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Proportional Integral Derivative Controller on Boilers Temperature and Flow Control Parameters

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Abstract

A proportional–integral–derivative controller (PID controller or three term controller) is a control loop feedback mechanism used in industrial control systems and a variety of other applications requiring continuously modulated control. In practical terms it automatically applies accurate and responsive correction to a control function. Boiler control is the critical process, where a small wrong action may lead to a big explosion. So, implementation of PID Controls makes it efficient. Here in this paper the results of controlling "Temperature and Flow" Parameter will be controlled using software PID in PLC have been discussed and the results have been drawn.The paper aims at controlling temperature of boiler using PID Controller and building a prototype. The proposed idea looks to integrate both of them and implement the same into Boiler Industries.

Keywords—*PLC, PID, Temperature, Flow, Sensors, Heating Coil*

1. Introduction

Boiler systems have numerous parameters that vary with respect to time and this may act as one of the main causes of reduction in boiler efficiency. The temperatures and the pressures that arise in a boiler system are very high which may affect the safety of the work environment if the system is not maintained properly. Boiler systems are prone to errors which has a major effect in the working of the boiler. Maintenance of the boiler systems is expensive and requires human intervention which increases the Human risk that is involved. The number of parameters and processes in a Boiler system in order for it to function properly is high, which increases the human effort. Plants require continuous monitoring and inspection at regular intervals. There are several ways to measure the errors and various stages involved with human workers and also the lack of few features of microcontrollers [1].

A steam turbine is a device that extracts thermal energy from pressurized steam and uses it to do mechanical work on a shaft which is rotating. The rotary motion generated by the turbine is particularly suited to be used to drive an electrical generator. The governor control of a turbine is essential as turbines need to be run up slowly to prevent damage and some applications require precise speed control. The SCADA is used to monitor the system, PLC (Programmable Logic Controller) is also used for the internal storage of instruction for the implementing function such as arithmetic, counting, timing, sequencing and logic to control through digital or analogue input/output modules various types of machines processes.

The boiler parameters such as temperature, pressure and level can be automatically controlled using PLC. This reduces manual workload and human errors. The automation technique involving the automatic control of all the processes which includes the monitoring and inspection needs provides for a very efficient system.

2. Literature Review

In one of their papers, Subhransu Padhee and Yaduvir Singh give an overview of data acquisition, data logging and supervisory control system of a plant consisting of multiple boilers. Data acquisition, data logging and supervisory control are the basic building blocks of plant automation. This paper takes a case study of plant consisting of multiple boilers where multiple process variables of the boilers need to be acquired from the field and monitored. The data of the process variables needs to be logged in a database for further analysis and supervisory control. [1]

Mihai Iacob, Gheorghe-Daniel Andreescu, and Nicolae Muntean presented us with an open loop dispatcher training simulator for boiler-turbine implemented in LabView for COLTERM heating power plant of Timisoara, Romania. The system employs real-time capability, graphical user interface (GUI), uninterrupted operator interaction, having as background a low order boiler-turbine model for dynamic simulation. The operator manually controls the fuel charge on each of the three boilers, the turbine valve position and the steam to consumers, to anticipate parameter evolution on each boiler and the electric power generated by turbine. [2] PID tuning methods: - Ziegler Nichols method, Tyreus Luyben method, Internal Model Control (IMC) and Fuzzy logic controller.

3. Experimental Setup

The temperatures and the pressures that arise in a boiler system are very high which may affect the safety of the work environment if the system is not maintained properly. Boiler systems are prone to errors which has a major effect in the working of the boiler. Maintenance of the boiler systems is expensive and requires human intervention which increases the Human risk that is involved. The number of parameters and processes in a Boiler system in order for it to function properly is high, which increases the human effort.

