indicates the closed loop execution based on their physical constraints.
2. For system to control it includes dynamic model of system.
3. To get a better performance ,it have to apply controller techniques or strategies.
4. Different controller have own platform to perform Better in their own way.
5. Apply suitable controller based on performance and based on requirement modify it.

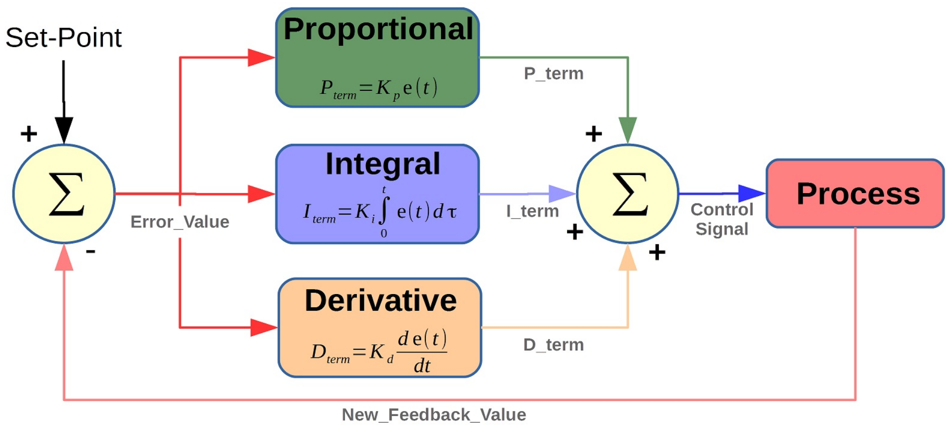

Figure 5.1: PID Controller Block Diagram

For tuning or control the P.I.D Controller,there are different methods for available; it is as below;

1. (T and E method)Trial and error
2. Relay method
3. Process reaction curve technique
4. Using software

5.2.1 PID Controller Structure

PID controller consist of of three terms. Their name is Proportional, Integral and derivative control.Now,the combination of these three controllers gives control techniques for Plant/Process Control.
There are several process/plant variables like Pressure,Flow,Speed,Temperature etc.so these Varibles can be controlled by PID controllers.

5.2.2 Application

- **Temperature Control**:-Give us a chance to take a case of AC (climate control system) of any plant/process. Setpoint is temperature (20 C) and current estimated temperature by sensor is 28 C. Our point is to run AC at wanted temperature (20 C). Presently, controller of AC, create motion as per blunder (8 C) and this flag is given to the AC. As per this flag, yield of AC is changed and temperature lessening to 25 C. further same procedure will rehash until temperature sensor measure wanted temperature. At the point when mistake is zero, controller will give stop order to AC and again temperature will increment up to certain esteem and again blunder will produce and same procedure rehashed ceaselessly.

- **Power Electronics Converter**:-PID controller is most valuable in power hardware application like converters. In the event that a converter is associated with framework, as indicated by change in burden, yield of converter must change. For instance, an inverter is associated with burden, if load increment progressively current will spill out of inverter. In this way, voltage and current parameter isn't fix, it will change as per necessity. In this condition, PID controller is utilized to create PWM beats for exchanging of IGBTs of inverter. As indicated by change in burden, criticism flag is given to controller and it will create mistake. PWM beats are produced by mistake flag. Thus, in this condition we can get variable info and variable yield with same inverter.

- **Designing of MPPT (Maximum power point tracking) charge controller for solar PV:**To discover MPPT, PID controller is utilized and for that current and voltage setpoint is given to the controller. On the off chance that environmental conditions will change, this tracker keeps voltage and current consistent.

5.3 Mathematical Modelling of PID System

5.3.1 PID Controller

The below diagram shows the closed loop feedback system setup. it is used to control heat exchanger temperature control.So,here we are using P.I.D controller for control purpose.

