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APPLICATION OF WOBBE INDEX ANALYSER FOR ENERGY EFFICIENCY OPTIMISATION OF COMBUSTION PROCESS CONTROL

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ABSTRACT

The increasing needs to optimise the cost of operation for the oil and gas industry has put more significant demand for Engineers to seek innovative technology and enhanced process design application to save energy. One of the key areas to improve energy efficiency is combustion equipment which consumes a significant amount of fuel gas. The conventional method of air-fuel ratio control using excess oxygen at the exhaust stack is the most common mean of combustion control. This method is effective if the fuel gas composition is stable with minimum fluctuation in Gross heating value. In practice, most modern refineries, gas processing plants, and petrochemical plants have multiple fuel gas sources from flash gas or residue off-gas generated by the intermediate process. The composition can vary widely, making it challenging for conventional air-fuel ratio control via access oxygen. A sudden change of the fuel gas composition can potentially result in unpredictability combustion, leading to equipment inefficiency and the possibility of causing damage to the equipment & product quality, thus leading to economic loss.

Wobbe index analyser can determine the exact heating value of fuel gas used for combustion and thus eliminate unstable fuel gas composition issues. The Wobbe index analyser provides compensated value to fuel gas control system to enhance the air-fuel ratio control, leading to more efficient energy management of combustion control equipment.

INTRODUCTION

With the low oil price and challenging world economic situation, one of the oil company key measures to overcome the challenges is to optimise and sweat the existing asset to add value. The potential area for energy optimisation in the refinery is fuel gas utilisation for combustion equipment.

The typical air-fuel ratio control in conventional combustion equipment (furnace, boiler) controls the excess oxygen at the stack, burner modulation, air-fuel cross-limiting, and total heat control. The most popular combustion control among these is excess oxygen which utilises an oxygen analyser to determine the residue O_2 at the stack of furnace or boiler. This type of control has its limitation when fuel gas composition is unstable (heating value varies > 4 MJ/NM_3), affecting the heating value of the fuel, hence the control's efficiency.

Therefore, measuring the heating value of fuel gas by its Wobbe index is a better option to enhance combustion efficiency. Wobbe Index (WI) measurement is unique such that it takes into account the gas-specific gravity. Doing this allows different types of gases to be compared in a meaningful way, ensuring that the plant operator can safely swap or blend fuel gases to produce the correct energy output by comparing their Wobbe Index value. Based on the experience of the installed Wobbe index analyser, the stability of fuel gas control was observed.

Table 1 Comparison of Specific Gravity and wobbe index for two different gases

Composition	Gases 1	Gases 2
CH_4	40%	58%
H_2	60%	0%
N_2	0%	42%
Heating Value	20,82 MJ/Nm_3	20,82 MJ/Nm_3
Specific Gravity	0.26	0.73
Wobbe Index	**40,55 MJ/Nm_3**	**24,39 MJ/Nm_3**

Optimisation using Wobbe Index Analyser

Two fuel sources with the same heating value will not necessarily produce the same amount of energy per unit of time due to the difference in their specific Gravity (SG) of the gases, as shown in Table 1 below. Whereas for Wobbe index measurement, the SG is considered to give the actual heating value of the gas.

Application of Wobbe Index for Ethylene Production Control

A typical ethylene cracking process is shown in Figure 1. The fuel gas system of an ethylene production process comes from multiple sources comprises sales gases(H_2&CH_4) + Tail gases(H_2 & CH_4) + Off Gases from Butanol plant(H_2 & CO) + C_4+ from Debutanizer. The current combustion control using excess oxygen as control has a limitation when fuel gas composition fluctuates. A sudden change of the fuel gas composition will immediately cause unpredictability of combustion, leading to unstable temperature control of the furnace and affect the ethylene cracking decomposition process causing plant upset, flaring, and low Ethylene production.

In establishing optimum thermal efficiency, it is important to have proper instrumentation in the furnace to determine the total heat (Megawatt) and total fuel gas flow. The heat energy of fuel gas

