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Automatic Airflow Loop Control in Industrial Gas Burner using LabVIEW

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ABSTRACT: This paper focuses on automatic air flow loop control in industrial gas burner using a PI controller scheme. Combustion in industrial gas burners is achieved using a non explosive mixture of Liquefied Petroleum Gas (LPG) and air. The LPG is injected to the industrial gas burner with constant pressure from the storage cylinder and the flow rate is controlled using the regulator attached to it. Whereas the air required for combustion is absorbed from the unregulated atmospheric stream. The variation in the ratio of LPG to the air leads to disturbance in combustion and low calorific output in gas burners. To avoid such situation, it is necessary to control air flow with fixed pressure of L.P.G. This is attained using a feedback control loop preferably with a PI control scheme is designed in LabVIEW software environment. CO_2/CO ppm measurement is done using gas sensor. Error analysis is done for the PI controller regarding IAE, ISE. Transient analysis is also carried out on the PI control strategy and rise time, peak time is evaluated.

KEYWORDS: Automation of industrial gas burner, PI controller strategy, Combustion controls, emissions, IAE, ISE, Rise Time, Peak Time.

I.INTRODUCTION

Generally in industries which requires the heating, melting, forging etc., will make use of the gas burners for its various applications and safety. The gas burner is a process of converting chemical energy in the fuel to thermal energy. The energy conversion is carried out by burning fuel with the aid of an oxidizer i.e., basically oxygen. During the conversion various bicarbonates which are CO_2, NO_x and CO are released due to lack of inefficient burning. Proportionate of fuel and oxygen is the main reason behind the amount of bicarbonates released. Since the industrial gas burner is a closed process the oxygen is externally supplied to it hence maintaining the proper proportionate is major issue in industries. Even though the CO_2 is natural outcome of any fuel combustion the other gases NO_x and CO released along with it causes the negative impact on the environment. The proper combustion will reduce the poisonous emission. If these gases are continuously emitted out causes the global increase in temperature and loss of ozone layer. (The environmental impact of vehicle emissions, as per the land transport rule 2007). The other impacts like pollution of water due to accumulation of the fine particles present in the emission. These emitted gases disturb the natural aquatic families. By regulating the proportionate of fuel and air can increase the efficiency of thermal energy output. Various researches are carried out in this area using the various available technologies. So in case study proper combustion of fuel is experimented by regulating airflow to increase the thermal efficiency and reduction in the unwanted emission. The optimum operating condition for increasing efficiency and the minimum contaminated emission is determined.

The various researches are carried out for identifying the exact mathematical model of the industrial gas burner-air pressure. The identified model is simulated for increasing combustion efficiency by applying different controlling methods. The same mathematical model is considered for case study to implement hardware model. Since the linear systems are well established the identified nonlinear mathematical model is linearzied for further applying of different controlling methods. The efficiency of burner is dependent on the percentage of airflow to fuel hence the airflow is controlled by applying PID controller. P, PI, PID controller are applied to compare the efficiency of the controller. Simulated results are compared [2]. The process plant consists of industrial gas burner, air blower, and actuator. 3 phase 415 volt motor actuates the given process system which helps in generating a constant air pressure to the burner.

The experiment is conducted to measure the associated level of emissions for burner. Test conducted on the burner shows emissions were obtained depending on the rate of gas valve opening without monitoring the air flow. The level of emissions released also depended on the amount of fuel used and the condition of combustion of the fuel. The emissions released are low and within permissible standards, mainly for the ½ gas valve opening operation which is identified as the optimum operating condition for the burner [3]. Flames formed by combustion of gaseous fuels with the air it will take two forms: premixed flames and diffusion flames. Premixed flames occur when fuel and the oxidizer are mixed upstream of the delivery to the combustion zone. Diffusion flames occur when the fuel and oxidizer are separately delivered to the combustion zone. Premixed flames are cleaner and burn more intensely, but the operating range is narrower than diffusion flame [5], therefore diffusion flame is implemented.