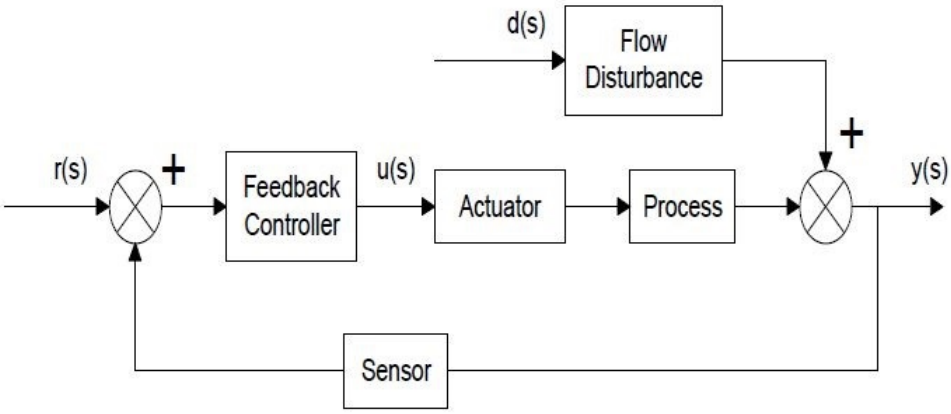

Figure 5.2: Schematic diagram of Temperature control loop

Now,We can show equation of PID controller as below,

$$Gc(s) = Ks\left(1 + \frac{1}{TiS} + TdS\right) \tag{5.1}$$

In this equation the gain is represented as Kc and Integral time Ti and for Td it indicates derivative time.PID controller are differentiate as many methods.In this few methods are empirical methods, some methods are based on frequency response analysis of the system.There are other methods which are based on minimization of performance measures. But for most of case P.I.D controller is being used and is tuned by using (T and E) Trial and Error method.

Now,The T.F equation of feed forward controlleris as below,

$$Gcf(s) = -\frac{Gd(s)}{Gp(s)} \tag{5.2}$$

Here,Gcf(s) is T.F of both the combine feedback and feed forward controller.The disturbance T.F is indicates as Gd(s).And now last the Process control T.F, in this equation is Gp(s).

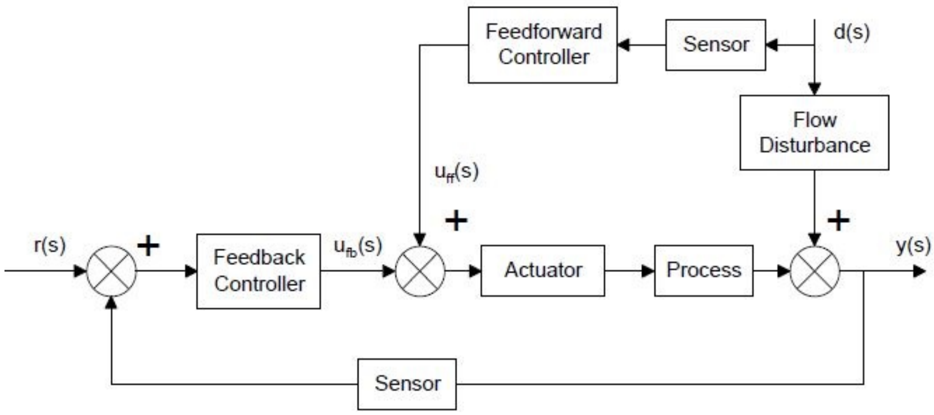

Figure 5.3: Block diagram of feedback plus feed-forward controller

Combination of Feedforward-Feedback Control:

Here,For set point tracking Feedback control is commonly used in system. while for reection measured disturbance feedforward control can be used.Then after we will see at the advantage of combination both plans. The Related control design shown in fig.5.3.

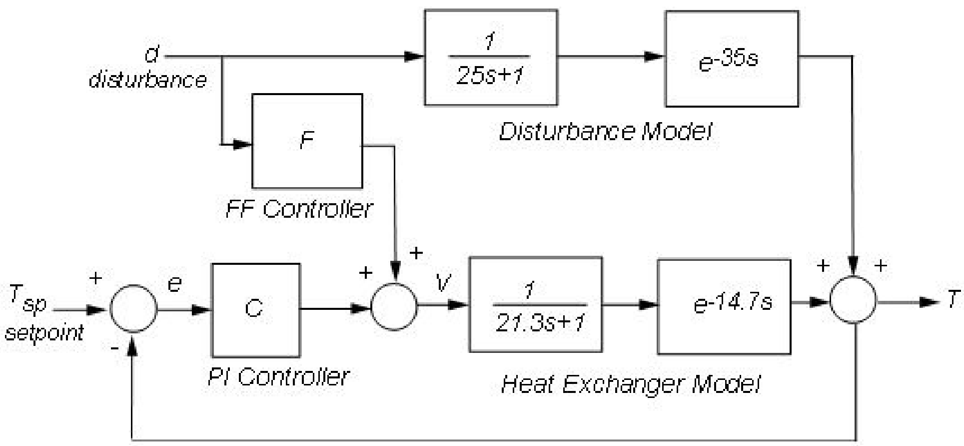

Figure 5.4: feedback-feed-forward control

Use connect to build the corresponding closed-loop model from Tsp,d to T. First name the input and output channels of each block, then let connect automatically wire the diagram.