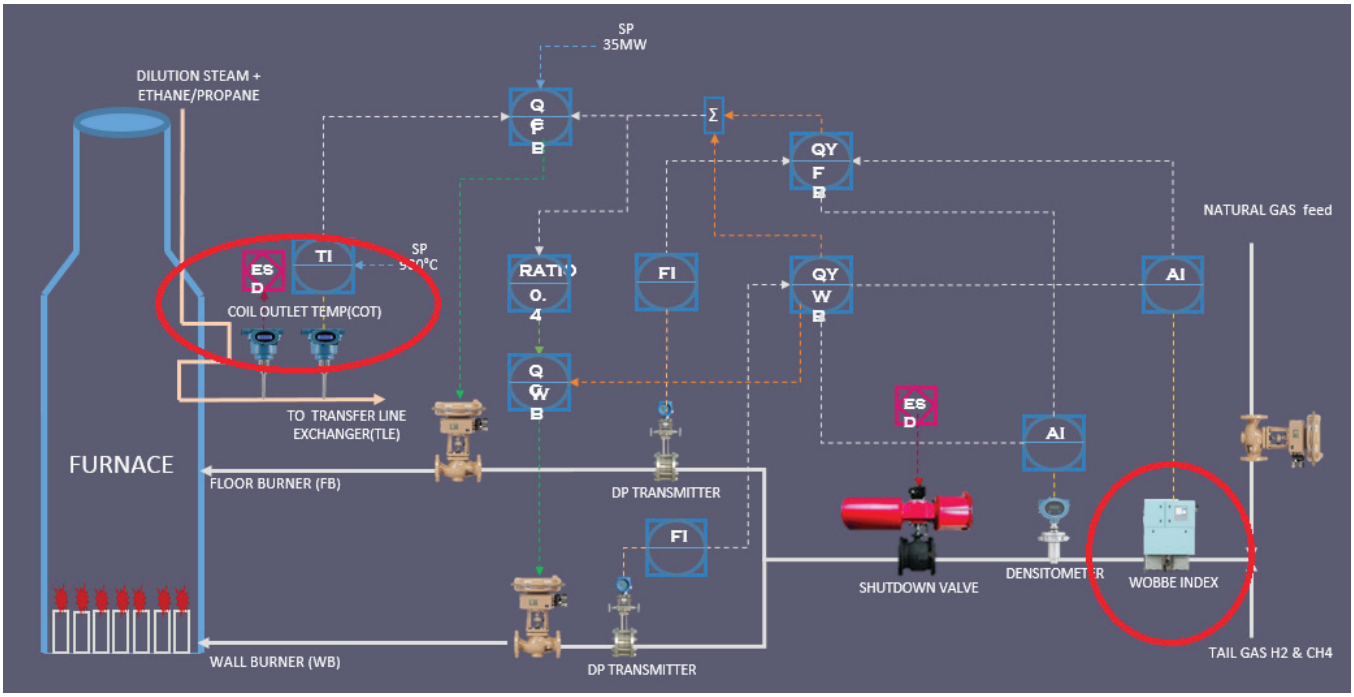

Figure 1 Control system of typical ethylene cracking process using Wobbe index analyser

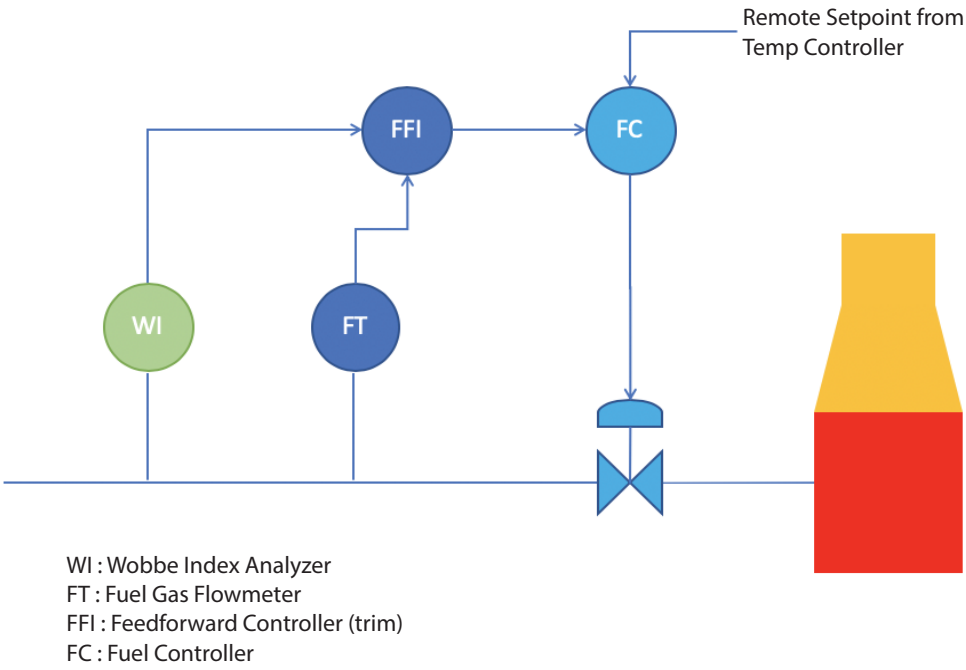

Figure 2 Wobbe Index Analyzer as a signal to Fuel Control Feedforward Controller

is measured online with a Wobbe Index analyser ensuring the energy is sufficient and constant for operating.

With the Wobbe Index analyser, the actual heating value of fuel gas can be determined correctly. The master controller uses this input at the furnace outlet temperature controller to stabilise the Coil outlet temperature (COT). In addition, the fuel gas utilisation is optimised, and the plant can operate more stable.

