

Improvement Program for Heat Balance Analysis Fuel to Steam Efficiency Boiler and Wireless Transducer Controlled

Nattapong Phanthuna , Thaweesak Trongtirakul

Abstract— This research is mainly purposed two objects, firstly, to improves and applies the sensors that were installed before with the PIC18F458 microcontroller at 2.4 GHz of frequency. Lastly, to increase the efficiency of combustion system processes in the industrial groups by heat balance analysis with wireless transferring. As a result of, both objectives can be advantages such increase the efficiency of steam generating, reduce the costs, and friendly environment. The results that the efficiency has been raised by 15 – 25% and can transfer into MESH network successfully.

Keywords— Wireless Data Transferring, Cogeneration energy, Boiler, Heat Balance

I. INTRODUCTION

During its economic and social development, Thailand has changed a lot in the section of technology, environment, as well as social and economic aspects. It has been promoted to be one of the important industrial hubs of South East Asia. Consequently, many more industrial groups have been built all over the country. This phenomenon should be observed carefully and followed up in order to avoid the problems of pollution and over energy consumption.

Industrial factories with large boilers consume a lot of furnace oil and gas. Both fuels have been increasing. At present, many factories are likely to find ways to economize energy, especially by using engineering techniques to decrease production costs and environmental effects.

Factories interest to increase the efficiency of boiler that its system was consisted the burner and heat exchanger, each element will be ordered in series. However, flue gas heating will be absorbed to steam generating process.

II. ORDINARY SYSTEM

A study co-generation system by using sensors and programmable logic controllers (PLCs) which were used to transmit 4-20 mA signals via process field bus (PROFIBUS) between electrical instrumentation and PLCs or Distributed Control System (DCS). Consequently, long-time processes are a load in the energy producing such as steam pressure and temperature, Forced Draft Fan and combustion system in the chamber, Induced Draft Fan and Differential Pressure in a chamber, etc. The ordinary systems had to be immediately unsupported due to various factors that must sometime control by operators.

This paper is recognized the processes development and improvement, new technologies can reduce human errors; an one of the causes might be an unstable of humans, by using a computer programme to recover energy before deflation throughout the atmosphere. Subsequently, programme development by Fluid Dynamic formulation and has received parameters from sensors and transducers that have been set up in a power plant via wireless network.[2]

All processes were started from Reverse Osmosis (R.O.) water that was treated and reduced substances until purely and will be de-oxygenized by De-aerator, usually it brought to corrosion. Among R.O. water, condensate return and saturated steam were feed in de-aerator before be warmed by economizer, it is a preheating sector which can exchange heat by flue gas. Especially, the warmed water that was

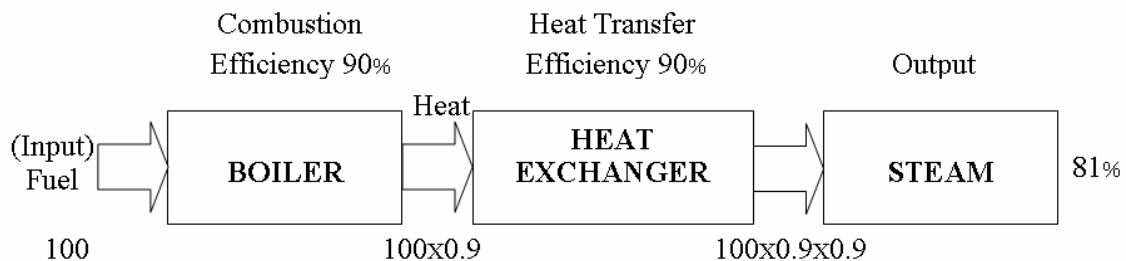


Fig 1. Fuel to steam generating

preheated by economizer will be flow throughout boiler, water will be boiled until as saturated steam and be collected that be called a steam collector. Inside boiler was consisted into two sections, radiation and convection part, radiation part was a combustion chamber, which is started points of flue gas systems. Before electricity generating was begun with 1,500 revolutions per minute at 50 Hz of frequency, saturated steam must be always changed the phase of energy until became to Superheat, the two super-heaters were installed after convection part.[3]

The Lived steam had been passed through on high-pressure turbine and throughout on low pressure, condenser had condensed weak steam, internal pressure of condenser was a vacuum always. Likewise, flue gas and ash system flowed out and were reduced temperature and particle by wet scrubber at less than 70^o C.