5.4 PID Controller

The P.I.D controller have several advantages.Because of Kc is bigger it does not display a rise time.It has advantage like faster settling time. It is possible of derivation action in a process variable. One of the result of this is a decrease in the rolling.Also decrease in oscillating nature in an PV graph.

Perhaps more significant, however, is the obvious difference in the CO signal trace for the two controllers. Derivative action causes the noise (random error) in the PV signal to be amplified and reflected in the control output. Such extreme control action will wear a mechanical final control element, requiring increased maintenance.

This unfortunate consequence of noise in the measured PV is a serious disadvantage with PID control. We will discuss this more in the next article[9].

Tune One, Tune Them All

In this study to finish it, we will compare the Dependent, Ideal form above to the performance of the Dependent, Interacting form:

$$CO = CO_{bias} + Kc\left(1 + \frac{Td}{Ti}\right)e(t) + \frac{Kc}{Ti}\int e(t)dt - Kc * Td\frac{dPV}{dt} \tag{5.3}$$

The IMC tuning correlations for this form are:

$$Kc = \frac{1}{Kp}\left(\frac{Tp}{Tc + 0.5\theta p}\right) \tag{5.4}$$

where, Ti=Tp;Td=0.5θp

we are explore moderate Output tuning:

Moderate Tc = the larger of 1.Tp or 8.θp

= larger of 1 (1.3 min) or 8 (0.8 min)

= 6.4 min

To get the tuning Values,here we are using Tc and our model parameter in a proper way:

Interacting PID: Kc = -0.36 % C; Ti = 1.3 min; Td = 0.40 min

Ideal PID: Kc = -0.47 %C; Ti = 1.7 min; Td = 0.31 min

Here a moderate tuning gives a fast PV output as result and during it will not produce overshoot.

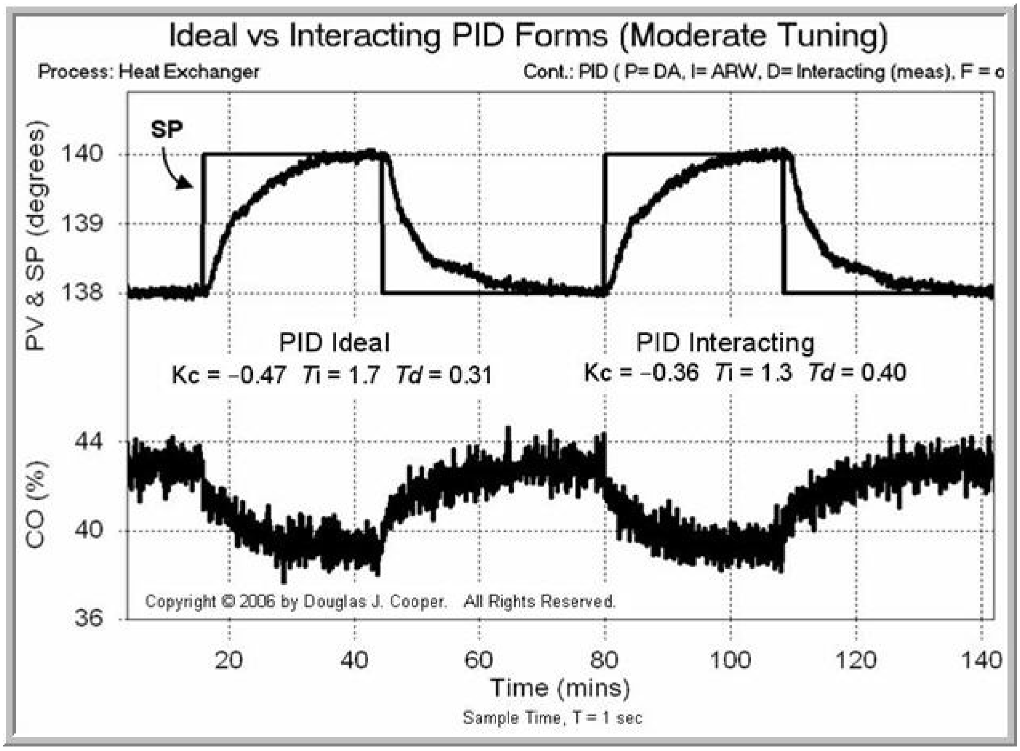

Figure 5.5: PID control of heat exchanger

The very important thing is , we set up the that the interacting PID form as well as the ideal PID structure when tuned with their very own connections[10].

5.5 Fuzzy-PID CONTROL

There are some steps to control the design of fuzzy logic controller. (1). The determination of variables for fuzzy logic is done.There are two input variables in fuzzy logic controller and also one output variable in it.The input is taken as error and also change in error in input.So it is basically the difference between actual temperature and set point temperature. The universe of Discourse for all the variables involved are then set.