Thermal Efficiency of Furnace Control using Wobbe Index Analyser

Figure 2 exhibit the typical combustion control of a furnace using a Wobbe index analyser. The traditional method of using only oxygen-excess control in the flue gas to trim the fuel controller may not be sufficient, especially if the fuel gas coming into the combustion comes from different sources, with varying heating values. Normal oxygen analysers used to measure excess oxygen in the flue gas are zirconium-oxide or paramagnetic-type.

As the oxygen-excess analyser in flue gas measures the outcome of the combustion process, it acts more as a feedback control to the fuel controller. It might not provide quick information for the controller to adjust the output to optimise the combustion process. The lags that contribute to this delay are mostly process lags associated with fuel gas coming into the chamber, mixed with air, and gets combusted, with the flue gas travels out of the combustion chamber towards the exit before being measured by the oxygen analyser. This might not become a concern for the process, with fuel gas having minor variation in heating value. The effect of variation is minimal, and a fixed constant can be added to the fuel-controller algorithm.

However, the Wobbe Index analyser measured the fuel's actual heating value for fuel gas from mixed sources. It provided a signal for the feedforward controller to trim the main fuel controller. This will help the fuel controller fine-tune the amount of fuel required for the combustion and ultimately improve the combustion efficiency by avoiding too-rich fuel, which can cause fuel wastage, and avoid too-lean fuel, which will negate process performance.

Figure 3 shows the DCS trending of fuel gas flow and excess O_2 at the furnace that has been installed with the Wobbe index analyser. It can be observed that the stability of the combustion control has improved with the installation of the Wobbe index analyser. There is less fluctuation on excess O_2 (blue line) and

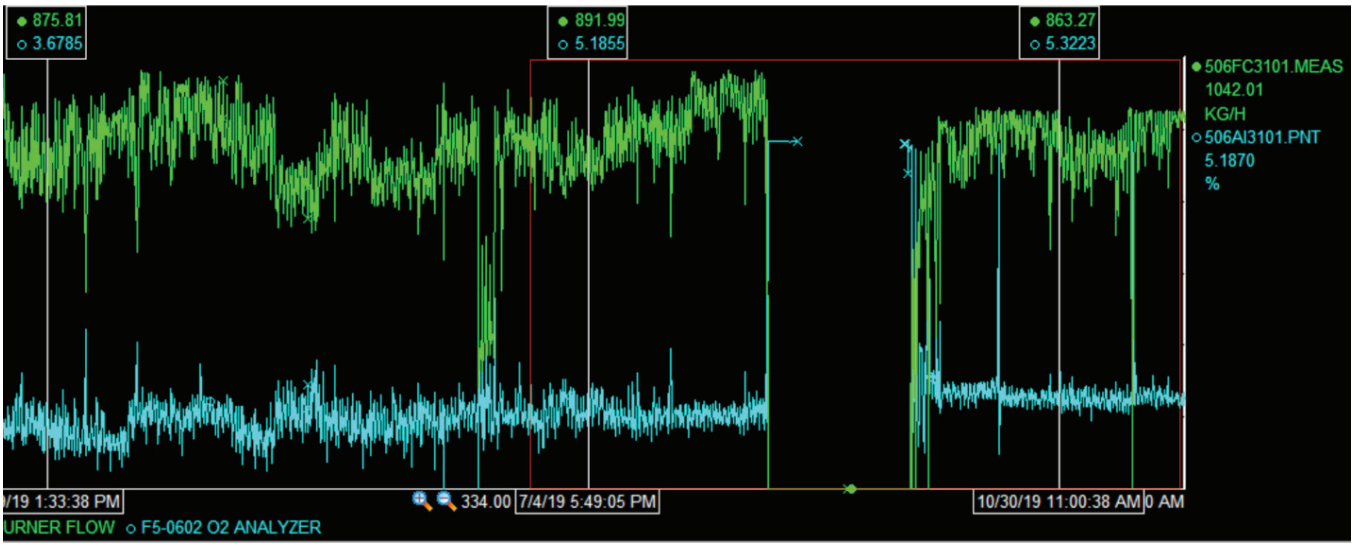

Figure 3 Comparison of combustion control stability before and after Wobbe index analyser installation

fuel gas flow (green line) post commissioning of the Wobbe analyser on 7/4/2019 (area marked with a red rectangle).

The stability of the control is contributed mainly by the feedforward action of the controller based on input from the Wobbe index analyser, which makes the fuel/air ratio adjustment faster, rather than depending on excess oxygen result.

CONCLUSION

Wobbe Index analyser is capable of measuring the actual heating value of fuel for combustion control. This type of control scheme is very efficient for fuel gas that varies in composition. Wobbe index analyser is the recommended measurement to optimise energy efficiency and control stability.

REFERENCES

P. S. Roy, C. Ryu, & C. S. Park, "Predicting Wobbe Index and Methane Number of a Renewable Natural Gas by The Measurement of Simple Physical Properties", *Fuel*, 224, pp. 121-127, 2018.