Boiler Operation and Process Control in Sri Lankan Industries

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Abstract— The steam boiler is the heart of the industry. Boilers are mainly used for steam generation and drive heavy mechanical machines. According to Sri Lanka, mostly boilers are used in sugar industries, wood processing factories, garment industries, paper manufacturing industries, brewing industries, laundry and rice mills. The boiler is the unit that supplies superheated steam and hot water to the industry. Gas, oil, coal, biomass fuels use as the feed fuels for the boiler. Alternatively, according to Sri Lankan's modern conveniences, new boiler feed fuels are suggested to improve the boiler output by using higher calorific values of suggested feed fuels and create new industries that are thinking of feeding fuel production. Other hands, the boiler feedwater-treatment system improvements are also useful for generated steam quality and maintain boiler efficiency and a lifetime of the boiler with cost-effectively.

Index Terms— Alternative fuel, Blow-down, Calorific Value, Economizer, Feed-fuel, Feed-pump, Feed-water, Fire-tube, Hardness, TDS (Total Dissolved Solids) level, Heat exchanger.

1 INTRODUCTION

In general, boiler or steam engine is used for the generation of electric power and industrials to work large machinery quickly, such as washing operations (the textile industry), food industry, cement factory, rice mills, etc. Many cylindrical mechanical engine machines use steam to drive and operate that equipment. Because steam includes significant power and there are two types such as High-pressure steam and Low-Pressure steam. High-pressure steam uses for drive turbines, and Low-pressure steam uses for operations and processes of boiler feed-pumps and other equipment. The boiler or steam generator is the system producing superheated steam and heated water from the fuel utilizing supplied feed-fuels; likewise, as a boiler operator, the guy who has worked the boiler application. With well-educated about boiler operation with process control, he must be known about these criteria such as acceptable weight, running period, boiler temperatures, water pH, water ionization frequency, etc. In general, industries are using two types of boilers, such as firetube boilers and water-tube boilers. Fig 1 is presenting fire tube, and Fig 3 is presenting water tube boiler previews below. Another thing is that the boiler drum underneath has a valve that is called a mud valve. It helps to extract water-generated by-products in the boiler [1]. Fig 2 is the cross-section view of the firetube boiler.

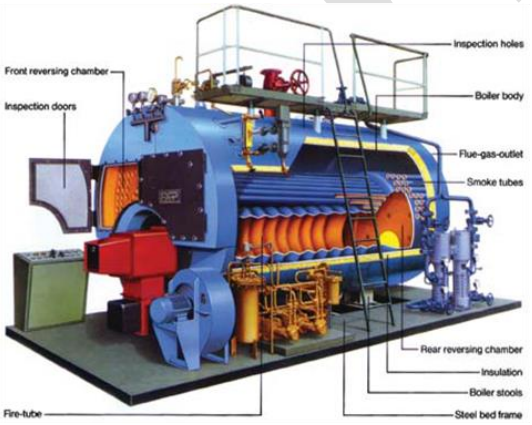

Fig. 1. Fire tube Boiler [2]

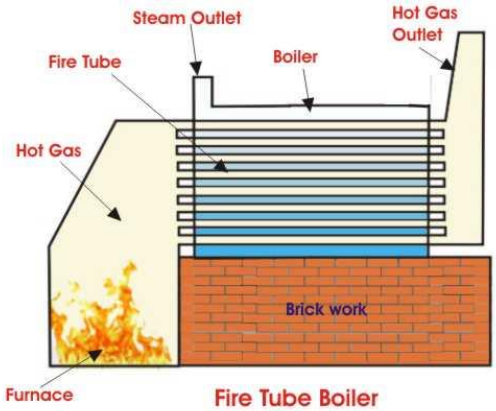

Fig. 2. Section of Fire tube Boiler [3]