III. HARDWARE SETUP

For constant air supply system brushless dc air blower is used, driven from 12 v .4 amps dc supply. The air from the blower is taken through the pipe for a flow meter. From the flow meter air is concentrated in a volume of box. Constant air flow is supplied to the combustion chamber because it is driven at constant speed from PWM mode.

The air supply hose from the air blower and the gas supply hose from the gas cylinder were connected to the burner. Burner
mounted on a support with nozzle projecting into the combustion chamber. Chimney outlet is connected to the air quality gas sensor in combustion chamber .Gas is valve is set to full opening while air blower is running with PWM mode with constant input the burner was ignited and emission readings were taken and when the flame has become bluish. Implemented hardware are setup as shown in Fig1.

Flow sensor (YF-S201): This sensor is solidly constructed and provides a digital pulse each time an amount of water passes pipe. But in this case it is used for measuring the air flow. By measuring the each pulse air flow output is calculated in L/Min. It is easily connected to a microcontroller for monitoring air usage .PWM digital output pulse is converted into the L/min using the formula: pulse frequency (HZ)/7.5=Flow rate in L/min.

MQ-135 gas sensor: MQ-135 sensor made of SnO_2 layer as gas-sensing material its conductivity is lower in clean air. The conductivity of the gas sensor increases along with the rise in concentration of the gas pollutants. After combustion of LPG emission contains CO_2, CO, Nox, and also HC (hydro carbons).This sensor measures all these emissions in PPM.

Software: LabVIEW PID toolkit, makerhub Linx, PWM VI, arduino IDE.

Arduino Uno: ATmega328, it has 6 pwm output pins, 6 analog inputs, operating at 5v, 7-12 input voltage

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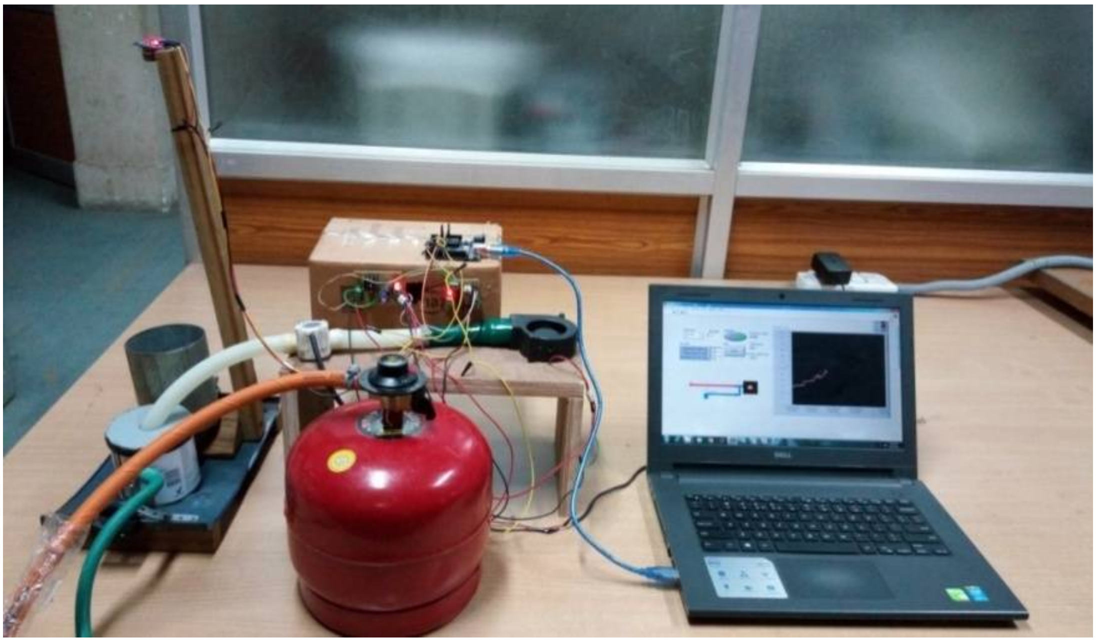