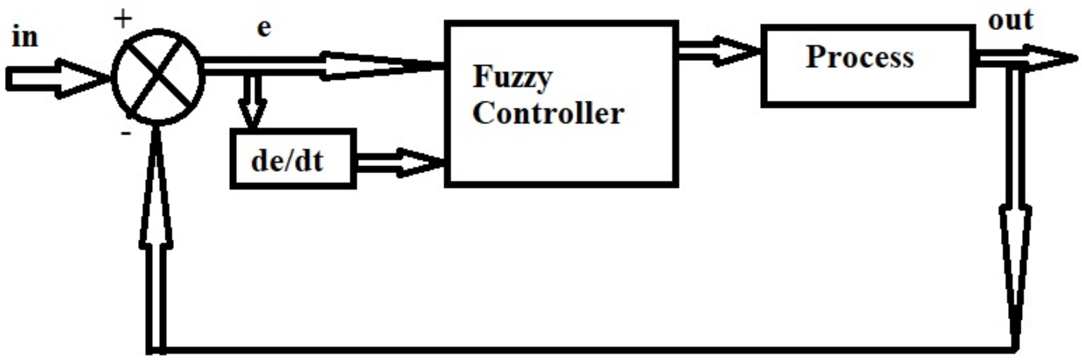

Figure 5.6: fuzzy logic controller structure

To control the temperature in the outlet with respect to error and change in error is shown in above figure.

The above figure shows the fuzzy logic controller to control the temperature in the outlet of the shell and tube heat exchanger system with error and change in error[11] .

Consider the heat exchanger shown in Fig.3.1. The top inlet delivers fluid to be mixed in the tank. To regulate the temperature of the tank fluid to a desired set point, the amount of steam supplied to the heat exchanger is modified via its control valve. Variations in the temperature of the inlet flow are the main source of disturbances in this process. This type of response is typical of a first order system with transportation delay, and can be approximated by the step response of:

$$H(S) = \frac{e^{-Ls}}{Ts + 1} \tag{5.5}$$

Here,L=14.7s T=21.3s.

The T.F in (5.6) models,Steam valve will open when the voltage changes .It also affects the tank temperature T.For the plant controller named PI Is being tuned by this model.For that we are using the following parameters:

$$C(S) = Kc\left(1 + \frac{1}{Tis}\right) \tag{5.6}$$

Here, the proportional gain KC and the integral time Ti are computed as follows. Since FLCs require most of the time a digital implementation, the continuous time controller in (2) is digitized with a sampling rate Ts=1s. (T 3.3L 48.5).
The resulting discrete time version of the PI controller is given in equation:

$$u(n) = Kc\left(e_n + \frac{1}{Ti}\sum_{j=1}^{n} e_j T_s\right) \tag{5.7}$$

The updated version of discrete time PI controller, we can write a equation as a form or re-write it as equation (5.9)

$$u_n = u_{n-1} + \Delta u_n \tag{5.8}$$

where $\Delta u_n denotes PD Component.$

$$\Delta u_n = K'_p\left(e_n + T'_D \frac{e_n - e_{n-1}}{T_s}\right) \tag{5.9}$$

And Parameters K'$_p, T'_D are computed based on K_c, T_i and have the following values.$

$$K'_p = \frac{K_c T_s}{Ti} = 0.027 \tag{5.10}$$

$$T'_D = T_i = 48.5 \tag{5.11}$$

Design and structure of self-tuning fuzzy PID controller

To Modify the PID controller we use fuzzy control in that we use tuning P.I.D controller while taking input as error and change in error. Here the parameters of PID controller basiclaly tuned by fuzzy tuner, we called it as self-tuning Fuzzy controller. The schematic diagram of self-tuning fuzzy P.I.D controller is as in 5.6 figure[12].

