

Feed Forward Analysis for Sulfur Recovery Units

The Process ... Process control considerations

The Claus sulfur recovery process is the partial oxidation of H_2S to SO_2 and conversion to elemental sulfur by maintaining a 2:1 ratio of H_2S to SO_2 . There are several factors that affect recovery efficiency of the sulfur recovery unit (SRU) but air control ("air demand") is by far the most dynamic and has the most influence on the recovery efficiency¹.

Primary air control using feed forward flow ratio of air to acid gas accounts for ~90% of the combustion air. Secondary air control using tail gas analysis (ratio 2 H_2S : 1 SO_2) controlling a trim air valve by feed back control (or cascading to the feed forward controller) accounts for the ~10% balance of combustion air. Feed back control based on process analysis provides the most precision however it is limited by the ~30 second process lag time, especially if the composition of the acid gas changes rapidly².

The primary feed forward air control assumes a fixed constant for the composition and hence the combustion air requirement of the various source(s) of acid gas unless there is a feed gas analyzer. Under steady state conditions air control is stable, but in the case of sudden changes in the composition of the acid gas it is not uncommon for air control requirements to exceed the ability of the feed back control loop. In these cases the excursion from the set point of [2 H_2S] : [1 SO_2] can be extreme, the cause of a serious loss of recovery efficiency and increased emissions.

Feed gas analysis has been widely applied for years and practical developments in process analytics can now provide for a multi component, comprehensive real time analysis of the acid gas. The compositional data can be used for feed forward control in the true sense³.

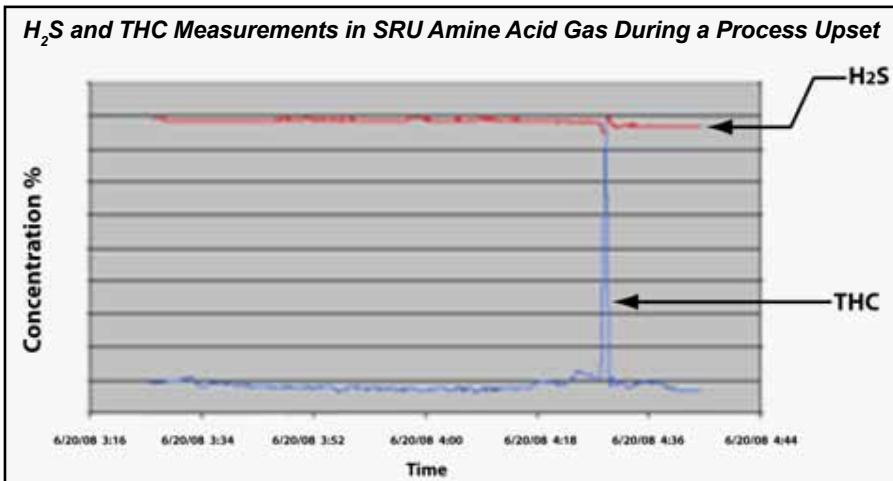
Analysis of Feed Gas Components.....What is really needed, how to use it

Feed gas analysis has been widely applied using a variety of analytical techniques and combination of discrete analyzers to make a comprehensive quantification of the components. What is required is a real time (< 5 seconds) analysis of the combustion components and so analysis time is paramount. What has complicated this is the multiple components of hydrocarbons (HC) present and the belief that each component had to be quantified. In the interest of speed, rather than try and speciate the HC components it is sufficient for control purposes to make a single measurement of total hydrocarbon (THC) content provided

it accounts for the total "air demand" and this can be accomplished using simple infrared techniques. In terms or real time control this is much superior to an individual component analysis of the HC requiring minutes rather than seconds³.

Quantification of H_2S is also required in feed forward analysis and NH_3 , CO_2 , H_2O depending on the application. The utility of all these measurements can be described as follows:

- ▶ H_2S is the major component and is normally slow moving in terms of compositional change.
- ▶ Hydrocarbon is a minor component but fast moving and has a significant combustion air requirement.
- ▶ Ammonia (NH_3) is present in sour water stripper gas and has to be accounted for if present.
- ▶ CO_2 is a relative minor contributor to air demand but can easily be included in the matrix analysis
- ▶ H_2O while not contributing to air demand can be used for gas gravity adjustments for air control.



The Analyzer

The only practical analytical method to consider for the required measurements is infrared and ultraviolet photometric spectrometry because of the need for speed of response. The most demanding analytical requirement, that of analyzing for the various HC components ($C_1 - C_6$) can be accomplished by measuring in the infrared spectrum using a relatively simple NDIR light bench. It is a legitimate question to ask; how can a simple integrated measurement of total HC be of utility when what is needed is a quantification of each HC component as each has a distinct air requirement? Fortunately, analysis at certain wavelengths in the mid infrared spectrum can accurately measure an integrated value of the carbon bonds and therefore, accurately account for the overall air demand without having to speciate each component³.

NDIR is also used to measure the CO_2 as well as H_2O and could possibly be used to analyze for H_2S , but H_2S is a weak absorber in the IR and while it is "slow moving" the contribution to the overall air demand requires the precision of ultraviolet (NDUV) spectroscopy (See Fig. 2). For this reason AMETEK combines both NDUV and NDIR in a single analyzer, the result is superior reliability, redundancy and precision.

