Reliable scrubbing of sulphur tank vents

Several technologies are used for sulphur tank vents to remove sulphur contaminants. H_2S scavengers provide economic H_2S removal at concentrations of 500 ppm or less in the gas stream. Scrubbing technology reduces operating costs at higher concentrations, but both scavengers and packed tower scrubbers suffer from pluggage caused by the entrained elemental sulphur particulates. **S. Meyer** and **A. Trapet** of MECS describe how the DynaWave technology offers a solution which reduces operating costs and maintenance issues.

Storage of molten sulphur in tanks or pits is a typical means of stocking sulphur for use in a variety of applications. In some cases, these tanks use air to purge the liquid sulphur to strip out H_2S, or SO_2. In other cases, air is used to "sweep" the vapour space above the liquid sulphur to remove accumulated H_2S and SO_2 gases plus Sulphur vapour. In both cases, the air must be removed from the vapour space and vented. Since this air will contain varying levels of H_2S, SO_2, and sulphur vapour, the vent air must first be scrubbed to remove the sulphur contaminates before it can be released to the atmosphere.

The most prevalent issue affecting sulphur tank or pit applications is the formation of elemental sulphur in the gas stream. Vaporous sulphur will condense into elemental sulphur when the gas temperature falls below the sulphur dewpoint. Elemental sulphur is sticky and will quickly plug ducting if the ductwork is not steam traced.

There are several "traditional" methods of treating the sulphur tank vent gas, two of which are; a typical packed tower and the use of a sulphur scavenger such as Sulfa Treat or LO-CAT. Each has their advantages and disadvantages. A third solution is the use of a DynaWave® Scrubber, a wet gas scrubber that scrubs H_2S, SO_2 and sulphur particulates from the vent stream.

DynaWave technology

The DynaWave scrubber is a unique wet gas scrubbing device that uses froth technology to create a highly energised gas-liquid contact zone with no internals that could become plugged with solid sulphur. The gas first enters the inlet duct and is contacted by a full cone, counter-current liquid spray. The liquid is not atomised, but instead relies on contact with the gas to create a froth regime. In this froth regime, the gas is immediately quenched, the H_2S and SO_2 is absorbed, and solid or vaporous sulphur is condensed and removed by particle growth and venturi effects (see Fig. 1).

Fig 1: **Typical DynaWave scrubber**

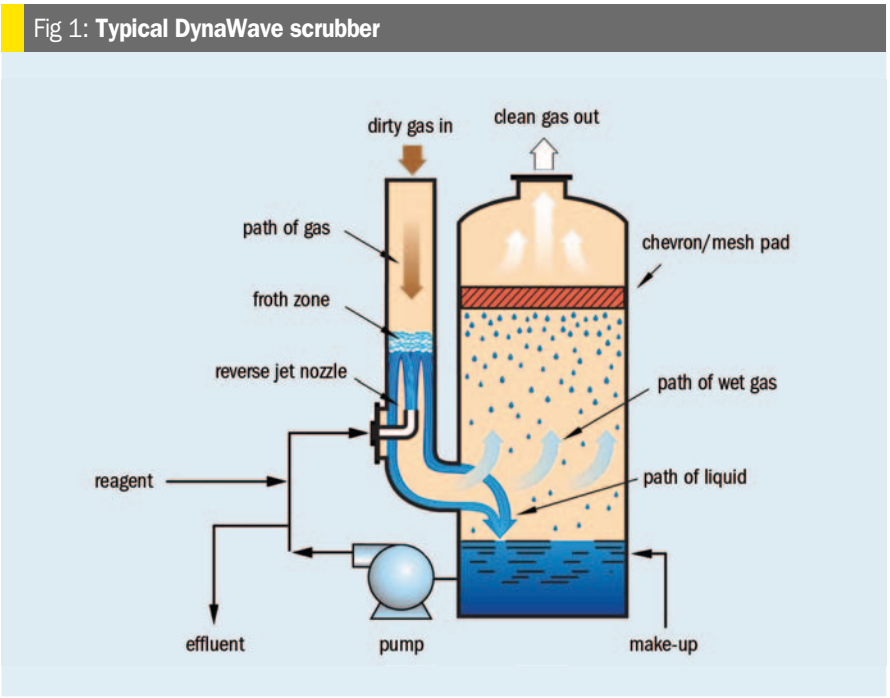

Fig 2: **Typical DynaWave nozzle**

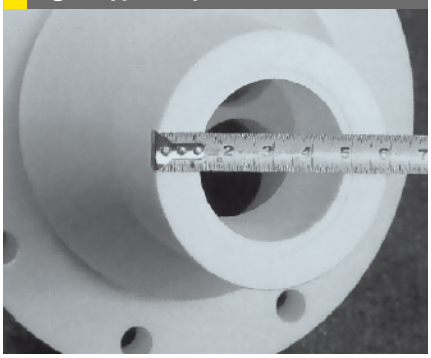

Table 1: **Typical tank vent contaminants and example stack outlet requirement**

Component	Vent concentration, ppm, vol basis	Stack outlet, ppm, vol basis
SO_2	100	< 10
H_2S	2000	< 10
Sulphur (solid and vapour)	500	< 5

The reverse jet nozzle (Fig. 2) is the heart of the DynaWave technology. It is a large open bore design that allows the scrubber to operate with very high levels of suspended solids in the circulating liquid without plugging. This is particularly important for sulphur tank vent scrubbing due to the presence of sulphur particles and sulphur vapours that will condense and form solid sulphur particles.

