**Recommendation ${REC}: INSTALL AIR-FUEL RATIO CONTROLLER‑ ON ${EQUIP}**

**Recommended Action**

Install the combustion system air-fuel ratio of the ${EQUIP} to the maximum efficiency conditions to save natural gas energy.

**Summary of Estimated Savings and Implementation Cost**

|  |  |
| --- | --- |
| Annual Cost Savings | ${ACS} |
| Implementation Cost | ${MIC} |
| Payback Period | ${MPB} |
| Natural Gas Savings | ${NGS} MMBtu |
| ARC Number | 2.1233.2 |

**Current Practice and Observations**

The plant has an ${SIZE} MMBtu/hr ${EQUIP} in the plant consuming natural gas. During discussions with plant personnel, it was estimated that the excess oxygen percentage in the flue gas could be as high as ${O2}. Many factors contribute to the efficient combustion of fuels, with load conditions being the major factor. Other factors are environmental considerations, cleanliness, quality of fuel, etc. It is necessary to monitor the performance of the boilers and tune the air/fuel ratio on a continuous basis. Therefore, it is recommended that the latest air-fuel ratio controllers be installed to modulate the air-fuel ratio of the ${EQUIP} all of the time.

**Anticipated Savings**

To be conservative, the savings calculations are based on a reduction in excess O2 to about 2%. Normally, the exhaust temperature will also drop after adjustment of the air/fuel mixture, leading to an additional increase in efficiency. However, to be conservative, any increase in efficiency due to decreased stack temperature has been neglected. Therefore, the stack temperature is assumed to be the same as the current conditions after the proposed air/fuel adjustments are made.

The annual natural gas savings, NGS, to be realized by increasing the efficiency of the ${EQUIP} can be estimated as follows:

NGS = CAP × OH × LF × SAV,

where,

CAP = Capacity of the ${EQUIP}: ${SIZE} MMBtu/hr

OH = Operating hours: ${OH} hrs/yr (${HR} hrs per day, ${DY} days per week, ${WK} wks per yr)

LF = Load factor: ${LF}%

SAV = Percent of natural gas savings due to tuning of boilers to maximum efficient conditions: ${SAV}%

NGS = ${SIZE} MMBtu/hr × ${OH} hrs/yr × ${LF}% × ${SAV}%

= ${NGS} MMBtu/yr

The annual cost savings, ACS, is estimated as follows:

ACS = NGS × Natural gas cost

= ${NGS} MMBtu/yr × ${NGC}/MMBtu

= ${ACS}/yr.

The percentage of natural gas savings based on O2 value is obtained from the Process Heating Assessment and Survey Tool, PHAST software calculator. Using the above relations, the natural gas savings and corresponding cost savings are calculated at different flue gas conditions. The following tables present the boiler flue gas conditions at different loads, the total natural gas savings, and corresponding cost savings.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Current Conditions** | | | | |
| **Oxygen** | **Flue Gas Temperature** | **Combustion Air Temperature** | **Available Heat** | **Natural Gas Savings** |
| ${O2}% | ${FGT} °F | ${CAT} °F | ${CAH}% | - |
| **Proposed Conditions** | | | | |
| 2% | ${FGT} °F | ${CAT} °F | ${PAH}% | ${SAV}% |

**Table 1: Primary Boiler Exhaust Gas Analysis.**

By installing a continuous monitoring controller, an annual natural gas savings of ${NGS} MMBtu could be realized, with a corresponding annual cost savings of ${ACS}.

**Implementation Cost**

It is recommended that the plant undertake in-house boiler tuning as part of its maintenance. The estimated cost for the air-fuel ratio controller is about ${PARTS}, with an additional cost of ${LABOR} for installation and commissioning. Therefore, the total implementation cost is estimated to be ${IC}.<REBATE>

However, there could be energy efficiency rebates available through your utility company, which could potentially reduce the overall capital cost and thereby the payback period. The savings from the rebate is calculated below.

RB = ${NRR}⋅yr/kWh × NGS

= ${NRR}⋅yr/kWh × ${NGS} kWh/yr

= ${RB}

The incentives are capped at 50% of the project cost, which makes the modified rebate savings, MRB, equal to ${MRB}. Hence, the modified implementation cost, MIC, is estimated as follows:

MIC = IC - MRB

= ${IC} - ${MRB}

= ${MIC}

The modified implementation cost is ${MIC}.</REBATE>

**The annual energy savings for this recommendation is ${NGS} MMBtu, resulting in an estimated annual cost savings of ${ACS}. With about ${MIC} in implementation costs, the payback period will be approximately ${MPB}.**

**Implementation Cost References**

The below links are for implementation cost references. We do not endorse/recommend these brands or products. Furthermore, these products may or may not be suitable for the application. The client should contact a vendor(s) to conduct a detailed study of the process, in order to determine the best product for the recommended application.

* <http://cleanboiler.org/learn-about/boiler-efficiency-improvement/efficiency-index/oxygen-control/>
* [https://www.energy.gov/eere/femp/boiler-combustion-control-and-monitoring-system](http://cleanboiler.org/learn-about/boiler-efficiency-improvement/efficiency-index/oxygen-control/)

**Boiler Efficiency Tips**

1. Conduct a flute gas analysis on the boiler every two months. Optimal percentages of O2, CO2, and excess air in the exhaust gases are 2.2%, 10.5%, and 10% respectively for natural gas-fired boilers. The air-fuel ratio should be adjusted to the recommended optimum values if possible; however, a boiler with a wide operating range may require a control system to constantly adjust the air‑fuel ratio.

|  |  |  |  |
| --- | --- | --- | --- |
| **Fuel** | **O2 %** | **CO2 %** | **Excess Air %** |
| Natural Gas | 2.2 | 10.5 | 10 |
| Liquid Petroleum Fuel | 4.0 | 12.5 | 20 |

2. A high flue gas temperature often reflects the existence of deposits and fouling on the fire and/or water side(s) of the boiler. The resulting loss in boiler efficiency can be closely estimated on the basis that a 1% efficiency loss occurs with every 40°F increase in stack temperature.

The stack gas temperature should be recorded immediately after boiler servicing (including tube cleaning), and this value should be used as the optimum reading. Stack gas temperature readings should be taken on a regular basis and compared with the established optimum reading at the same firing rate. A major variation in the stack gas temperature indicates a drop in efficiency and the need for either air ‑ fuel ratio adjustment or boiler tube cleaning. In the absence of any reference temperature, the stack temperature will normally be less than 100°F above the saturated steam temperature at a high firing rate in a saturated steam boiler (this does not apply to boilers with economizers and air pre-heaters).

3. After an overhaul of the boiler, run the boiler and reexamine the tubes for cleanliness after thirty days of operation. The accumulated amount of soot will establish the criterion as to the necessary frequency of boiler tube cleaning.

4. Check the burner head and orifice once a week and clean if necessary.

5. Check all controls frequently and keep them clean and dry.

6. The frequency and amount of blow down depend upon the amount and condition of the feed water. Check the operation of the blow down system to ensure that excessive blow down does not occur. Normally, blow down should be no more than 1% to 3% of steam output.

7. For water tube boilers burning coal or oil, blow the soot out once a day.