Fig.1 Hardware setup

IV.BLOCK DIAGRAM

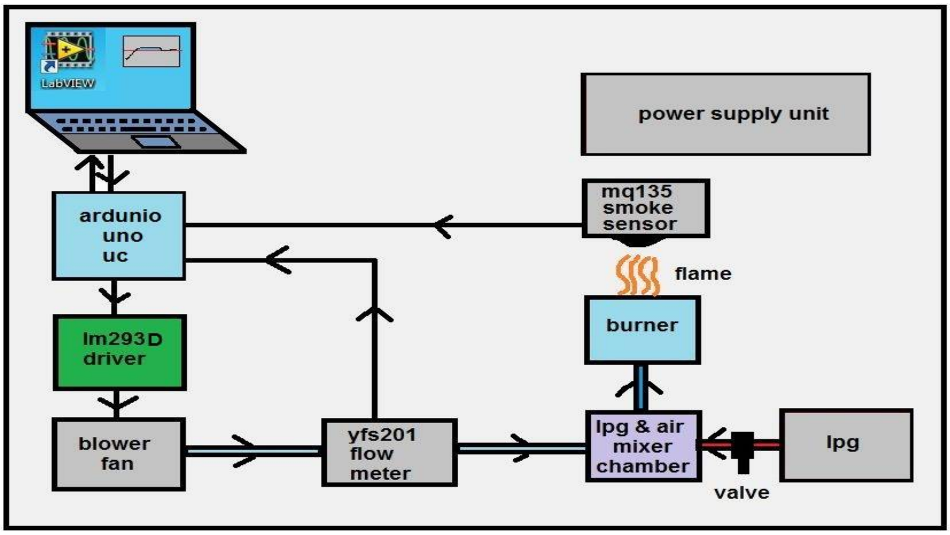

Fig .2 Process block diagram

The hardware and software setup are shown in Process block diagram Fig 2.It consists of industrial gas burner, air blower, smoke sensor , flow sensor, LPG as fuel, aurdino uno, driver cricuit. 12 and 5V power supply. LabVIEW is used for interfacing and controlling of process system. The industrial gas burner intakes both fuel and air ,then external combustion of the fuel takesplace. The air from the blower is controlled by flowmeter using PWM technique interfacing it with LabVIEW. Aurdino uno interfaces the LabVIEW with the hardware setup. The combination of CO_2, NO_x and CO present in the burner output is measured in PPM using MQ 135 smoke sensor. Flow sensor measures the airflow rate and applied as a feedback to control airflow in burner. Data acquisition from computer and process is accomplished through arduino uno .

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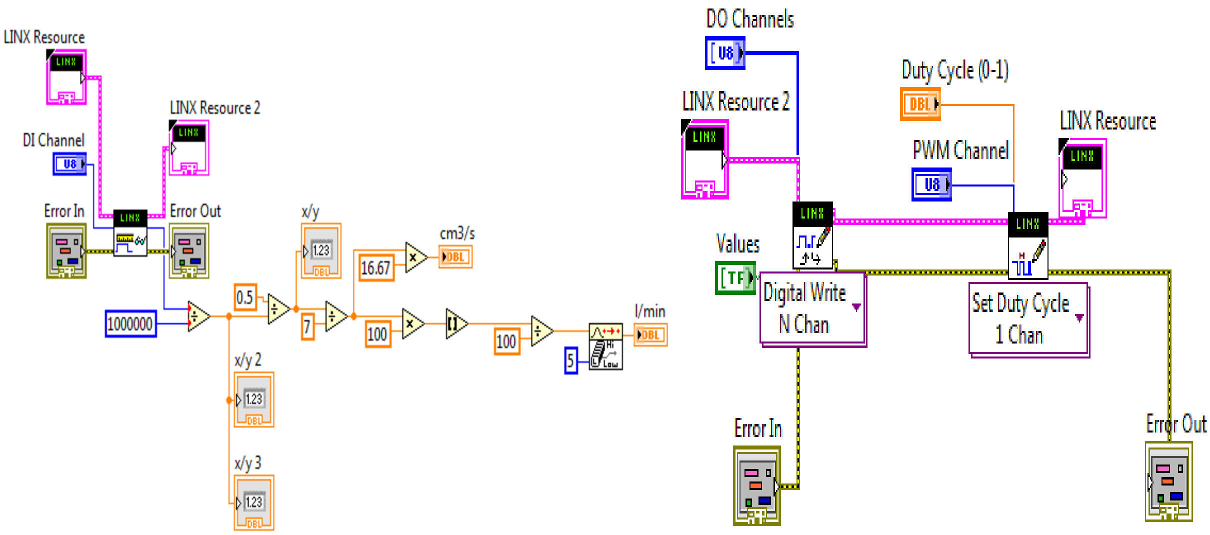
IV.IMPLEMENTATION

