Use of the WIM Compas[tm] in SAGD operations

Keywords:

- Significant fuel gas cost savings and Energy Efficiency gains to increase steam production
- Optimize steam quality
- Reduce maintenance by increase lifetime of boiler tubes
- Reduce emissions

To meet the global demand for energy, the petroleum industry has been increasing its development and exploitation of unconventional heavy-oil reserves. The production of heavy oil can be profitable, but operators usually generate lower profit margins than in light-oil production because:

- the added need for diluents.
- higher cost for extracting and upgrading.
- lower market price for heavier crude oils.

Consequently, producers of heavy oil, have to minimize their total cost of operation to ensure a timely return on investment.

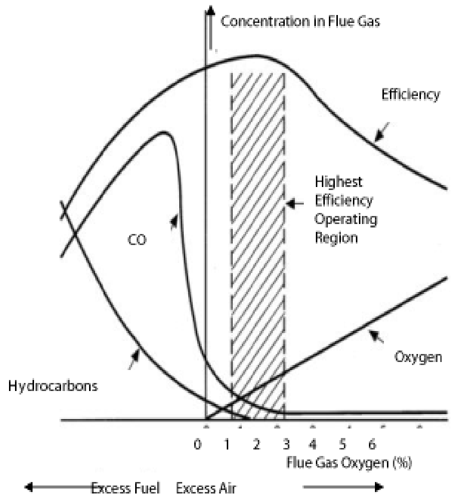
Energy Efficiency

Continuous improvements for energy efficiency are extremely valuable for SAGD plants as approximately 60-70% of total operating cost can be associated with steam-generation-boiler consumption of natural gas. Therefore, implementing technologies that facilitate optimum performance of the steam generators are essential.

The steam generators are fired with grid quality natural gas in combination with off-gases from the process. The mixing ratio depends per location. Typically the ratio of off-gases blended in the natural gas is 30-50%. These off-gases have considerable methane content but also contain 20-40% CO2. CO2 is relative heavy but does not contribute to the heating value of the gas. As both the natural gas and off gas quality are not consistent, this mixture creates a challenge for the burner management. Both the air-fuel ratio as the gas and energy flow will fluctuate with the composition.

For a steam generator, the air-fuel ratio is controlled using stack O2 analysers. Due to the slow response of these analysers they only allow for small corrections. The typical set point is at 3-4% residual O2 while the optimum combustion efficiency is typically reached at 1.5-2% residual oxygen (and low ppm CO). The additional safety bandwidth of 2% residual oxygen is incorporated to handle the fluctuations in the fuel gas. The air used for combustion contains only 21% O2 while 79% is nitrogen. The nitrogen does not contribute to the combustion and cools down the process. To compensate for this loss of heat, the fuel gas flow has to be increased and combustion efficiency is lost.

On a SAGD process, optimizing the residual oxygen from 4 - 1.5% can save multiple hundred thousand dollars annually on fuel gas cost!



Example calculation:

Furnace capacity: 70MW operating
Flue gas temperature: 200°C
Ambient temperature: 0°C
Wobbe Index Fuel gas: 34 MJ/Nm2 (60% natural gas, 40% off gas)
Fuel gas price: 0,034 Euro/kWh (60% of natural gas price)
Based on this information the fuel gas flow will be: 2.06 Nm3/s
Annual fuel gas cost: 20,6 million Euros ($26.8 million dollars)

By reducing the residual oxygen in the stack from 4% to 1.5% you will save 215.000 euro ($280,000 dollars) per year on fuel gas.

Note: This calculation is based on reducing residual oxygen in the

stack only. Increased throughput, steam quality, availability, maintenance and reduced emissions are not taken into account.

Optimize Steam quality
Although the water used for steam generation is treated, still considerable amounts of minerals are present. When producing steam, these minerals will cause additional (unplanned) maintenance due to scaling of the boiler tubes.

In order to optimize your combustion process, monitoring the input fuel for swings in BTU value into the steam generator is crucial as it allows feed forward control of your combustion process and therefore control of your steam quality.

Measuring and controlling the amount of energy introduced to the steam generator is the only practical way to optimize the process, as steam quality is extremely difficult to measure (mixed phase) and the feed back signal does not allow compensation for rapid fuel gas fluctuations. Mixed fuel with a high CO2 content has a low heating value, light petroleum solvent, such as butane in the mixed fuel has a high heating value. The heating value of the fuel change rapidly throughout any given period of time.

Reduce maintenance by increasing the life of the boiler tubes
Being an expensive production process, unplanned downtime, drastically reduces the oil production and therefore the profitability. Keeping your process up and running requires control of the combustion process.

