OPTIMISE TO THRIVE

Richard Koeken, Fluid Components International (FCI), and Alessandro Esposito, Precision Fluid Controls, explain how flow meters can help refiners to optimise boiler air feed for sulfur recovery units (SRUs).

Sulfur is present in various forms during the production and refining of hydrocarbon fuels (crude oil), including sulfur dioxide (SO_2) gas and hydrogen sulfide (H_2S) gas. The sulfur found in crude oil products is toxic and presents a serious hazard to workers, equipment and facilities.

Exposure to sulfur becomes toxic at 10 ppm and lethal at 800 ppm, and it is flammable when present in excess of 4.3% by volume in air. The presence of sulfur and exposure to it in its various forms is highly regulated worldwide by health, safety and environment (HSE) agencies.

The removal of sulfur from hydrocarbon fuels is therefore essential for safe and efficient refinery operations. H_2S gas has a rotten egg smell, but in high concentrations a worker's sense of smell can be quickly overcome, leaving them vulnerable to respiratory issues and even death. For these reasons, H_2S gas detectors are strategically placed in refineries.

To remove the sulfur from hydrocarbon fuels, refineries typically install sulfur recovery units (SRUs) that utilise the Claus process (see Figure 1). The multi-step Claus process is dedicated to processing the H_2S stripped from the hydrocarbon fuel.

The typical SRU Claus process operation consists of a burner system for the combustion of the sulfur-rich sour gas (acid gas) followed by a catalytic converter to produce harmless sulfur powder, water and waste gas (tail gas). Tail gas from the SRU can be further treated by either flue gas desulfurisation (FGD) or a thermal oxidiser.

The resulting sulfur powder can then be used in other manufacturing processes for fertilizer, pesticides, rubber, medicines and cosmetics. Oil refineries, gas processing plants and petrochemical facilities are the primary source of the world's sulfur production.

Figure 1. An SRU.

Case study

The problem

A refinery in Saudi Arabia needed to optimise its SRU system (see Figure 2) in order to increase its efficiency and reduce costs. The plant team at the refinery quickly identified the need for more accurate and reliable measurement of air on the boiler's main air feeder line, which would require a more robust air flow sensing technology.

The refinery's engineering company in southern Europe contacted the applications specialists at Fluid Components International (FCI) and Precision Fluid Controls. They explained the importance of closely controlling the ratio between the H_2S acid gas, the tail gas, and the available oxygen (air), as this was crucial to the effective operation of the SRU system. The system's air feed included a main air feed and a trim air feed to closely control the total air feed to the boiler.

The plant team explained that the new flow meters selected for the main air feed, trim air feed and tail line must be responsive. They would have to quickly sense air or gas flow and measure the flow rate fast enough to ensure that the air flow would not over and/or undershoot the process set point. The tight tolerances specified would ensure more efficient combustion in the first thermal phase of the process, where the acid gas is burned to heat the boiler system and produces the high-temperature steam necessary for the reactors in the catalytic phase of sulfur recovery.

The SRU system's air feed lines, where the new flow meters were to be installed, would typically have a pipe diameter of 8 – 40 in., depending on the size of the SRU system. The flow meters selected for this process must also have a response time of < 1 sec.

The flow meters would need to be able to withstand process temperatures of up to 140°C (184°F), and the flow sensing technology employed needed to introduce no more than a pressure loss of < 0.005 bar (< 0.07 psi) in order to ensure the effectiveness of the SRU system.

In addition to these specifications, the flow meters would need to be rugged enough to minimise any maintenance requirements and operate over a long life cycle. They would also need to have Ex approvals due to the presence of combustible hydrocarbon gases such as H_2S, as well as SIL compliance to ensure reliable and safe operation.

The solution

The applications engineers at FCI

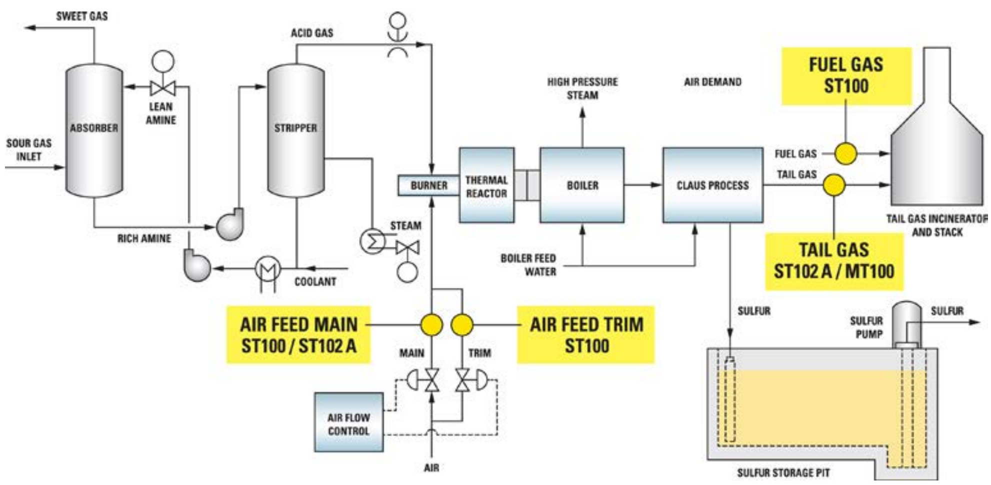

Figure 2. Flow block diagram of the SRU process.

recommended the installation of its advanced ST100 Series thermal mass flow meter (see Figure 1). This meter's thermal dispersion sensing technology offers direct mass flow measurement of air and gases without the need for additional pressure or temperature sensors, which is common with many other flow measurement technologies and adds to their complexity as well as the cost of initial installation and maintenance.