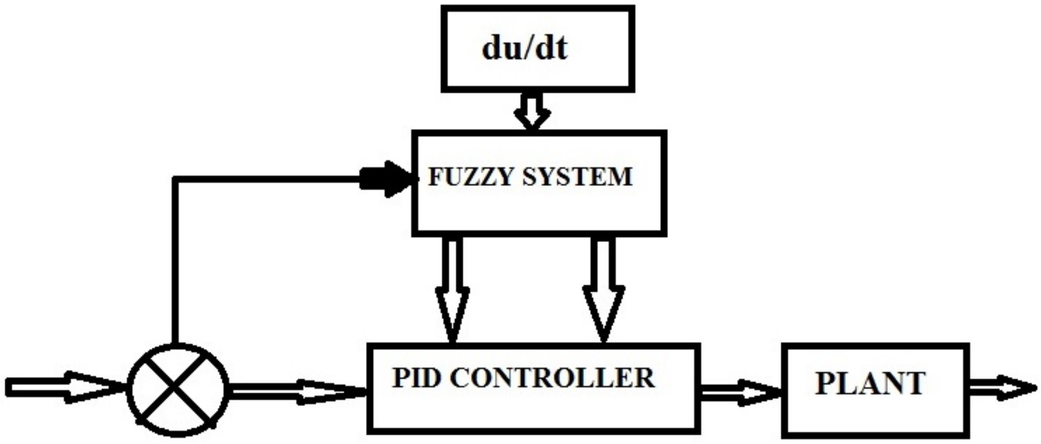

Figure 5.7: Self-Tuning Fuzzy PID Controller structure

Here,the fuzzy-PID type control system is consist of both PID and fuzzy block. With this combination there are some changes include the formula that is apply to value like Kp,Ki,and Kd from the fuzzy type block. The error can be changed by using parameters like Kp,Ki, and Kd which is tuned by singals from fuzzy logic based. so,the PID controller is tuned by applying fuzzy controller. The amount of error is decrease or overcome by using above Method. The result or output shows that the Combine PID-Fuzzy control system is more satisfied and better efficient to the Only PID one[13].

Chapter 6

Software Used

6.1 Matlab Simulink

Simulink is a part of Mathworks. It is programming language tool for the simulation of different models.it also involves Modeling and Analyzing of system. Matlab interface is block diagram tool for graphical blocks and a different types of libraries. So, Matlab can offers more integration.The use of Simulink is very broad way.It basically used in control theory. And digital signal processing,which is for multi domain simulation models.

Here,Simulink has an advantage to draw diagram in multiple domain for simulation purpose. It has capabilities to supports simulation of diagram .It has also feature of generation of code by automatically.Matlab can test the system and also it's verification is done in it[14].

Capabilities

1. We can create model..
2. It can simulate the Model.
3. It can manages the Projects.
4. We can analyze the Simulation Output.
5. We can also connect it with hardware.

6.1.1 Basic Control Theorem for System

In any Control system, there are types of loops available.one is Open loop control system and another is closed loop system. in an open loop control system ,there is no actions or no any kind of control algorithm applied for that, only whatever the input is given to the particular plant is to be shown in output as it it.In this there is no role of controller.

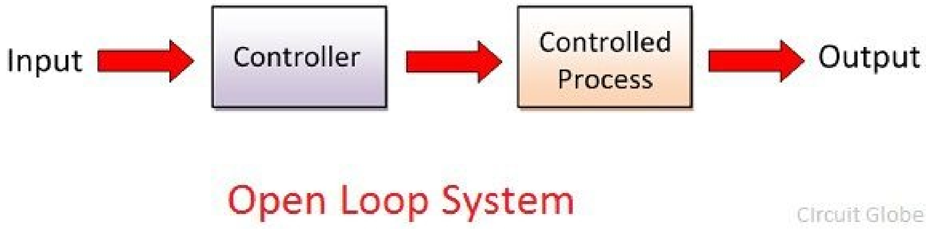

Figure 6.1: Block diagram of open loop system

While in Closed loop Control system,Controller has to take action according to whatever the Values it got from the output side.so in this closed loop system Controller is fully depend upon the Output or feedback that we got from Output of the process of system.

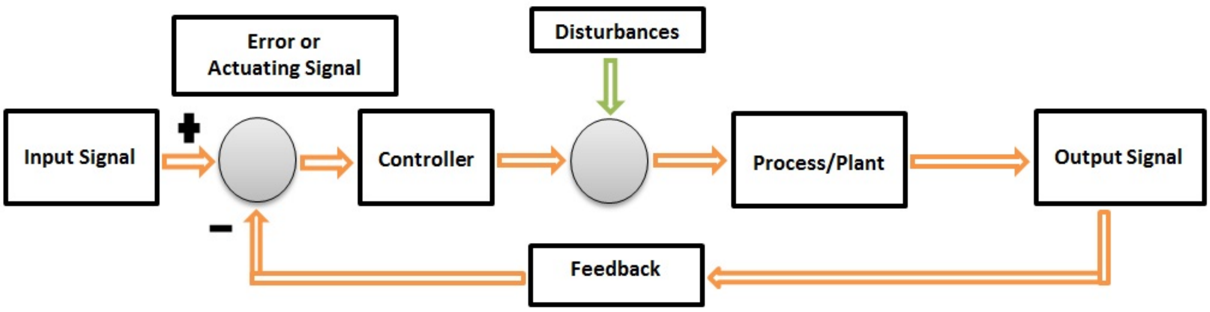

Figure 6.2: Block diagram of closed loop system

As shown in above diagram the output signal is given as feedback to the controller again.So that the the error from output of the plant can be minimised through it.