The following subVIs are used for PI, PID control scheme shown in fig .3
Flow sensor VI: This subVI takes the input from flow sensor and measures the air flow rate in terms of L/min
PWM VI: This sub VI gives the duty cycle of PWM and analog output on pin number 3 of arduino uno.



(a) (b)

Fig.3 (a) flow sensor VI (b) PWM VI

Designing of PI control scheme in LabVIEW

In PI controller there are two tuning parameters to adjust integral action eliminates offset. Introducing derivative gain produce a oscillation compared to PI controller.

In LabVIEW same PID toolkit is used for PI controller only derivative constant is removed .Tuning parameters are determined by trial and error with Z-N method.

PI controller tuned for following parameters gain K_P =1.5, Ti=0.08 and it is reached the desired system response.

PID is tuned for the following parameters gain $K_{P=}$1, Ti=0.05,T_d=0.009

Control scheme block diagram as shown in fig. 4

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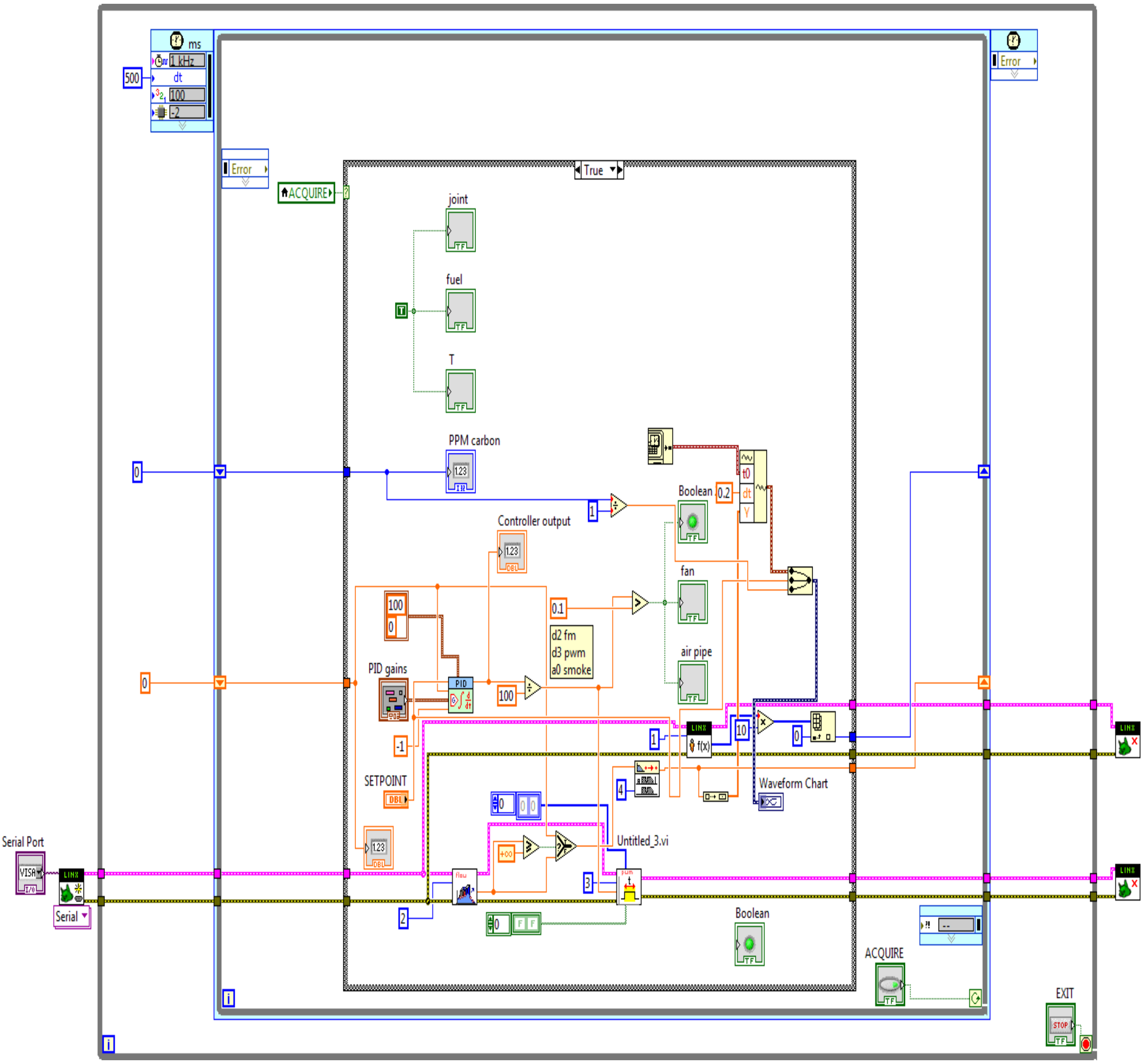