The single-point version of the meter was recommended for the refinery's SRU air main header line and the tail gas line, as it provides the best accuracy for pipe diameters from 8 to 12 in. For inline sizes larger than 12 in., or where a line's air/gas flow profile is unstable, a dual-point meter configuration is recommended for optimum accuracy. This dual-point meter's transmitter integral or remote electronics average the input of two independent flow elements to provide the required accuracy and repeatability.

The meter recommended for the SRU system application featured an AST™ drive technology, which ensures both fast response, and facilitates the widest flow ranges possible. In the event that wetted parts of this flow meter are subject to high H_2S concentrations (as was the case at this refinery), the meter can be ordered with its flow element constructed of all-welded Hastelloy C276 materials. In addition to this, a NACE compliance certificate can also be provided.

The refinery engineers agreed that the recommended thermal mass meter exceeded their needs, with accuracy of +/- 0.75% of reading, +/- 0.5% of scale, with 100:1 turndown over a wide operating range of 0.07 – 305 normal meter per second (NMPS), which equates to 0.25 – 1000 standard feet per minute (SFPM). The meter performs as per the refinery's required specification of < 1 sec., 63% of final value (one step change).

The refinery team appreciated the meter's insertion configuration with optional threaded tap or flanged connection, which made it simple and inexpensive to install as compared to inline meter designs. The full meter was approved for hazardous areas, which allowed its integral transmitter to be installed at the point of measurement, rather than requiring a remote installation with additional cabling, cable glands, etc.

The meter's robust electronics and ultra-rugged enclosure are also IEC 61508 (SIL 1) compliant (confirmed by third-party FMEDA report), ensuring reliable and safe operation. If maintenance is required, the meter's insertion design with ball valve construction allows it to be removed for cleaning without shutting down the process line.

Whether the outputs required are traditional 4-20 mA analog, frequency/pulse, or advanced digital bus communications such as PROFIBUS, HART, Foundation Fieldbus or Modbus, this meter's versatile transmitter accommodates them all. In addition, should there ever be a need to change or upgrade, the meter can be converted to any of these outputs with a simple card change in the field.

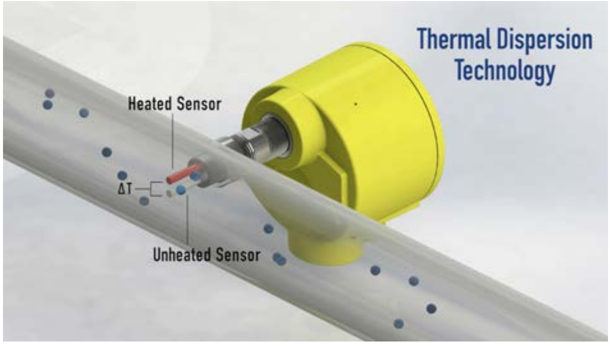

Figure 3. Thermal dispersion sensing theory of operation.

The transmitter's digital display/readout provides comprehensive data, including flow rate, totalised flow and extensive diagnostics. This digital readout is designed with a backlit LCD and four optical touch buttons. The backlight has a unique proximity detector that illuminates it only when a technician approaches, or it can be set to 'always on'. The display and button functions can be rotated electronically, via the buttons, in 90° increments, in order to optimise display viewing and button activations.

Thermal dispersion flow sensing

The recommended flow meter is designed with thermal dispersion sensing technology. The sensor operates by placing two thermowell protected platinum resistance temperature detector (RTD) temperature sensors in the process stream. One RTD is heated while the other senses the actual process temperature. The temperature difference between these sensors is proportional to the media cooling effect and directly proportional to the gas mass flow rate without the need for additional pressure or temperature transmitters.

With this direct mass flow sensor technology, the meter selected by the refinery plant team also includes built-in, real-time temperature compensation. This capability ensures repeatable and reliable measurement in applications where wide process temperature variations are present. With no moving parts or orifices to plug or foul, the thermal mass flow meter is immune to dust and dirt, resulting in virtually maintenance free, continuous operation and lower life cycle costs.

Conclusion

The thermal mass flow meters were installed and commissioned on the main air feed and trim air feed line without any issues. Their robust design and dependable accuracy have helped the refinery team to achieve its efficiency and cost reduction goals for the operation of the SRU system.