6.1.2 Heat Exchanger Temperature control system

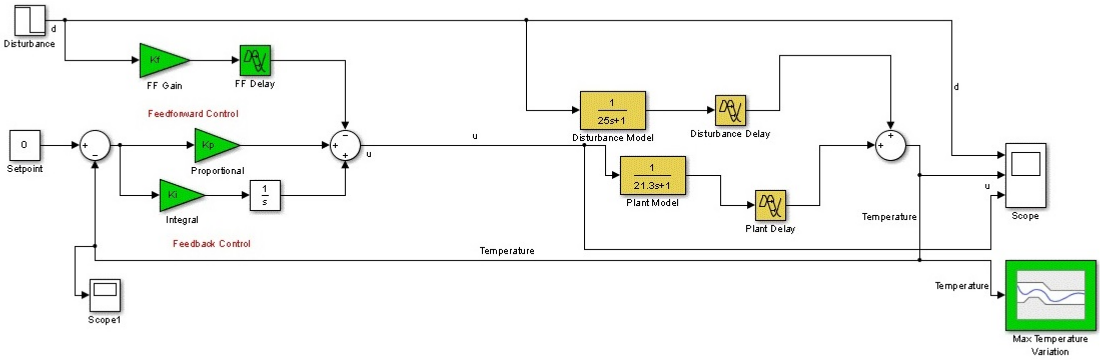

Figure 6.3: Block diagram of Heat Exchanger control Model

As shown from the above diagram the first part is the controller side Part and the second part is the plant side model.The controller side is made up of P,I and D with feedback control type and the second part is made of Transfer function with some delay function.

6.1.3 Simulation Result of PID control system diagram

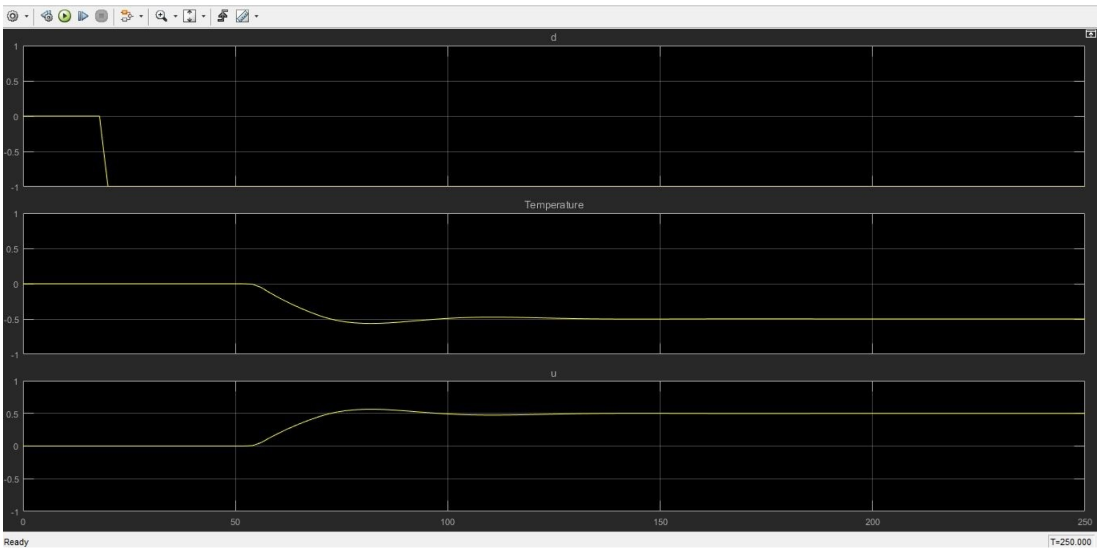

Figure 6.4: Response of System

From the graph,it shows that the response from above simulation above graph for disturbance(d),Temperature(t) and Control signal(U). The main drawback is a capability to respond to the various disturbances in a feedback control. And if so many disturbances occur in a system with perticular magnitude, it may be posiiblity to create the process is not recoverable in it[15]. .