Fig. 4 PI control scheme block diagram

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V.EXPERIMENTAL RESULTS AND COMPARISON

Set point tracking is done for PI and PID controllers and corresponding IAE, ISE is calculated for both controllers

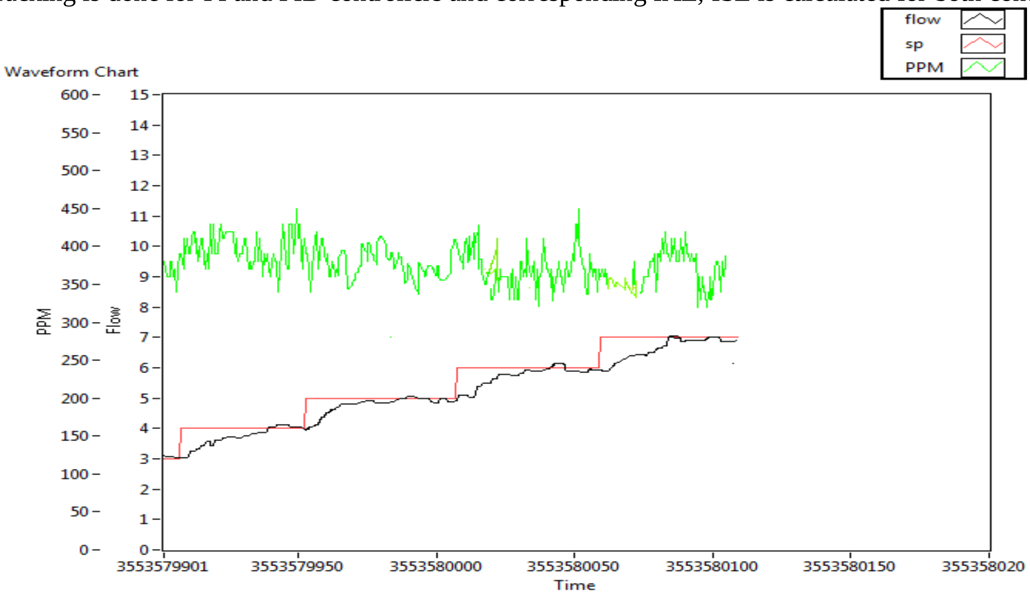

Fig .5(a)

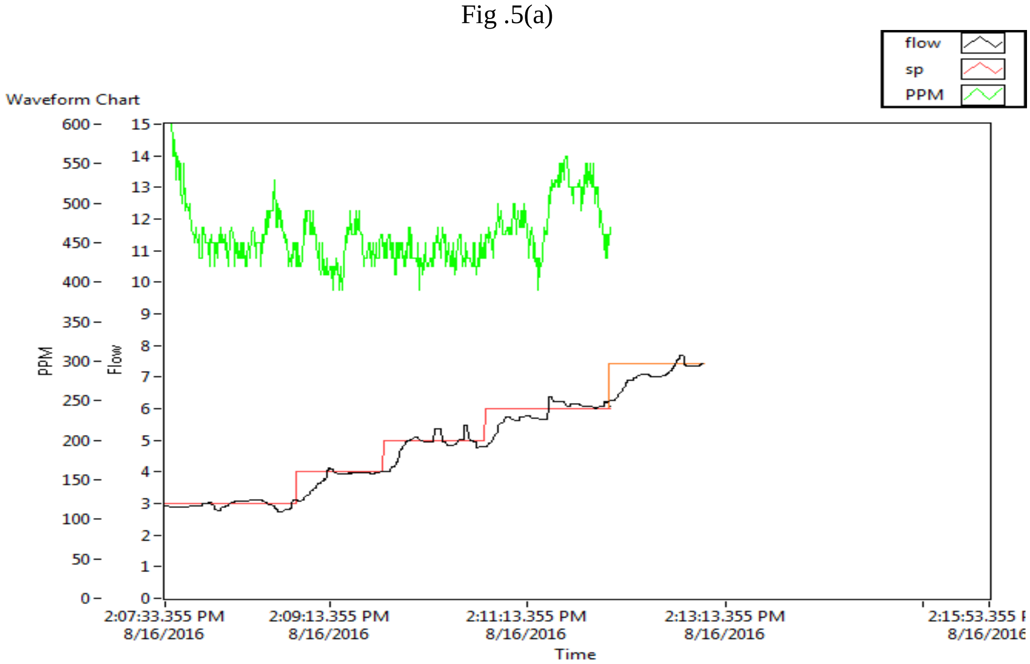

Fig.5 (b)

Fig Set point tracking of (a) PI controller (b) PID controller

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A change in step input is done for PI and PID controllers. The following results are tabulated for set point changes from 4-5cms, 5-6cms and 6-7cms.

		PI	PID
IAE	4-5 cm	19.05	28
	5-6 cm	11.92	21.2
	6-7 cm	21.71	31.4
ISE	4-5 cm	10.61	12.2
	5-6 cm	4.36	10.36
	6-7 cm	14.1	17.5

Table.1 IAE and ISE for PI and PID controller

The IAE, ISE is calculated for both PI and PID controller. Maximum IAE for PID is found to be 31.4 and for PI is 21.71.Similarly ISE for PID is 17.5 maximum in comparison to 14.1 PI controller.

Parameters	PI	PID
Rise time(in sec)	20.5	25.5
Peak time(in sec)	38.5	56
Percentage of peak overshoot(in sec)	2	5

Table2. Transient response of PI and PID control strategy

Transient response results helps in identifying the better controller. The obtained transient response results for different controller techniques are tabulated in Table 2. Rise time of the PI controller is less compared to PID also the peak time and percentage of overshoot also has considerable good performance in PI control scheme. Hence PI controller gives better transient response to the system.

VI. CONCLUSION

Transient response infers that PI controller faster than PID, error analysis indicates that PID has maximum IAE and ISE in comparison to the PI controller. Therefore PI controller is suitable than PID for fast process and in removing the large errors. Associated Emissions level released for burner after combustion of fuel is in optimum range (350-450 PPM) for PI controller and for PID it is varying in wide range (550 -300 PPM) even with the controlled air flow. It is found that PPM of emission level is reduced(350-450 PPM) against standard emission level (1000 PPM).From the above analysis it indicates controlled air using PI control scheme reduces emissions released into the environment.

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