Whereby the principle losses that occur in a boiler are loss of heat due to: [4]

1. Dry flue gas
2. Evaporation of water formed due to H₂ in fuel
3. Evaporation of moisture in fuel
4. Moisture present in combustion air
5. Unburned fuel in fly ash
6. Unburned fuel in bottom ash
7. Radiation and other unaccounted losses

Losses due to moisture in fuel and due to combustion of hydrogen are dependent on the fuel and cannot be controlled by design.

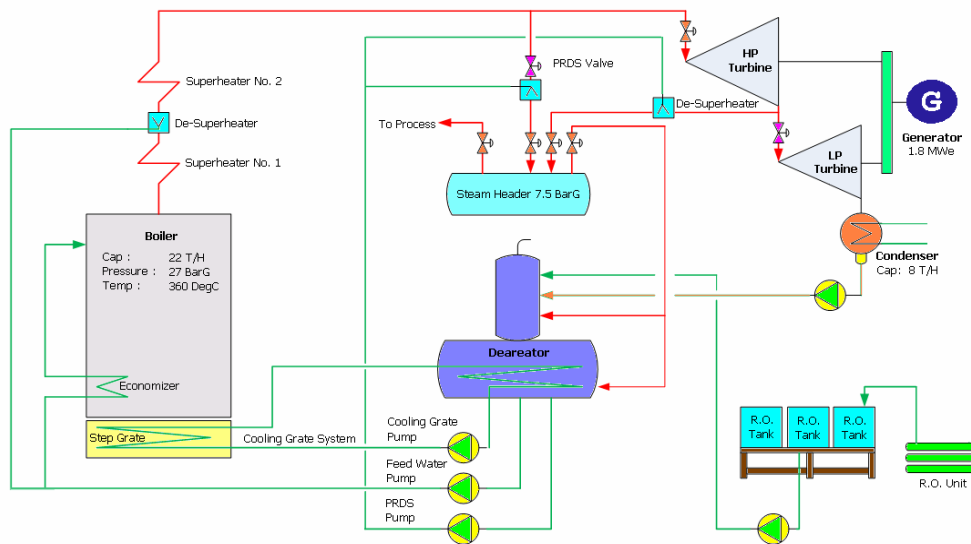


Fig 2. Steam generating

III. METHODOLOGY

The reference standards for Boiler Testing at Site using the indirect method are the British Standard, BS 845:1987 and the USA Standard ASME PTC-4-1 Power Test Code Steam Generating Units.

The indirect method is also called the heat loss method. The efficiency can be calculated by subtracting the heat loss fractions from 100 as

follows:

$$\% \eta = 100 - \sum_{i=1}^n \text{losses}_i \quad (1)$$

The data required for calculation of boiler efficiency using the indirect method are:

- Ultimate analysis of fuel (H₂, O₂, S, C, moisture content, ash content)
- Percentage of oxygen or CO₂ in the flue gas
- Flue gas temperature in degree ^oC (T_f)
- Ambient temperature in ^oC (T_a) and humidity of air in kg/kg of dry air
- GCV of fuel in kcal/kg
- Percentage combustible in ash (in case of solid fuels)
- GCV of ash in kcal/kg (in case of solid fuels)

A detailed procedure for calculating boiler efficiency using the indirect method is given below. However, practicing energy managers in industry usually prefer simpler calculation procedures.[5]

