One Day Course on "Boiler/ Steam Plant – Operations and Maintenance"

AGRICULTURAL AND FOOD ENGINEERING TECHNICAL DIVISION

by Ir. Tang Hee Teik

THE Agricultural and Food Engineering Technical Division (AFETD) had successfully organised a one-day course on "Boiler/Steam Plant – Operations and Maintenance" at the TUS Lecture Room of Wisma IEM, Petaling Jaya, on 10 June 2010. The course, attended by 54 participants, was delivered by Mr. Canaraj Ramamorthy, who holds a First Grade Steam and Internal Combustion Engine (ICE) Engineer Certification issued by JKKP, DOSH.

The speaker gave a brief introduction on the different kinds of commercial boilers; *i.e.* water-tube boilers and fire-tube boilers with each having its own advantages and disadvantages.

	Water-Tube Boilers	Fire-Tube Boilers
Designs	Water Tube Boilers circulate water in tubes within a furnace enclosure. Hot flue gases pass over the tubes, heat the water, and then exit through a stack. Water-tube boilers are usually specified in all situations where operating pressures of ≥20 barg are required because of their greater structural integrity.	Fire-tube boilers force hot combustion gases through tubes submerged in water, to evaporate the water outside to become steam. Fire-tube boilers have mechanical constraints limit capacity to 30T/hr and pressure up to 15-20barg.
Applications	A wide variety of sizes and designs of water-tube boilers are used in power stations, ships and factories.	Fire-tube boilers are widely used in small installations to heat buildings and to provide power for SMI factory processes.
Advantages	• Low risk of disastrous explosion compared to fire-tube boiler. • Space saving. • Rapid steam raising. • Ease of transportation. • Large capacity and pressure units available.	• Cheap to build. • Easy to install and operate. • Smaller in size.
Disadvantages	• The supply water has to be pure and specially treated to protect the steam tubes. • Water tube boiler systems are often complicated require special maintenance procedures. • Water tube boiler cannot serve as steam reservoirs because the fluid volume is minimised. • The water feed system has to be very accurate (small fluid volume).	• The steam is generated in a large containment vessel which is at risk of catastrophic failure due to the high stresses developed at high pressures. • Arguably not good for superheated steam.

He also explained the importance of some typical components used in a boiler system or steam plant, *i.e.* starters, burners, steam drum, water drum, superheaters, economisers, relief valves, fans, sootblowers, water level gauge, chimney, ducts, dampers, and *etc*. The selection of fuels, treatment of

feed water quality, use of chemicals, separations of steam, blowdown and some good tips in boiler maintenance were also highlighted in order to maximise the steam energy efficiency and practical economics reason.

The speaker shared his experiences about the safety operations at a steam plant. He pointed out that the knowledge needed to operate a boiler plant efficiently is reflected in the preventive steps taken against accidents and injuries. Mistakes such as opening the wrong valve, starting the wrong pump, or neglecting the equipment may cause injury to the operator and damage to the plant. Accidents generally result from human error or an equipment or material defect. Some chapters in the Factories and Machinery Act (ACT139) were briefly touched on for knowledge. However, industrial practitioners were reminded that the act is to be followed as a guideline for compliance as a boiler operator.

In addition to increasing the participants' confidence to operate and supervise a steam plant, the following topics were also discussed:

i) Boiler Water Treatment

Only use soft water. 95% of impurities should be removed prior to entering boilers; 5% of the remainder should be treated with chemicals. Common impurities found in raw water: mineral salts (*i.e.* $CaCO_3$, $MgCO_3$), mineral acids (*i.e.* H_2SO_4, HCl), alkaline (*i.e.* OH^-, HCO_3^-, CO_3^{2-}), others elements such as SO_4^{2-}, Cl^-, F^-, Na^+, Mn^{2+}, Fe^{2+}, Fe^{3+}, Al^{3+}, O_2, SiO_2, H_2S, *etc*. Experience shows that poor quality feed water will cause scaling & fouling, corrosion, and carryover. As a result, the boiler becomes inefficient in the use of energy and this may lead to tube failures due to overheating. Thus, the feed water treatment plant should be well designed to produce the required feed water quality, monitored and maintained by competent personnel.

ii) Theory of Combustion and Basic Steam Process

Three elements are required for combustion, *i.e.* fuel, air (oxygen), and heat. In an ideal combustion, fuel and oxygen present in exactly the right quantities for a complete reaction is called stoichiometric combustion. Air-fuel mixtures are frequently explosive so its ratio needs to be carefully controlled. In steam generation, excess air represents heat loss, because the additional air carries away heat in the flue gases, which should be transferred to the process. In other hand, too little excess air may cause inefficiency due to unburned fuel and combustible intermediate compounds leaving the furnace. In practice, complete combustion cannot be achieved but the excess air allows for a nearly complete combustion. Oil usually require about 25% excess air to achieve maximum combustion, while pulverised coal usually require about 20% excess air for complete combustion.

Boiler efficiency is defined as the amount of heat supplied to the steam with respect to the chemical energy of the fuel available on combustion.

$$\text{Boiler Efficiency} = \frac{m_s(h_s - h_w)}{m_f(\text{calorific value of fuel})}$$

- m_s = Mass flow rate of steam (kg/s)
- m_f = Mass flow rate of fuel (kg/s)
- h_s = specific enthalpy of steam generated from boiler (kJ/kg)
- h_w = specific enthalpy of feedwater (kJ/kg)

Net Calorific Value is the calorific value of fuel, excluding the energy in the steam discharged to the stack, and is the figure generally used to calculate boiler efficiencies. In broad terms:

Net Calorific Value = Gross Calorific Value – 10%

The fuel combustion process :

$$\underbrace{[C + H]}_{\text{Fuel}} + \underbrace{[O_2 + N_2]}_{\text{Air}} \xrightarrow{\text{combustion}} \underbrace{[CO_2 + H_2O + N_2]}_{\text{Heat}}$$

iii) Boiler Construction Codes and Standards

Fire-tube boilers : BS EN 12953

Water-tube boilers : BS EN 12952, ASME 1.

Other subjects such as boiler preventive maintenance and repairs, operations and trouble shootings, steam boiler failures, non destructive testing and the basic of metallurgy were lectured in the last section of the course. Mr. Canaraj concluded his lecture by sharing his knowledgeable experiences with the participants through an open discussion. The AFETD Chairman, Ir. Kumar Subramaniam, then presented mementos to the distinguished speaker. ■