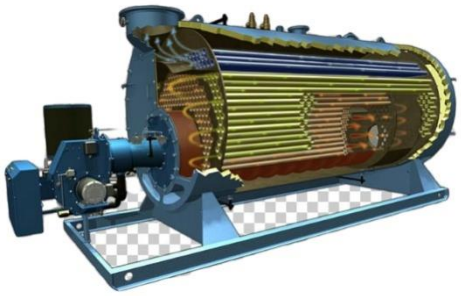

Fig. 3. Water Tube Boiler [4]

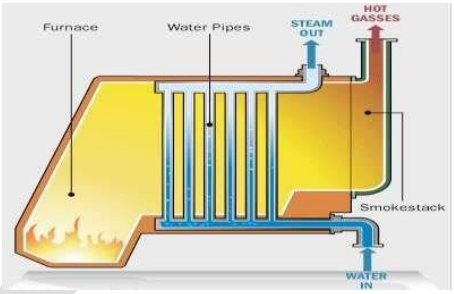

Fig. 4. Section of Water Tube Boiler [5]

The water tube boiler is the development of achieving higher steam pressure with higher steam generation during higher rate compared with the fire tube boiler. According to the water tube boiler, the water and steam flow inside the tube and hot, exhausting gas outside of the tube. Fig 4 is the cross-section of the water-tube boiler.

Steam Drum

The steam drum is a collection vessel for steam and water. As well it has steam separators. Steam is going to the topside in superheater and water is going to downside mud shell, and it circulates from the bottom of furnace water hall (furnace bottom ring headers). It comes again thought water tubes absorbing heat from the furnace. It has two draining arrangements.

1. Continuous blow-down – This is used when SiO_2 or TDS is on the higher side.
2. Emergency blow down – This is used when drum level is got high value.

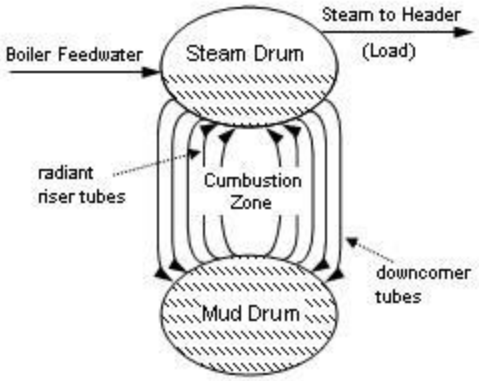

Fig. 5. Steam and mud drum [5]

Boiler mountings and accessories such as the safety valve, water level gauge, pressure gauge and feed water inlet connections install on this drum. The primary function of the steam drum is to provide water storage and space to separate steam from water.

Water or Mud Drum

Mud drum is the lower drum of the boiler, and this is attached to steam drum in upper of the boiler from a large number of straight bundles of tubes. Its call boiler bank tubes. Sludge can be settled in this mud drum for removal through periodic blow-down. The drainage arrangement for this drum is through one or two boiler blow-down connections to control TDS or to drain the boiler completely while out of operation.

Water Walls

Tubing arrangement around the furnace is called water wall circuit to extract heat from the fuel to generate steam. These water walls can be placed in a line or stagger arrangement. Water walls receive heat from radiation and absorb approximately 50 per cent of the total heat generated in the furnace.

Superheater

The superheater (heat exchanger) is used to increase the temperature of the steam. Superheated steam is the point of saturated steam point passed. SA-213 material is used to manufacture bundles of high strength tubes. There are convection, radiant and conv-radiant superheaters.

Economizer

Economizer (heat exchanger) is the attachment to the boiler used to restore heat from the flue gas fuel that exits the boiler by heating feed water (nearly 60 degrees increase). So the efficiency of the boiler can be increased by using this (up to save 1% fuel).

Air Heater

Supplying air for combustion to generate flue gas in boiler helps air heater by recovering the heat from waste flue gas that leaves the economizer. Rising the combustion air temperature by 20°C will save up to 1% of the overall fuel. The process of pulverized coal furnaces needs pre-heated air, too. Primary air in the pulverizer is required to dry the gas.