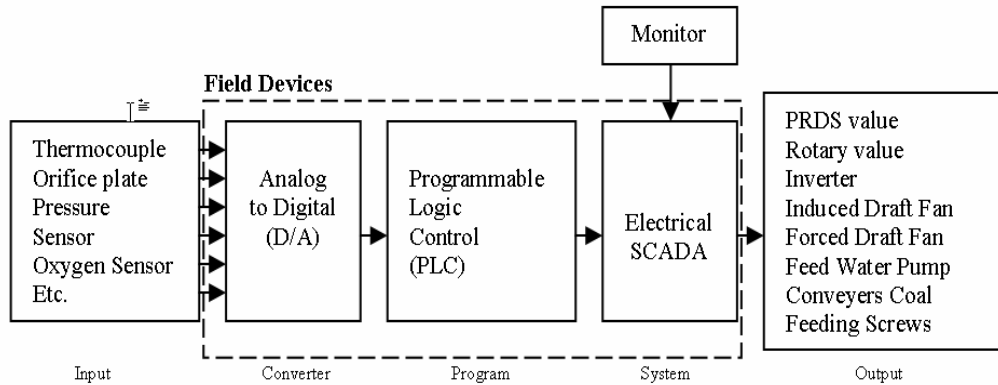


Fig 3. Ordinary controller system

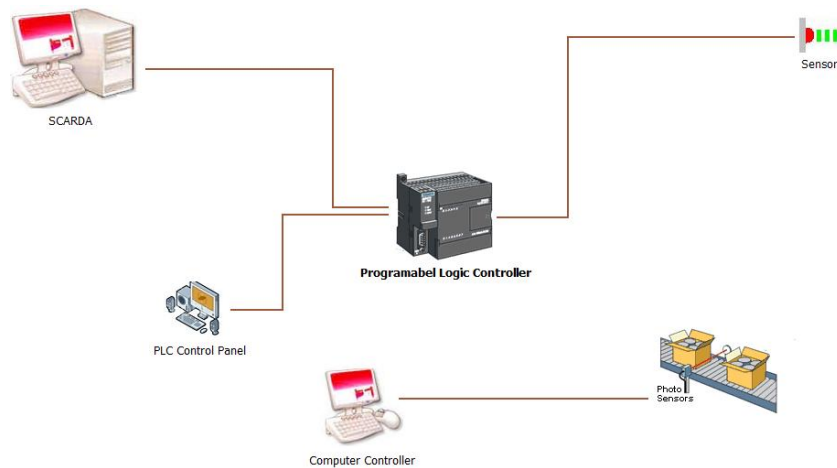


Fig 4. The System before improve

Step 1: Calculate the theoretical air requirement

$$(11.43 \times \text{carbon}) + \left(\frac{34.5 \times (\text{hydrogen} - \text{oxygen})}{8} \right) + \left(\frac{4.32 \times \text{Sulfur}}{100} \right) \quad (2)$$

Step 2: Calculate the percent excess air supplied

$$\frac{\text{oxygen} \times 100}{21 - \text{oxygen}} \quad (3)$$

Step 3: Calculate actual mass of air supplied/kg of fuel

$$\left(\frac{1 + \text{excess air}}{100} \right) \times \text{theoretical air} \quad (4)$$

Step 4: Estimate all heat losses

4.1 Percentage heat loss due to dry flue gas

$$\frac{m C_p (T_f - T_a) \times 100}{GCV_{fuel}} \quad (5)$$

Where, m : mass of dry flue gas in kg/kg of fuel

$$\frac{9 \times \text{hydrogen} (584 + C_p (T_f - T_a)) \times 100}{GCV_{fuel}} \quad (6)$$

Where, C_p : specific heat of superheated steam (0.45 kcal/kg)

4.3 Percentage heat loss due to evaporation of moisture present in fuel

$$\frac{\text{moisture} (584 + C_p (T_f - T_a)) \times 100}{GCV_{fuel}} \quad (7)$$

4.4 Percentage heat loss due to moisture present in air

$$\frac{A_m H_f (C_p (T_f - T_a)) \times 100}{GCV_{fuel}} \quad (8)$$

Where, A_m = actual mass of air supply
 H_f = humidity factor
 C_p = Specific heat of superheated steam (0.45 kcal/kg)

$$\frac{m_{ash} \times GCV_{bottom_ash} \times 100}{GCV_{fuel}} \quad (10)$$

4.7 Percentage heat loss due to radiation and other unaccounted loss

$$E_p = \frac{H_s}{H_A} \quad (11)$$

Definition E_p = Evaporate Ratio
 H_s = Heat utilized for steam generation
 H_A = Heat addition to the steam

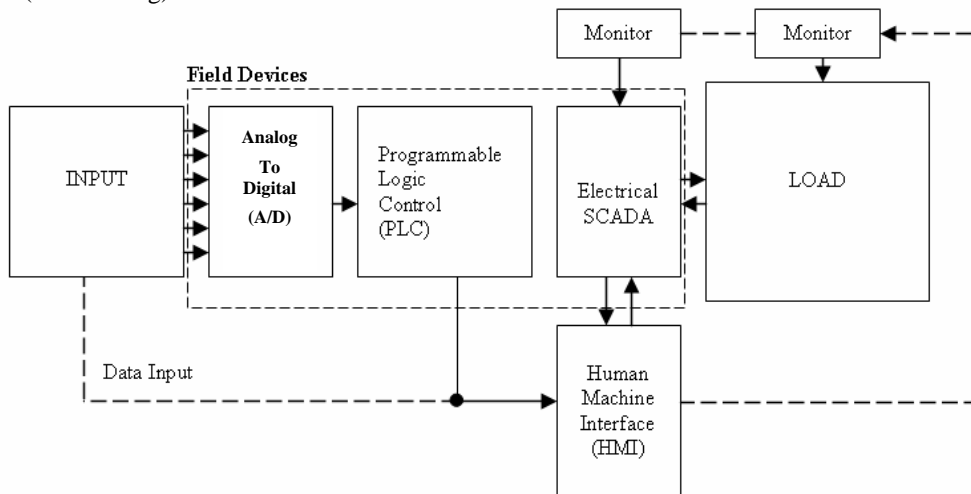


Figure 5. Adaptive controller system

4.5 Percentage heat loss due to unburned fuel in fly ash

$$\frac{m_{ash} \times GCV_{flyash} \times 100}{GCV_{fuel}} \quad (9)$$

Where, m_{ash} = total ash collected per kilogram of fuel burn

4.6 Percentage heat loss due to unburned fuel in bottom ash

IV. ADAPTIVE SYSTEM

Due to creating the software for efficiency analysis of boiler with real-time signal detecting by transducers. For example, thermocouple installed can be sent analogue signals and will be digitalized by the expansion cards. Signals were directly processed by the supervisory control and data acquisition

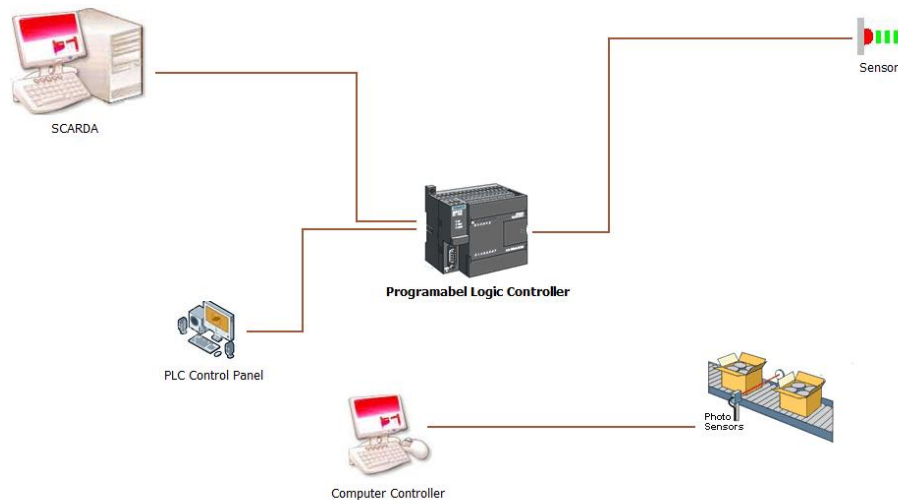


Figure 6. The System before improve

(SCADA). This project is consisted mainly of two sections as follows:

First sector; the field device is an electric device that connected with PLCs inputs.

Second sector; the human machine interface (HMI) is also called the man machine interface. (MMI) is a computer software that can controls and monitors processes as graphic, it is called graphic user interface (GUI).

Standard system shown in figure 3 and figure 4 are an open-loop control. Analogue signal inputs on first block have been received from sensors and transducers will be converted and amplified by second block and then amplified signals be sent to PLCs and be monitored by SCADA. [6]

An adaptive system is a closed-loop control as shown in figure 5 and figure 6 respectively. Processes stability automatically reaches a peak of maximum set points. Elementary, HMI will compare between set points and actual value every time in sampling a period that it is a direct factor when SCADA has also been working effectively as well as higher an open-loop control simultaneously.[7]

The significant variable inputs, programme must be required to efficiency analysis such a combustion chamber temperature, differential pressure, stream pressure, stream temperature and percentage of excess air. Pursuant to their variable, it will be effected to control valves, feeding screws, feed water pump, FD fan and ID fan.