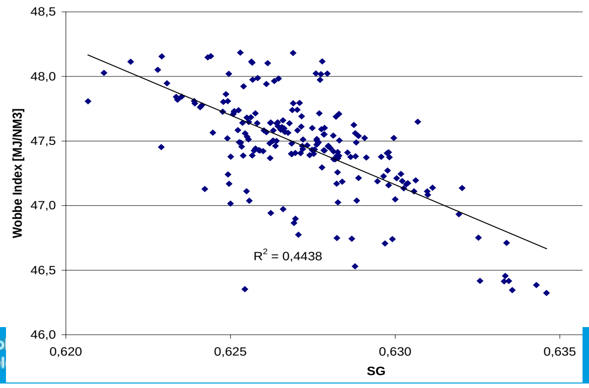
1. Maintain target Steam Quality to prevent excess scaling of the boiler tubes.
2. Implement real time Burner control to prevent hot spots on the boiler tubes.

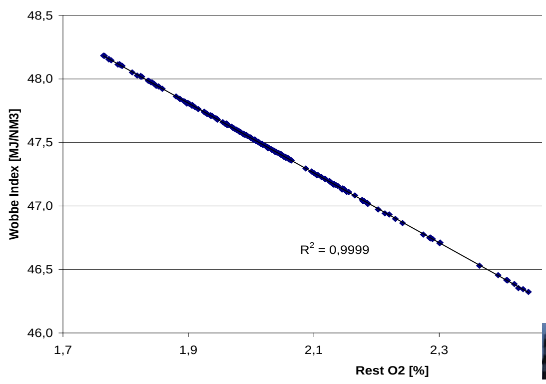
Besides measuring energy flow and air-fuel ratio control, close attention should be paid to the actual combustion process in order to prevent for oxygen lean and rich areas in the steam generator. Oxygen lean locations cause incomplete combustion of hydrocarbons and formation of CO. The CO will eventually combust in other areas in the steam generator (for instance on the surface of the boiler tubes) resulting in reduced efficiency, hot spots and increased maintenance to the boiler tubes.

Use dedicated Wobbe/Heating Value measurement devices!
The use of algorithms in combination with density / specific gravity to correlate to heating value / Wobbe Index or Cari / Air demand will not bring you the desired result to optimise your combustion process. Both natural gas and off-gas contain fluctuating amounts of CO2 and/or N2. The presence of CO2 and N2 results in large inaccuracies in the correlation as both are relative heavy but do not contribute to the combustion process.

The correlation between specific gravity and Wobbe index based on 200 natural gas samples with limited fluctuation is given in the graph below (left graph). The graph on the right gives the correlation used in a dedicated analyser based on residual oxygen principle (WIM Compas F).
The inaccuracy in the correlation between SG and Wobbe (left graph) is caused by the minor CO2 and N2 fluctuations. When introducing off-gases with 20-40% CO2 fluctuations, the correlation between SG and Wobbe Index will even be worse!

The correlation between SG and air demand will give a similar results. Due to the introduced measuring error, optimization of the combustion efficiency based on such a poor correlation will not result in optimisation. With the possible savings in mind, the cost difference between a density meter and a dedicated analyser can not be difficult to justify.





	min	max
CO2	1,15%	1,66%
N2	0,92%	3,58%
C2H4	0,00%	0,00%
C2H6	4,52%	5,58%
C3H6	0,00%	0,00%
C3H8	1,09%	1,50%
C4H10	0,38%	0,56%
C5H12	0,11%	0,18%
C6H14	0,07%	0,10%
CH4	87,78%	90,74%

Instrument installation and selection
When it is decided to install an analyzer for feed forward fuel and air/fuel ratio control, following requirements should be fulfilled to gain optimum result.

1. Do not compromise on response time (analyzer response time < 5 seconds)
It makes no sense to install an analyzer with a 30 seconds response time if changes occur within seconds. The WIM Compas F has a response time of less than 5 seconds for a 90% response to a step change in sample composition - lag or "dead" time included.

Ideally the fuel gas heat value / Wobbe Index and air demand / Cari signals should be available before the fuel gas leaves the burner tip. This means that the travelling time of the fuel gas from sample tap point to the burner should be longer than the travelling time from sample tap point to the analyzer *plus* the analyzer response time.

2. Signal noise (<0.1%)
High signal noise levels will require smoothening of the signal, typically by averaging. As a consequence the response from the control system to a step change will be slower. The WIM Compas F has a repeatability of 0.05% of measured value!

3. Feed forward air/fuel ratio control can help to optimize combustion efficiency and reduce emissions
The heating value and/or Wobbe Index can be poor indicators for the air/fuel ratio in fuel gas applications containing large swings in Olefins, Carbon monoxide, H2 and oxygen. The WIM Compas F is based on the residual oxygen content principle and stores separate calibration lines for Wobbe Index/Heating Value and CARI/Air Demand.

4. Range ability of the analyzer should match all possible cases
Typically the analyzer should be able to handle large fluctuations in the fuel gas composition. The WIM Compas F can analyze fuel gases of all possible compositions in the 0-120 MJ/Nm3 (0-3000 BTU/SCF) range without the risk for flame-out or overheating.

5. Thorough application and site installation review
Each application is different and proper review is essential.

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