The IPS-4 "Dual Bench" analyzer has an independent UV and IR photometer utilizing a common platform, electronics, sample cell and sample handling system. It is ingress rated IP65 for installation without an analyzer house or cabinet. It has a web-enabled interface for complete remote interrogation and diagnostics. Exact configuration depends on the application; following is a list of typical components and typical ranges.

Component	Range %
H_2S	0-100
Hydrocarbon	0-5
NH_3	0-50
CO_2	0-10
H_2O	0-10

Fig. 2

Sampling System.....The safety aspect

SRU acid gas / feed gas analyzer installations number in the hundreds but a great many have been abandoned or underutilized because of the perceived safety risk in the sample handling. For this application the sample system was given special attention. The toxicity of high concentration H_2S is well known and so the sample system design is simple and compact to minimize the possibility of leakage. A sample probe with built-in particulate and membrane filters is used to extract the sample from the gas line, while removing any liquids or particulates. This allow the sample point to be moved upstream of the knock-out drum, closer to the amine unit outlet, providing faster response time and early warning of changes in acid gas composition. The probe can be isolated from the process and back flushed (along with the analyzer) so

safety integrity is maintained during service intervention. AMETEK refers to this integrated sample system as the Heated Acid Gas (HAG) probe and it as well as the entire sample system is maintained above the dew point of the sample so it is a true "hot-wet" analysis (See Fig. 3 and 4).

One additional safety aspect of the IPS-4 analyzer is the web-enabled interface. This is a complete interface allowing for remote; logging of alarms, interrogation of the analyzer and configuration changes. The maintenance technician has less reason to go to the unit thereby minimizing exposure to potentially hazardous situations. The combination of the HAG probe and the web interface makes for a huge improvement in reliability.

Implementation and Practical Use of Feed Forward Analysis

Improved control is the obvious objective and true feed forward control is possible with the individual compositional components available from the analyzer. While closed loop feed forward control may only demonstrate recovery efficiency improvements of 0.3 to 0.5% over the long term⁴ it is the recovery from gross upsets where the real benefit lies. There are several examples where feed gas upsets have resulted in recovery efficiency losses of 5% or more and for the event to last many hours. Mitigating recovery



efficiency losses with quick recovery and preventing an environmental exceedence proves the true value of the measurement.

There are other benefits that are not as apparent. While gathering user feedback from process operators, we were told it was not so much the sudden appearance of hydrocarbons in the feed gas that gave the most severe operational problems but rather the sudden disappearance of the hydrocarbons. In the absence of feed composition data the first indication of hydrocarbons in the acid gas can be the tail gas analyzer when the H₂S spikes up, the SO₂ goes to zero and

the control response is to “add air” to come back to 2:1. Conversely, when the hydrocarbon episode suddenly ceases the SO₂ in the tail gas spikes up and this can cause damage in the tail gas treating unit (TGTU) as it is difficult to get back off the air before SO₂ breaks through the reduction reactor in the TGTU⁴ (See Fig. 1).

Another way to utilize acid gas analysis is to perform a material balance on the SRU and calculate instantaneous recovery efficiency in combination with CEMs mass emission or a process H₂S measurement in the TGTU.

The AMETEK Solution

AMETEK Process Instruments has a fifty year history of providing process analyzer solutions to the sulfur recovery industry. The measurement, the sample system, the safety and the experience to implement feed forward analysis into a SRU are brought together to provide this solution. Each application has unique requirements and we suggest you contact your AMETEK representative to arrange a detailed review of your requirements.



Fig. 3. HAG Probe

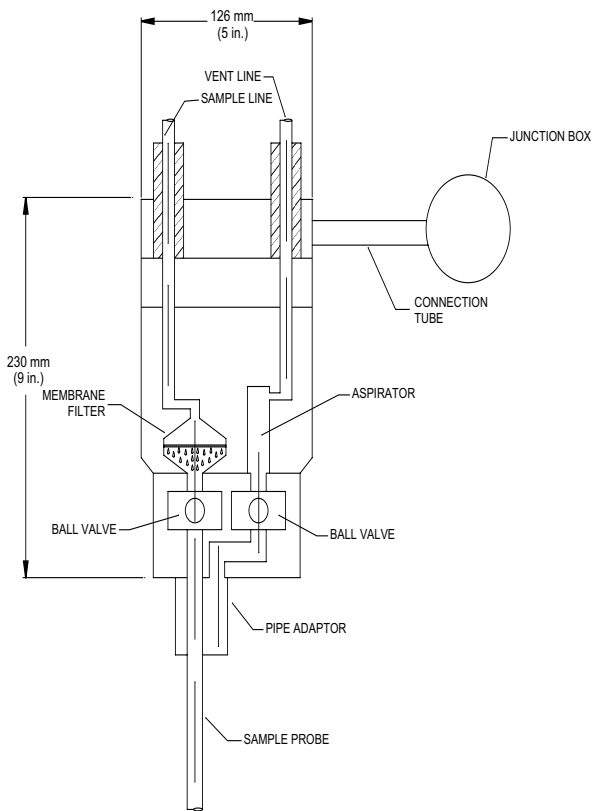


Fig. 4. HAG Probe Flow Diagram

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F-0299 Rev 3 (0312)

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