V. PROCESSES

The semiautomatic is a control process as shown in figure 4. On the other hand, the equipments cannot intermediately response due to irreconcilable various factors. A steam regulation had been maintained; their processing will bring high efficiency for electricity generating and has a vantage of completed combustion. This paper is declared efficiency analysis that concerns mainly flue gas and combustion system for the steam and electricity generating. Parameters must be controlled smoothly by automatic efficiency analysis system.

All variables such a specific heating value, ambient temperature, oxygen percentage and carbon dioxide percentage, their parameters will be proceeded and compute to control each necessary item thereby, software can calculate each of valve percentage and real-time control to highest efficiency and not disturbed inside systems.

VI. WIRELESS MODULE DESIGNATION

A designation is a without difficulty utilizing, The XBee Pro has been preferred and installed on the micro controller board with XBee dongle for link to computer.

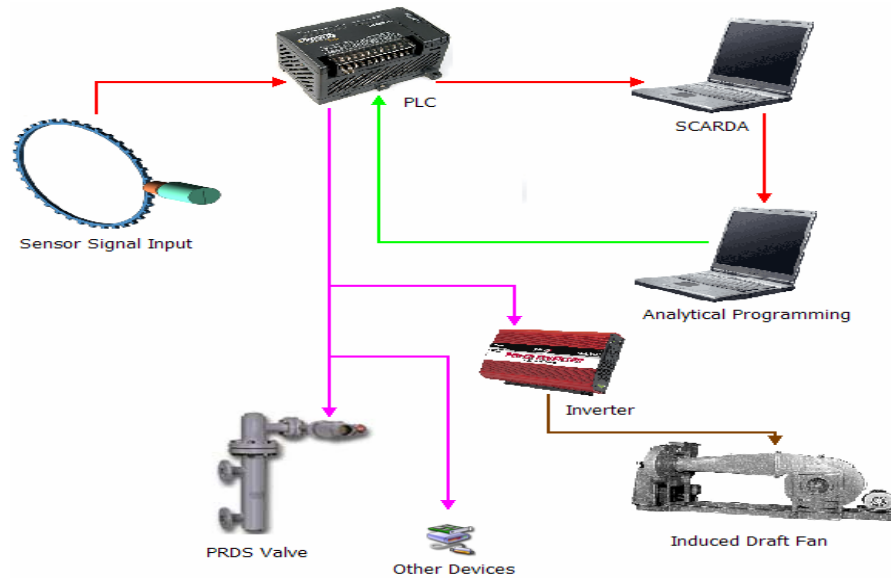


Fig 7. Component relation

A construction of the MCU ports will be commanded by instruction lists. IC number of IC74LS245 was buffering signals that categorized in to two ports, A0 – A5 port and C0 – C5 port. IC74HC595 is a shift register that convert series signals to parallel signals and communicate to computer. Receiver was made up of PIC18F458 that was 2.4 GHz of wireless module (IEEE 802.15 protocol).

The Wireless Mesh Network Improved seeks to develop a flexible platform for various experimental studies with wireless mesh network.

In current Internet, new generation of devices connecting to the network will be mostly through wireless such as notebooks, PDAs, phones, cameras and sensors. Wireless network has been a hot topic in these years. But there are still many networking issues. In terms of routing, we may need to know how to save bandwidth/energy, how to maximize capacity, how to make use of multicast nature of wLAN. In terms of traffic control, we may need better media access (MAC) and traffic control (TCP congestion control) to optimize bandwidth/energy or support QoS for multimedia.

In order to research various issues with wireless network, However, simulations often assume idealized physical layer. A wireless test-bed is a must for applied research in this area. A serious test-bed needs larger scale and serious instrumentation, and it should also be a tool for easy management, and data collection.

VII. PROGRAMME DESIGNATION

An algorithm was created to use visual communication port on a computer, all instructions were tested. As a result, an algorithm testing can confidently believe that its will not be a software bug and system failure.