3.1 Prototype Details

Table I - Prototype Specifications details of the 5% prototype created

ITEM	SPECIFICATION	QTY	DIMENSIONS/DETAIL
Boiler	PVC Pipe	1	Diameter = 0.1524 mts Length = 0.7112 mts
Level Sensors	Reed Type Proportional Relay Sensors	3	
Temperature Sensor	DH11	2	Heat and Humidity Measurements
Pump	230V Immersible Pump	1	
Outlet Valve	Proportional Valve	1	Pneumatic Actuator Valve
Heating Coil	Tungsten Coil	2	Stainless Steel Tungsten Spring
PLC	14 I/O	1	
Indicator Board	Foam Board	1	
Indicators	LED Bulbs	8	Level, Coil ON and OFF purposes only
Stand for Boiler and Misc.	Steel and Foam Board As per need	1	As per requirements

3.2 Setup

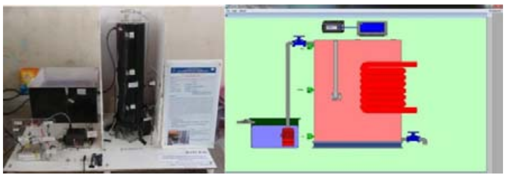

Fig. 1 Setup and Programmed Structure.

4. Testing

The designed prototype (Fig. 1)built was experimented based on various parameters and trials to obtain necessary results from the same. The following sections of the paper encompasses the various tests conducted on the Prototype.

4.1 Temperature Errors in Real Time v/s Simulation

Upon building of the 5% Prototype model, the model was calibrated and checked for errors in real time and simulation. According to the required values of temperature, the values were checked upon in real time. The temperature of water is measured using a Digital Thermometer. A total of 3 trials were taken and considered for error calculation as shown in Fig. 2.

Observations made with the above experiment are

1. With increase in temperature, the error value decreases. This is due to the reason that water in the boiler starts to stabilise with time and as temperature increases, it takes lesser time to attain even temperature.
2. Since it is a 5% Prototype error values are considerably high, in real time application, error values will be lesser and constant values of temperature can be obtained.

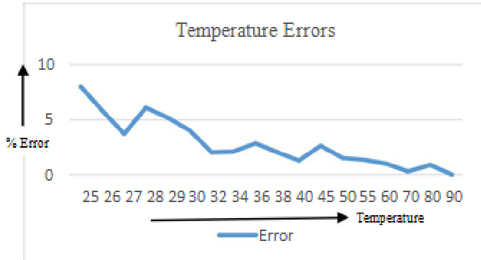

Fig. 2 Graph of the Temperature Error Plot

4.2 Time Difference to reach a certain temperature in real time v/s simulation from 25^{0}C

Time Lag, a period of time between one event and another, is a very important parameter when it comes to Industrial Applications of the Project. To calculate the time lag between temperature reaching in real time and that in simulation, a stop watch was kept at each temperature. Values of the experiment are plotted in Fig 3.

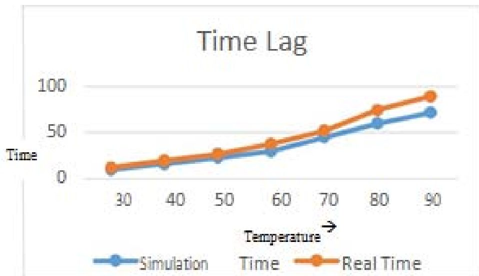

Fig. 3 Time Lag Plot

4.3 Volume V/s Time Plot

To better understand concept of integration of software into the system, it is necessary to understand the automatic filling time of the prescribed volume of water into the prototype boiler. Fig 4 shows the measured volume of water input into the tank at specific time periods of the working system. Time period taken is in minutes.