6.1.4 System Response of PID control system

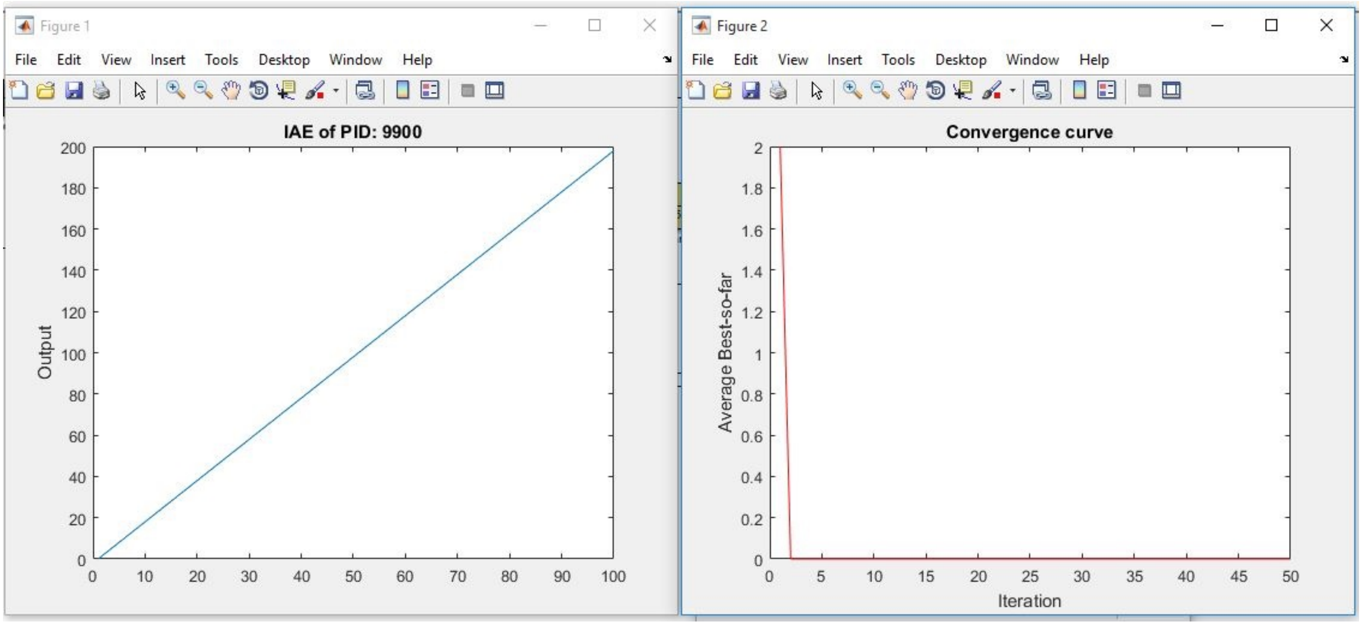

Figure 6.5: Output Waveform

As shown from the above figure the output of heat exchanger with PID control gave continuous signal response and convergence curve graph gave avg best value decreasing from 2 to near to zero value.

6.2 Simulink model of Fuzzy-PID Control

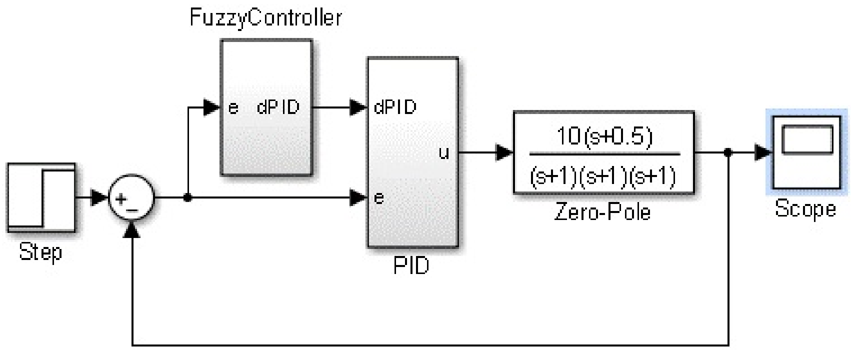

Figure 6.6: Output Waveform

As shown from the figure we are connecting Fuzzy controller with the PID controller to show the response at output side. In an Fuzzy controller we are reducing an error which are comes from the output of plant.The main aim of fuzzy logic controller is to Optimize or minimize the error from the system.