The gas and liquid leave the froth zone or contact zone and enter the separation vessel where the liquid will collect in the vessel sump and the cleaned gas will exit through a chevron gas-liquid separation device and then to a stack. The collected H_2S and SO_2 are then further reacted with caustic and sodium hypochlorite to produce harmless sodium sulphate and sodium chloride per the following reactions:

$$SO_2 + 2NaOH + NaOCl \rightarrow Na_2SO_4 + NaCl + H_2O$$

$$H_2S + 2NaOH + 4NaOCl \rightarrow Na_2SO_4 + 4NaCl + 2H_2O$$

Sodium hypochlorite is added to oxidise the sulphur salts after they have been reacted with caustic. The effluent from the scrubber will consist of sodium sulphate salt, sodium chloride salt, and suspended solid sulphur. If necessary, the solid sulphur can be removed by a clarifier and the remaining liquid containing sulphate and chloride salts can typically be sent to a waste water treatment plant.

Table 1 shows a typical gas contaminate concentration from a sulphur tank vent as well as an example stack outlet requirement.

Stack outlet requirements can vary greatly from site to site. The example in Table 1 indicates what is achievable.

Packed tower technology in sulphur treatment

As mentioned, a typical method of scrubbing the sulphur contaminants from sulphur tank vents is a packed tower. A packed tower is a mass transfer device that will readily absorb H_2S and SO_2 as per the same chemical reactions as shown above. Like the DynaWave, a packed tower uses caustic and sodium hypochlorite to convert the H_2S and SO_2 to sodium sulphate. However, vent streams from sulphur tanks also contain elemental sulphur in the form of a solid or vapour.

The vaporous sulphur will immediately condense to a solid upon contact with the scrubbing liquid. The elemental sulphur then becomes a suspended solid in the circulating liquid. This becomes a plugging problem for packed towers. In contrast, for the DynaWave scrubber suspended solids in the circulating liquid are not a problem. The DynaWave is designed as a slurry scrubbing device that can handle 20 wt-% of suspended sulphur solids in the circulating liquid. It is practically impossible to plug.

Solid sulphur collected by the DynaWave is suspended in the circulating liquid and eventually discharged through an effluent stream with the sodium sulphate. If desired, the solid sulphur can be separated with a small clarifier. The ability of the DynaWave scrubber to handle solids gives it a distinct advantage over a packed tower.

Scavengers in H_2S removal

H_2S scavengers are prevalent in the market, and are very appropriate solutions when the H_2S concentration is low, for example, 500 ppm or less. Capital cost is low, and reagent cost, although high as regards dollars per lb of H_2S removed, remain relatively interesting because of the small amount of H_2S treated. Liquid scavengers are more expensive per lb of H_2S than solid scavengers, but the drawback of solid scavengers is that the changeout is difficult and time consuming, and there is a significant volume of spent material to dispose of after each changeout. In addition, both liquid and solid scavengers can become plugged with the suspended solid sulphur which causes the same problem in packed towers.

Since the economic effectiveness of scavengers is limited to H_2S concentrations of 500 ppm or less, the sulphur vent application, at 2,000 ppm or more, is not the best application for scavengers. Although capital cost is higher for a DynaWave system, the savings in reagent cost, reduced maintenance, and easier effluent handling quickly make up the difference (see Table 2).

DynaWave H_2S, SO_2 and solid sulphur experience

There are various installations where the DynaWave has proven the ability to handle H_2S and suspended solid sulphur. In one installation in particular, the inlet gas flow had a concentration of over 40% H_2S. During commissioning, the presence of suspended solid sulphur was very evident and would have quickly plugged other removal technologies. This DynaWave installation has continued to perform to the satisfaction of the client, without shutdown or maintenance required.

Another client has chosen the DynaWave technology for the sulphur melt tank application based on installed experience in sulphur melt tank as well as the above described success of the DynaWave. In addition, this client and their engineering firm spent a number of months evaluating all of the options described in this paper. Their final choice was a DynaWave system based on capital cost, estimated maintenance and downtime, operating costs, and effluent handling. Another factor was that the client already had a DynaWave installed in another application and was familiar and satisfied with the technology.

Table 2: **Comparison of H_2S removal technologies**

	Plugging	Maintenance	Downtime	Reagent costs	Quench	Effluent handling
Scavenger	yes	medium	minimal	high	additional vessel	difficult
Packed tower	yes	high	high	low	additional vessel	neutral
DynaWave	no	low	minimal	low	included	neutral