Boiler Draft Fan

The fuel combustion in the boiler, furnace air is drawn out of the atmospheric air pushed through the ducts from forced draught fan to furnace where air reacts with fuel and becomes as hot flue gas. It is then extracted from the furnace with the help of Induced draught fan. FD (Forced Draft) fans, ID (Induced Draft) fans, Main air fans, Secondary air fans, and Gas recirculation fans are the fans used in large water tube boilers

2 BOILER OPERATION AND PROCESS CONTROL

2.1 Keep the Boiler Clean

Having already stated, any materials (Ca, Mg ions, Oxides) that covers the boiler's heat transmission surfaces, such as soot or scale, may decrease its output and thus raise the risk of machinery failure. The residue that covers a boiler's tubing can interact with heat flow and increase the temperature of the flue gas. Where incomplete combustion happens, the resultant soot will collect on the tubes' combustion face. Similarly, inadequate water management methods may allow the water side of the tubes to collect in volume. Just 0.03 inches thick layer of soot or scale will minimize heat transmission by 9.5 per cent. A layer thickness of 0.18 inches will minimize heat transfer by 69% [6].

2.2 Water Treatment

Proper treatment of boiler water with chemical substances is essential for efficient operation. That chemical treatment method must be adjusted depending on the minerals contained in the formation of water, the percentage of the returned condensate and the existence or absence of a de-aerator. Solids are dissolved in the boiler water, and level of treatment chemical water is tested daily in low pressure and low volume boiler plants and hourly tested in high-pressure high-volume boiler plants. Otherwise, instruments should be manually adjusted. Annual boiler service will provide a detailed examination of the water-side surfaces for signs of scaling and corrosion. Just a thin scale coating interferes with heat transport and hence reduces the performance of combustion. The upward increase in flue gas temperatures over weeks or months typically means that a layer has formed upon the boiler heat exchange surfaces either on the fireside or on the water-side. If this condition is

met, the boiler should be promptly inspected [6].

2.3 Minimize Boiler Blow-down

Too much total dissolved solids (TDS's) can cause scale in the boiler water and decrease boiler efficiency. Hence the solids must be held within those thresholds. When the concentration of TDS decreases, the dissolved solids are more prone to precipitate out of the size of the water and the shape. Water drainage, known as boiler blow-down, is required to remove some of these dissolved solids and keep the TDS concentration below the precipitation level. Consistent and repeated blow-downs of the limited volume are a safer technique than occasional high-volume blow-downs, as it conserves electricity, water, and chemicals. Big steam boilers with steady loads will provide continuous blow-down, where a limited amount of water is removed from the boiler continuously until fresh water is added [6].

3 FEED WATER TREATMENT

It is typically required to ensure efficient processing and steam generation efficiency. Most effective boiler-feed water management device would help the facility prevent costly plant damage, costly repair costs and boiler loss due to boiler and downstream machinery scaling, corrosion and fouling. A boiler feedwater treatment device is a network consisting of many different technologies that meet the water treatment needs of your particular boiler [6].

Boiler feedwater treatment is essential for both high- and low-pressure boilers [7]. Ensuring adequate maintenance when issues like fouling, scaling, and deterioration would go a fair way to prevent expensive replacements/upgrades. A practical and well-engineered water treatment system for boiler feeds should be able to,

- ✓ Effective handling of boiler feed water and extract damaging impurities before joining the boiler.
- ✓ Foster internal regulation of the composition of boilers
- ✓ Maximize the usage of condensate vapour
- ✓ Control return-line corrosion
- ✓ The industry is prolonging the operational life of the equipment.
- ✓ Prevent system downtime and boiler loss

As described above, the specific components of a boiler feedwater treatment device depend on the quality of the water from which it is drawn concerning the water quality needed for the particular boiler. Usually, specific simple boiler feedwater treatment method includes species with,

1. Filtration/ultra-filtration
2. Ion exchange or softener
3. Membrane processes (Reverse osmosis and Nanofiltration)
4. Deaeration or degasification
5. Coagulation or chemical precipitation

Depending on the impurities present in area water, any mixture of these treatments that better match facility and make up industry treatment method, and these essential components are typically appropriate depending on the needs of the plant and operation. However, if the plant needs a program that offers a little more flexibility, the industry may need to put in specific enhancements or technologies [6].