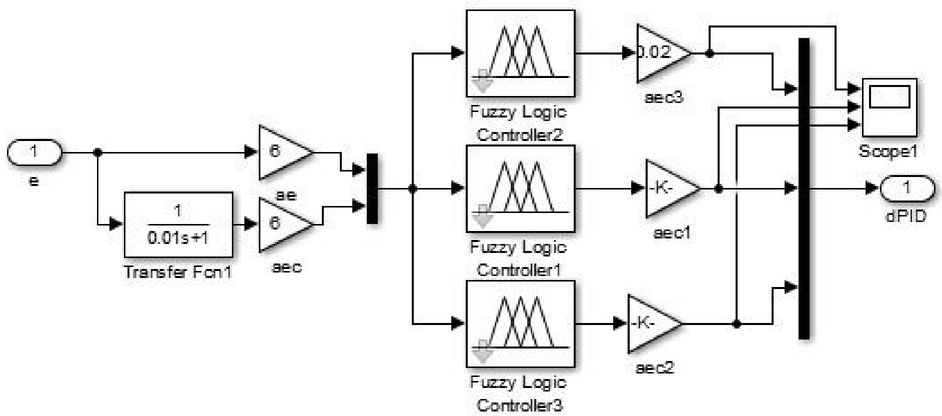

Figure 6.7: fuzzy controller

Here in diagram transfer is used to analyse a system.Also it controls the system.Transfer function is basically ratio of output to input considering time.The gain block is basically multiplied with the input value.There are three fuzzy logic block for different structures like Kp,Ki and Kd.Then it is given to the three gain parameters.

Now,The block of Zero-Pole display basically T.F of system and it Depends upon the parameters like gain ,pole and zero. The block for zeros will be make to describe Zeros,gain and poles like as below,

Figure 6.8: T.F on zero-pole block

So,here we are taking block parameters zeros:[-0.5],poles:[-1 -1 -1],and gain:10.

6.2.1 System Response of Fuzzy-PID control system

By using Fuzzy-PID control mechanism,the output diagram shows the linear output and it reduces the error and achieve graph near to the value.so the updated optimization technique is good to the normal control one technique.

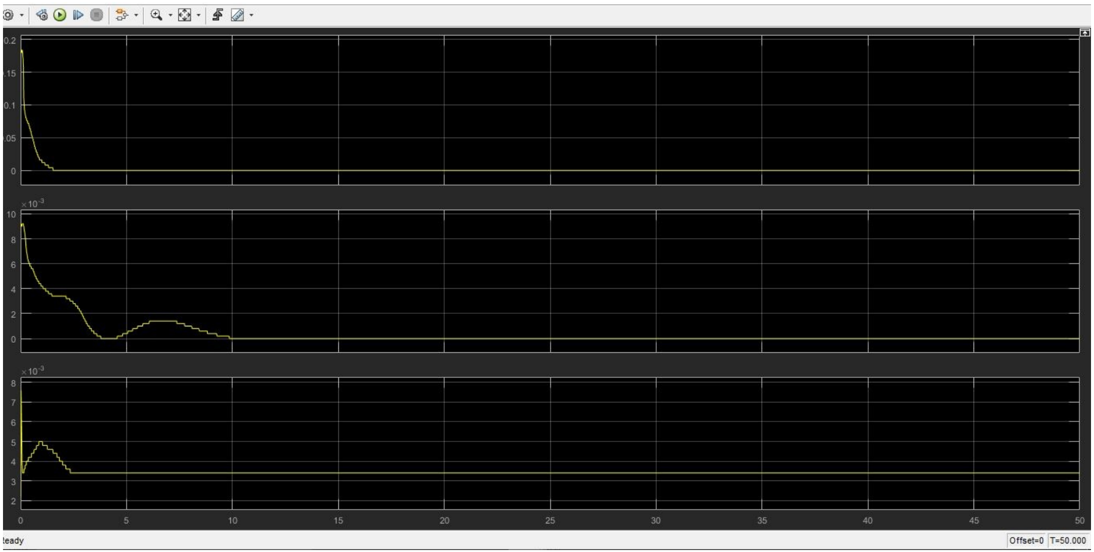

Figure 6.9: Output Waveform

Chapter 7

Conclusion

This research compares Two kinds of controller to find the most effective controller that should be applied in heat exchanger system and the simulation conducted in Simulink MATLAB software. The main reason for the project is to get the minimum error from the required controller which is used in heat exchanger temperature control system. This project includes on the temperature control of shell-tube heat exchanger system.To control the temperature,we are using simple predictive controller, it basically reduces the complexities and we can also filter inputs signals by the rolling optimization sequence of the controller.So the temperature control of heat exchanger we can get good control results and can able to meet requirements.By doing simulation, the approach has been shown to be very effective for first order plus dead time processes.if we Compare PID controller to the Fuzzy PID,so we can show through the result that Fuzzy-PID is more suitable for the process control variation. Both of the controllers have shown magnificent results. The Simulation results show that the system is stable work,reliable and it can more meet the requirements of high control precision of the system.

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