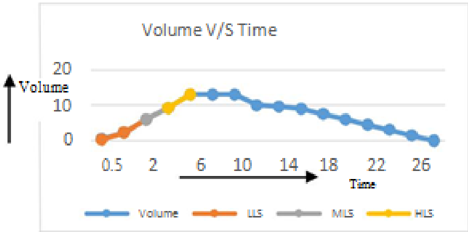

Fig. 4 Volume V/S Time Plot

5. Results And Discussions

According to the testing and experimentation done using temperature and pressure gauges on our proposed model, the concept of PID Controller on Boilers using LabView and SCADA by OPC Integration can comprehensively act to cut down the extensive problems of human dangers, mishandling of equipment's in many industries.

5.1 Comparisons

- **For Industrial Boiler**

The Input Parameters are - Temperature of feed water, Tw1 = 25^0C Temperature of dry saturated steam, T1 = 100oC Enthalpy of feed water at Tw1, hw1 = 104.8 kJ/kg

Enthalpy of steam at T1, h1 = hf1 + hfg1 = 419.1 + 2256.9 = 2676 kJ/kg

Mass flow rate of steam, m1 = 163 kg/hr
Equivalent Evaporation of Industrial Boiler is, (E.E) s = 163(2676 – 104.8)/2257 = 185.69 kg/hr

- For 5% Prototype Boiler

The Input Parameters are - Temperature of feed water, Tw2 = 25oC Temperature of dry saturated steam, T2 = 50oC | Enthalpy of feed water at Tw2, hw2 = 104.8 kJ/kg

Enthalpy of steam at T2, h2 = hf2 + hfg2 = 209.3 + 2382.9 = 2592.2 kJ/kg

Mass flow rate of steam, m2 = 52.8 kg/hr

Equivalent Evaporation of Design Prototype Boiler is, (E.E) p = 52.8(2592.2 – 104.8)/2257 = 57.30 kg/hr.

TABLE II – Comparison of Boilers

BOILER	INDUSTRIAL STANDARD	5% PROTOTYPE
E. E	185.69 kg/hr	57.30 kg/hr

5.2 Discussions

- Time Lag is lesser by 15% compared to the Current Industrial Standards.
- Error value upon integration of two software's decreases by 2.6%.
- Hardware handling and data analytics is easier, and efficiency of the boiler increases by 1.5 -2% for an Electric Boiler.
- Feedback is faster and better compared to present IIOT. SELF TUNED PID using PLC.
- Upon usage of OPC, independent platform for usage and working was obtained.
- Data Analytics and handling of the process were obtained by the use of SCADA.

5.3 Advantages

1. Skilled Labour not required.
2. Open and Independent Platform database and easily accessible to everyone within the company.
3. PID control algorithms with PLC controllers with 2 I/P and O/P enable control of many control loops and processes.
4. Cost Effective and easier to implement.
5. Designed system will have low robustness due to the PID gains which result in non resistance to uncertainties and disturbances .The designed PID gains may not resist the uncertainties and disturbances and thus present low robustness.

5.4 Disadvantages

1. Temperature Sensor sensitiveness
2. OPC slows down the system at times, leading to need for maintenance check-ups by Technical Team
3. Data Analytics can lead to need for sudden changes, hence cost efficiency is lesser but innovation and growth is high. VI.

6. Conclusion

One of the advantages of PLC is that it can be integrated into an open platform by using the software known as Object Linking and Embedding for Process Control (OPC). This allows for transparency throughout the levels of management in an industry. This open platform allows the data to be accessed over other software's such as SCADA, LabView, SQL, Java etc. This helps in data analytics as well as predicting failure of components or process. [1, 3]

This prediction helps the control engineers before it occurs. We successfully integrated LabView and SCADA into KepServerEX and obtained 15% better efficiency in the heating capacity as compared to current Industrial Standards. The Control of Temperature was done using LabView and flow is controlled using SCADA. Main focus of the project is on making it able to be remotely controlled is achieved by creating a unique login on SCADA software that can be accessed by anybody and anywhere in the Management of the industry.

As per the tests conducted the project was able to achieve steady state output at High Temperatures that an Industrial Boiler works on.

7. Acknowledgment

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