Development Program for Heat Balance Analysis Fuel to Steam Efficiency Boiler And Data Wireless Transfer

NATTAPONG PHANTHUNA* ,WARUNEE SRISONGKRAM**, SUNYA PASUK***,THAWEESAK TRONGTIRAKUL*
The Faculty of Electrical Engineering  
*Rajamangala University of Technology Phra Nakhon  RMUTP Bangkok  
** Rajamangala University of Technology RMUTSB Nonthaburi  
***Rajamangala University of Technology Srivijaya Srongkra  
THAILAND
Nattapong100@gmail.com,waruneesri@rmutsb.ac.th,psanya@hotmail.com,ton0605@truemail.com

Abstract: - This research aim to improve a combustion system of boiler within increase combustion efficiency and use all out of the energy. The large boilers were used in the industrial factories which consume a lot of energy for production. By oil and gas fuel will be increasing costs everyday cause many factories interested in energy saving with any method technical engineering, specifically for production costs and environment effect decreasing. This researching was installed and program was invented in the industrial factory. This industry factory consumed cogeneration energy for fabric dying. The efficiency before installing the software is measured about 65.85 – 71.98% which heat in exhaust gas about 20% of overall energy is filled in the system. After installing heat loss in the system has been fallen until remain about 5 – 12% and efficiency of heat in system has been reached a peak of 80 – 85 

Key-Words: - Heat Balance, Steam Efficiency, Boiler, Cogeneration energy, Wireless Data Transfer

1 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.[1]

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.

2 Ordinary Systems
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 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°C.

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:

\[ \%\eta = 100 - \sum_{i=1}^{n} losses_i \]  

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. 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 °C (Tf)
- Ambient temperature in °C (Ta) 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]

Step 1: Calculate the theoretical air requirement

\[ (11.43 \times \text{carbon}) + \left( \frac{34.5 \times \text{(hydrogen oxygen)}}{8} \right) + \left( \frac{4.32 \times \text{Sulfur}}{100} \right) \]  

Figure 1. Fuel to steam generating

3 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.
Step 2: Calculate the percent excess air supplied

\[
\text{oxygen} \times \frac{100}{21 - \text{oxygen}}
\]

(3)

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

\[
\left( \frac{1 + \text{excess air}}{100} \right) \times \text{theoretical air}
\]

(4)

Step 4: Estimate all heat losses

4.1 Percentage heat loss due to dry flue gas

\[
\frac{m C_p (T_f - T_a)}{GCV_{\text{fuel}}} \times 100
\]

(5)

Where, \( m \) : mass of dry flue gas in kg/kg of fuel
\( C_p \): Specific heat of flue gas (0.23 kcal/kg)

4.2 Percentage heat loss due to evaporation of water formed due to hydrogen in fuel

\[
\frac{9 \times \text{hydrogen} (584 + C_p (T_f - T_a))}{GCV_{\text{fuel}}} \times 100
\]

(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

\[
\frac{\text{moisture} (584 + C_p (T_f - T_a))}{GCV_{\text{fuel}}} \times 100
\]

(7)

4.4 Percentage heat loss due to moisture present in air

\[
A_m H_f (C_p (T_f - T_a)) \times 100 \times \frac{GCV_{\text{fuel}}}{GCV_{\text{fuel}}}
\]

(8)

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

4.5 Percentage heat loss due to unburned fuel in fly ash

\[
\frac{m_{\text{ash}} \times GCV_{\text{flyash}}}{GCV_{\text{fuel}}} \times 100
\]

(9)

Where, \( m_{\text{ash}} \) = total ash collected per kilogram of fuel burn

4.6 Percentage heat loss due to unburned fuel in bottom ash

\[
\frac{m_{\text{ash}} \times GCV_{\text{bottom ash}}}{GCV_{\text{fuel}}} \times 100
\]

(10)

4.7 Percentage heat loss due to radiation and other unaccounted loss

\[
E_p = \frac{H_S}{H_A}
\]

(11)

Definition
\( E_p \) = Evaporate Ratio
\( H_S \) = Heat utilized for steam generation
\( H_A \) = Heat addition to the steam

---

Figure 3. Ordinary controller system
4 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 (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 is 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]

5 Processes

The semiautomatic is a control process as shown in figure 3. On the other hand, the equipments cannot intermediated 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.

![Figure 4. Adaptive controller system](image)

An adaptive system is a closed-loop control as shown in figure 4 and figure 5 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.

6 Wireless Module Designation

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

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).
7 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:

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

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]

8 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.

References:


