Abstract—The RLNG conversion incorporates LNG as fuel in addition to heavy oil, thereby a dual firing scheme is employed. The quality of heavy fuel oil for industrial users has declined significantly in recent years. At the same time, plant operators have to comply with more and more stringent pollution control regulations. Drum level and combustion control are critical for the safe operation of the boiler. Too low a level may overheat boiler tubes and damage them. Too high a level may interfere with separating moisture from steam and transfers moisture into the turbine, which reduces the boiler efficiency. Various controlling mechanisms are used to control the boiler system so that it works properly.

I. INTRODUCTION

A boiler is an enclosed vessel that provides a means for combustion heat to be transferred into water until it becomes heated water or steam. The hot water or steam under pressure is then usable for transferring the heat for the steam requirements of process industries or for power generation.

Boilers are manufactured in many different sizes and configurations depending on the characteristics of the fuel, the specified heating output, and the required emission controls. Some boilers are only capable of producing hot water, while others are designed to produce steam. Boilers can burn coal, oil, natural gas, biomass as well as other fuels and fuel combinations. Most boilers are classified as either water tube or fire tube boilers, but other designs such as cast iron, coil type, and tubeless (steel shell) boilers are also produced.

II. RLNG CONVERSION

Each burner equipped with a main fuel gun for main flame. And pilot gun for pilot flame.

Earlier day’s heavy oil is used as main fuel, now LNG also included as a main fuel there by duel firing scheme is employed, that means LNG or heavy oil is used as a main fuel according to the availability. Atomizing provision is given if main fuel is heavy oil. LPG/LNG can be used for the pilot gun firing. It is provided with gas igniter to light up the pilot flame and pilot flame in turn light up the main flame. Flame scanner is for scanning main flame.

2.1. Introduction to burner management system

The Burner Management System must be designed to ensure a safe, orderly operating sequence in the start-up and shutdown of fuel firing equipment and to reduce possible errors by following the operating procedure. The system is intended to protect against malfunction of fuel firing equipment and associated systems. The safety features of the system shall be designed to provide protection in most common emergency situations; however, the system cannot replace an intelligent operator’s reasonable judgment in all situations.

In some phases of operation, the BMS shall provide permissive interlocks only to insure safe start up of equipment. Once the equipment is in service, the operator must follow acceptable safe operating practices. It is essential that all parts of the BMS are in good working order and in service whenever the burner is in service if the system is to provide the protection for which it is designed. Regular maintenance and inspection of the system and its associated hardware is essential for its continued safe operation.
2.1. Flow chart for BMS

2.1. Visualization of BMS
III. DRUM LEVEL CONTROL

Maintaining the correct water level in the drum is critical for many reasons. Water level that is too high causes flooding of the steam purification equipment, resulting in the carryover of water and impurities into the steam system. A water level that is too low results in a reduction in efficiency of the treatment and recirculation function. It can even result in tube failure due to overheating from lack of cooling water on the boiling surfaces. Normally drum level is expected to be held within 2 to 5 cm of the set-point with some tolerance for temporary load changes.

3.1 Single element control

Process variable (PV) coming from the drum level transmitter. This signal is compared to a set point and the difference is a deviation value. This signal is acted upon by the controller which generates corrective action in the form of a proportional output. The output is then passed to the boiler feed water valve, which then adjusts the level of feed water flow into the boiler drum.

3.2 Two element control

The two element control scheme utilizes steam flow in addition to drum level. In two-element control, steam flow is measured along with boiler drum level. The steam flow signal is used in a feed forward control loop to anticipate the need for an increase in feed water to maintain a constant drum level.

3.3 Three-Element Drum Level Control

It utilizes steam and water flow in addition to drum level. The steam flow adjusts the feed water control valve based on the steam flow signal and the drum level controller signal. As the steam flow increase/decrease, the steam flow adjusts the output of the summer and directly sets the feed water controller set point.

3.4 Comparison of results

Through three element control more fast response is obtained, the application of the three element control includes the Combination of batch and continuous type operations such that a plant steam load characteristic varies continuously and usually unpredictably. Most industrial power applications fall into this category.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Single element control</th>
<th>Two element control</th>
<th>Three element control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rise time (s)</td>
<td>.504</td>
<td>48</td>
<td>.412</td>
</tr>
<tr>
<td>Settling time (s)</td>
<td>9.74</td>
<td>5.41</td>
<td>5</td>
</tr>
<tr>
<td>Over shoot (%)</td>
<td>24.7</td>
<td>10.9</td>
<td>5.36</td>
</tr>
</tbody>
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IV. COMBUSTION CONTROL

The primary function of combustion control is to deliver air and fuel to the burner at a rate that satisfies the firing rate demand and at a mixture (air/fuel ratio) that provides safe and efficient combustion. Insufficient air flow wastes fuel due to incomplete combustion and can cause an accumulation of combustible gases that can be ignited explosively by hot spots in the furnace. Too much air flow wastes fuel by carrying excess heat up the stack. Combustion controls are designed to achieve the optimum air/fuel ratio, while guarding against the hazard caused by insufficient air flow.
4.1. Fuel-air ratio control

It is equally important to control for proper airflow. To event process disturbances caused by airflow disruptions originating outside the boiler a cascade system must be established. Such an airflow control loop would consist of a flow transmitter measuring airflow and sending its signal directly to an air flow controller as the measured variables. The boiler master thus originates the signal used as flow demand; it becomes the set point of the air flow controller in turn, the air flow controller’s output goes to an inlet line or a speed control on the forced draft fan, establishing combustion air flow.

4.2. Fuel-air ratio control with \( \text{O}_2 \) trim

Automatic air/fuel ratio adjustment is generally based on the percentage of excess oxygen (\( \text{O}_2 \)) in the flue gas. If air and fuel are mixed in chemically correct. Proportions, the theoretical products of combustion are carbon dioxide and water vapor. Under ideal conditions, all of the oxygen supplied with the air would be consumed by the combustion process. Due to incomplete mixing, however, it is always necessary to provide more air than the theoretically correct mixture. This results in a small percentage of excess \( \text{O}_2 \) in the flue gas. A flue gas oxygen analyzer supplies feedback on the combustion process and is the basis for trimming the Air/fuel ratio to maintain optimum combustion.

4.2. Comparison of results

These models indicate that the \( \text{O}_2 \) sensor control is more effective in controlling air/fuel ratio and achieving closer combustion control reducing \( \text{CO}_2 \) emissions. Improvement in control strategy design involves compensating for the variability in optimum fuel air ratios at different fuel flow rates. (This variability becomes most dramatic as fuel flow becomes low) to do this the excess air level first is determined by measuring the oxygen in the exhaust gas. This signal is used in a controller to provide an output that adjusts the fuel air ratio device for the correct level of excess air an index of load such as steam or fuel flow can adjust the oxygen set point for optimum levels throughout the entire operating range of the boiler.

V. Conclusion

The RLNG conversion incorporates LNG as fuel in addition to heavy oil, there by a dual firing scheme is employed. The quality of heavy fuel oil for industrial users has declined significantly in recent year. Natural Gas is not only efficient, clean, eco-friendly and flexible in control, it meets many of the fuel requirements of modern industrial society.

The primary purpose of any boiler control system is to manipulate the firing rate so that the supply of steam remains in balance with the demand for steam over the full load range. In addition, it is necessary to maintain an adequate supply of feed water and the correct mixture of air and fuel for safe and economical combustion. Maintaining the correct water level in the drum is critical for many reasons. The three element system can provide fast and efficient control.
REFERENCES