A boiler feedwater treatment may consist of the technology required to extract hazardous dissolved solids, suspended solids, and organic content, including any amount of the following;

- ✓ Copper can allow deposits to settle in high-pressure turbines, decreasing their output and requiring costly cleaning or changing of equipment.
- ✓ Silica, if not reduced to low rates, particularly in high-pressure boilers, the scaling of silica can be extremely hard.
- ✓ Depending on the chemistry of the boiler, feedwater Calcium can induce scaling in many ways. (calcium silicate, calcium, phosphate, etc.)
- ✓ Magnesium when combined with phosphate, magnesium can bind to the boiler and coat tubes within, attracting more solids and contributing to scale.
- ✓ Aluminium deposits as a scale bottom of mud drum in the boiler, and can react with silica to improve the chance of scaling.
- ✓ Hardness also allows the boiler sections and pipes to become concentrated and size.
- ✓ Dissolved gasses, chemical reactions on boiler pipes and sections due to the existence of dissolved gases such as oxygen and carbon dioxide may cause significant corrosion.

Specific treatment procedures differ based on boiler conditions and feed and maquillage water quality/chemistry, but a standard boiler feedwater treatment scheme would usually contain the following steps,

Ion-exchange softening

A softening resin may be used when pretreating boiler feed water when there is high hardness complexed with bicarbonates, sulphates, chlorides, or nitrates. This procedure uses an intense acid cation exchange process, whereby the polymer is charged with a sodium ion and, as the hardness passes through, has a higher affinity for calcium, magnesium, and iron so that the molecule is captured and the sodium molecule is released into the water [6].

DE alkalization

Some boiler feedwater treatment systems will use DE alkalization after the softening process to reduce alkalinity / pH, an impurity in boiler feed water which can cause foaming, corrosion, and embrittlement. Dealing with sodium chloride uses durable anion exchange resins to replace bicarbonate, sulfate, and nitrate for chloride anions. While it does not remove 100 per cent alkalinity, it removes most of it with what can be an easy-to-implement and cost-effective process.

Reverse osmosis (RO) and Nanofiltration (NF)

In the boiler feedwater treatment system process, reverse osmosis (RO) and Nanofiltration (NF) are often used down the line, so that most of the harmful impurities that can foul and obstruct the RO / NF membranes have been removed. Similar separation processes force pressurized water through semi-permeable membranes, trapping bacteria, salts, organics, silica, and hardness Purified water while allowing concentrated water through. Not always required in the treatment of boiler feed water, these filtration units are mostly used with high-pressure boilers where the concentration of suspended and dissolved solids should be deficient [6].

De-aeration or degasification

Any condensate returned to the system will be mixed with the treated make-up water at this point in the boiler

feedwater treatment process and enter the deaeration/degasification process. Any amount of gasses (oxygen and carbon dioxide), when attached to them, can be extremely corrosive to boiler equipment and piping, forming oxides, and cause rust. There are several types of deaeration devices. Those come in a range of configurations depending on the manufacturer, but generally, for degasification or oxygen scavengers, you might be using a tray- or spray type de-aerator [6].

8 CONCLUSION

The boiler is the main section unit of the industry, and it must be operated with standard conditions with the best quality. The leading case is the industry boiler unable to operate with the best efficiency because they do not have sufficient calorific valued feed fuel. So, the boiler is working lower value of efficiency. As a solution to it suggested alternative fuels. In this country, we can easily supply alternative fuels. Another thing is the feedwater treatment. It must do with standard conditions with the best quality. After then, the lifetime of the boiler can be increased with the best quality. Then we can calculate using equations what we need to be developed to achieve the best efficiency of the boiler and steam quality.

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