The designed protocol for control and sent between each equipment and computer as follows:

\$TA=XXX,TB=XXX,TC=XXX,TD=XXX,H2=XX.XX,H
M=XX.XX,O=XX.XX,PA=XX.X,PB=XX.X,PC=XX.X@

Where ; T : temperature

P is meaning pressure

O is meaning oxygen

H is meaning hydrogen

Other restrictions are not concerns anything about sensors and transducers will be defined inside software such as specific heating value or fuel density.[8]

This software was created by computer language, had been already supported, and operates on a 64-bit operating system. The program will make visual communication ports and sent command series type only.

An interface can be categorized into 7 segments as following:

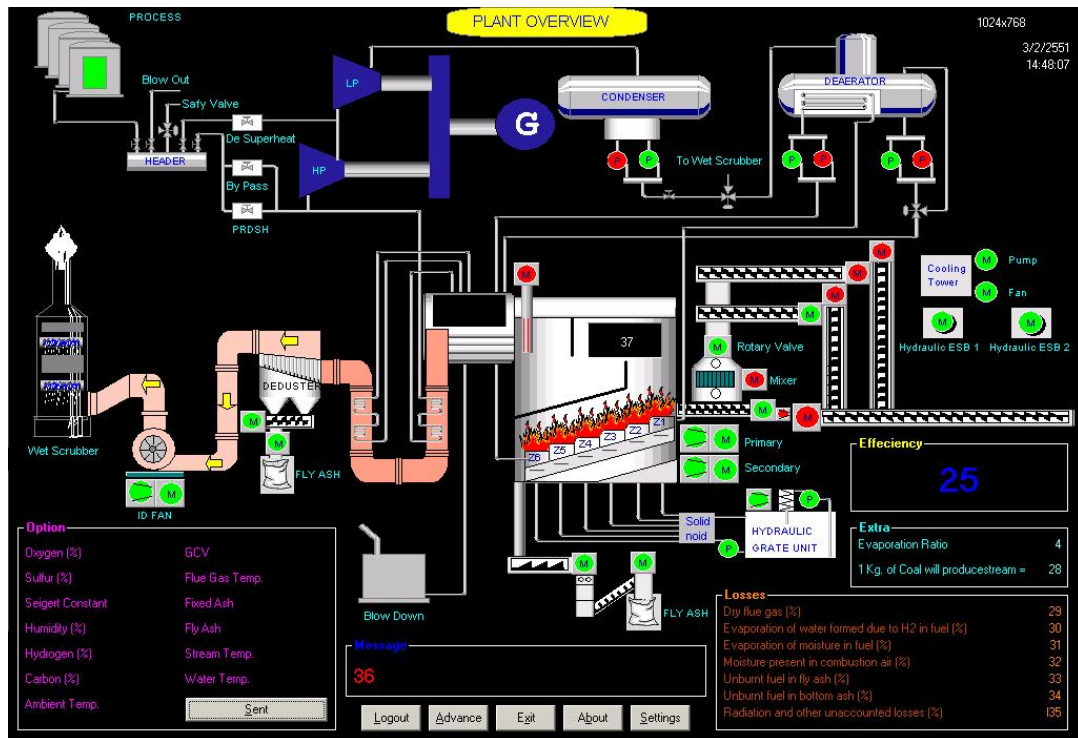


Fig 8. Graphic User Interface (GUI)

1. Graphic User Interface (GUI)

2. Fixed parameters, in this section, user can change any parameters that parameter will be analyzed in laboratory correctly whenever change the type of fuel.

3. Various factors, which will be detected in real-time conditions by wireless sensors and transducers.

4. Results, which will be computed and shown in this a part that can see also above equations.

5. Efficiency was indicated and relates between inputs (fuel) and output (steam).

6. Evaporated ratio relates a Heat utilized for steam generation and a Heat addition to the steam.

7. Message will display a problem, warning, and how to solve them whenever detectors explore some conditions that it might be at risk.

VIII. CONCLUSION

As the experimental results, the centralized management using will be maintained an efficiency of all over system by 80 – 85% instead of 65.85 – 71.98% before adaptive, decrease the air pollution and heat loss due to dry flue gas air by 15% and 5-12% respectively.

A complete mass and energy balance can be obtained for everyone stream, making it easier to identify options to improve boiler efficiency.

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