From the European Union to the US, national and international bodies are putting in place increasingly stringent legislation to limit emissions. Along with power generation, the oil refining and gas sector is seen as one of the largest emitters of air pollutants and is under pressure to reduce emissions year on year. One of the key sources of pollutants are sulfur recovery units (SRUs), which are now required to reduce sulfur emissions further before the gas can be discharged to the atmosphere. Sulfur recovery units typically use Claus technology to recover sulfur in offgases from refineries and gas plants. Whether or not they are followed by a tail gas treater unit to recover additional sulfur, the tail gas is generally incinerated. The treatment converts H₂S into SO₂. Reducing the resulting SO₂ can be accomplished by the installation of a tail gas scrubber. If properly designed, these tail gas scrubbers can cut the sulfur dioxide (SO₂) emissions from a sulfur plant to levels of 20 to 50 ppmv (dry basis) and in some cases as low as 5 ppmv (dry basis).

However, it is important that the right SRU tail gas scrubber is used to ensure it addresses the typical challenges it faces, which include:

- The requirement to meet and guarantee low SO₂ emissions.

Yves Herssens, MECS/DuPont, Belgium, and Steven Meyer, MECS/DuPont, USA, explain how tail gas scrubber sulfur plant bypass ability aids emergency shutdowns and startups.
The ability to handle a wide range of inlet SO2 loadings.
A high turndown required.
Reliability and proven experience.

With over 500 scrubber references around the globe and in various industries, DuPont is well aware of the parameters sulfurous offgas scrubbers have to meet. With the combined expertise of DuPont and MECS, it believes the proven flexibility of the MECS® DynaWave® Wet Gas Scrubber is well suited to the specific challenges of SRU offgas treatment in all circumstances.

Several plants have found added benefits to having an SRU tail gas scrubber. With the proper scrubber design, startups and emergency shutdowns are easier as the sulfur plant can be bypassed and the feed gas sent directly to an incinerator where sulfur is converted to SO2. The SO2 rich stream is then directed to a tail gas scrubber in order for the SO2 to be removed and so achieve acceptable emission limit levels before discharge to the atmosphere. Under bypass conditions, the level of SO2 sent to the scrubber can be as high as 20% vol. The scrubber must therefore be able to handle very high SO2 loadings.

**Sulfur dioxide emissions reduction with tail gas scrubber**

In most sulfur plants, process gas is typically sent to an incinerator where any H2S or sulfur compounds not removed in the sulfur plant are converted to SO2. Some plants have a waste heat boiler downstream of the incinerator to take advantage of the 1400° F (760° C) exit gas to produce steam. At times, the incinerator offgas can be sent directly to the stack. However, as mentioned above, many new and existing sulfur plants are now required to install tail gas scrubbers to reduce the SO2 to even lower levels before being discharged to the stack.

Figure 1 shows a schematic of a typical flow scheme depicting the sulfur recovery unit (SRU), incinerator and tail gas scrubber.

In the scrubber, SO2 is absorbed into the scrubber circulating liquid where it reacts with sodium hydroxide, (NaOH) also known as caustic soda. The acid base reaction produces a sodium sulfate soluble salt after air oxidation.

**Designing for sulfur plant gas bypass**

As shown in Figure 2, a properly designed incinerator and tail gas scrubber makes it possible to bypass the sulfur plant and treat the sulfur solely with an incinerator and tail gas scrubber.

In order to take advantage of a tail gas scrubber’s ability to handle a sulfur plant bypass, the scrubber must not only be designed to handle extremely high levels of SO2 coming into the scrubber in the inlet gas, but it also must reduce the SO2 to extremely low outlet levels. In many cases, this requires SO2 removal efficiencies of +99.9% or higher. To meet both of these constraints, the scrubber has to have multiple contact stages and a high liquid circulation. A typical packed tower is limited in the amount of liquid that can be circulated. The DynaWave® Wet Gas Scrubber, however, uses three distinct contact stages, two of which work with froth technology that produces the extremely high liquid circulation rates necessary for high SO2 loadings. All three contact stages are in a single vessel, as shown in Figure 3.

The gas is first contacted in a vertical duct with a liquid stream that is injected counter current to the gas stream. As the gas and liquid make contact, a froth regime, or zone, is developed. This zone is a highly mixed gas liquid area where the gas is instantly quenched and the SO2 is absorbed into the liquid.
stream. Because of the nature of the froth zone, very high liquid circulation rates are possible. To describe this, scrubbers and packed towers use the term ‘liquid to gas ratio’ (L/G ratio) to express the amount of liquid that is in contact with the gas. In the UK, the L/G ratio is expressed in gallons per minute per 1000 actual cubic feet per minute, or gal/min/1000 ft³/min. In metric units, the L/G ratios are m³/hr of liquid/1000 m³/hr of gas flow. A typical L/G ratio for a packed tower is 40 gal/min/1000 ft³/min (300 m³/hr/1000 m³/hr). In the DynaWave® Wet Gas Scrubber froth zone, the L/G ratio can be as high as 300 gal/min/1000 ft³/min (2200 m³/hr/1000 m³/hr). Using two such high L/G contact stages in conjunction with a packed section results in a total DynaWave® Wet Gas Scrubber L/G ratio of 640 gal/min/1000 ft³/min (4800 m³/hr/1000 m³/hr) (Figures 3 and 4). This circulation rate contains 16 times the amount of liquid per unit of gas scrubbed compared to a typical packed tower. This extremely high L/G ratio makes it possible for the DynaWave® Wet Gas Scrubber to remove up to 10 vol% of SO₂ from a gas stream down to low ppm levels. Although the capital cost increase for a combination DynaWave®-Packed Tower above a typical packed tower is approximately 30%, that is still well below the cost of the multiple vessel arrangements that would be required to remove high levels of SO₂ from a sulfur plant bypass condition.

Sulfur plant bypass enables maintenance

As the tail gas scrubber is able to handle a sulfur plant bypass, plant personnel have the option to operate in bypass mode in order to perform maintenance on the sulfur plant or to change a catalyst bed. With the scrubber designed for the bypass case, any incidents in the sulfur plant can be accommodated by the DynaWave® Wet Gas Scrubber system and SO₂ emissions would not exceed the plants permit level. If desired, the DynaWave® Wet Gas Scrubber can be operated using a single Froth Zone contact stage during normal operation, thereby saving pump power. It should be noted that the cost of the caustic reagent can be high while operating the sulfur plant in the bypass mode. However, as this mode of operation should only be temporary, this cost is relative compared to the cost of a complete plant shutdown.

Conclusion

Should a sulfur plant have to be shut down for maintenance, the ability of a DynaWave® Wet Gas Scrubber to handle very high levels of SO₂ in the gas stream makes it possible to bypass the sulfur recovery plants. At the same time, the DynaWave® Wet Gas Scrubber offers additional operational flexibility if the level of sulfur exceeds the capacity of the sulfur plant. Some of the gas normally sent to the sulfur plant can be bypassed to the incinerator and then to the scrubber to accommodate a temporary surge in sulfur feed to the sulfur plant. The additional capital cost for the combination DynaWave®-Packed Tower Scrubber is minimal, making it an attractive addition to a sulfur plant.