

Liquid Scavenger vs. Fixed Bed H₂S Adsorbent. Working in Harmony or Against Each Other for H₂S Removal

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ABSTRACT

Natural gas sweetening extensively utilizes both liquid scavengers and fixed bed adsorbent technology. Typically, an operator uses one of these chemical treatment options for the selective removal of Hydrogen Sulfide in crude oil and natural gas processing. Few suppliers provide both liquid and fixed bed adsorbent and are therefore unable to look objectively an optimized natural gas sweetening solution using both technologies together.

In this paper, we discuss the advantages and disadvantageous of each natural gas sweetening technology. This review focuses on an overview of both liquid scavenger and fixed bed adsorbent, including a process description, chemistry, equipment required, footprint, method of monitoring performance, system maintenance, and the resulting economics.

A successful case study demonstrating hybrid system operation is included. This case study demonstrates how a hybrid system, using a liquid scavenger followed by a fixed bed adsorbent can be more effective in meeting customer's specific requirements. A hybrid system can improve control of both CAPEX and OPEX and provide flexible operation.

Key words: Hydrogen Sulfide Scavenger, liquid scavenger, fixed bed adsorbent

INTRODUCTION

Hydrogen Sulfide (H_2S) is an organic compound created naturally during the decaying process. In crude oil and natural gas H_2S is generated when Sulfur is removed from petroleum products. This phenomenon occurs at various stages during exploration, production and refining. In addition to the naturally occurring H_2S , sulfate reducing bacteria or SRB produce Hydrogen Sulfide (H_2S) souring the reservoir production. SRB's are living organisms that require a specific set of circumstances to grow; they need organic carbon, a sulfur source, water and the correct temperature to produce H_2S .

Some facilities may not have a desulfurization plan especially when the reservoir was initially identified as a 'sweet well'. In this case desulfurization treatment was not considered in their operations and maintenance strategies. However, over recent years the enquiries for desulfurization on brown field operations have increased indicating that 'sweet wells' may or have turned sour, possibly due to introduction of SRB from the surface via water injection.

Surface Treatment Facility

Surface treatment of H_2S can be broadly segmented into groups (Figure 1). These are split based on the feasibility and economic viability to treat a certain tonnage per day of H_2S .

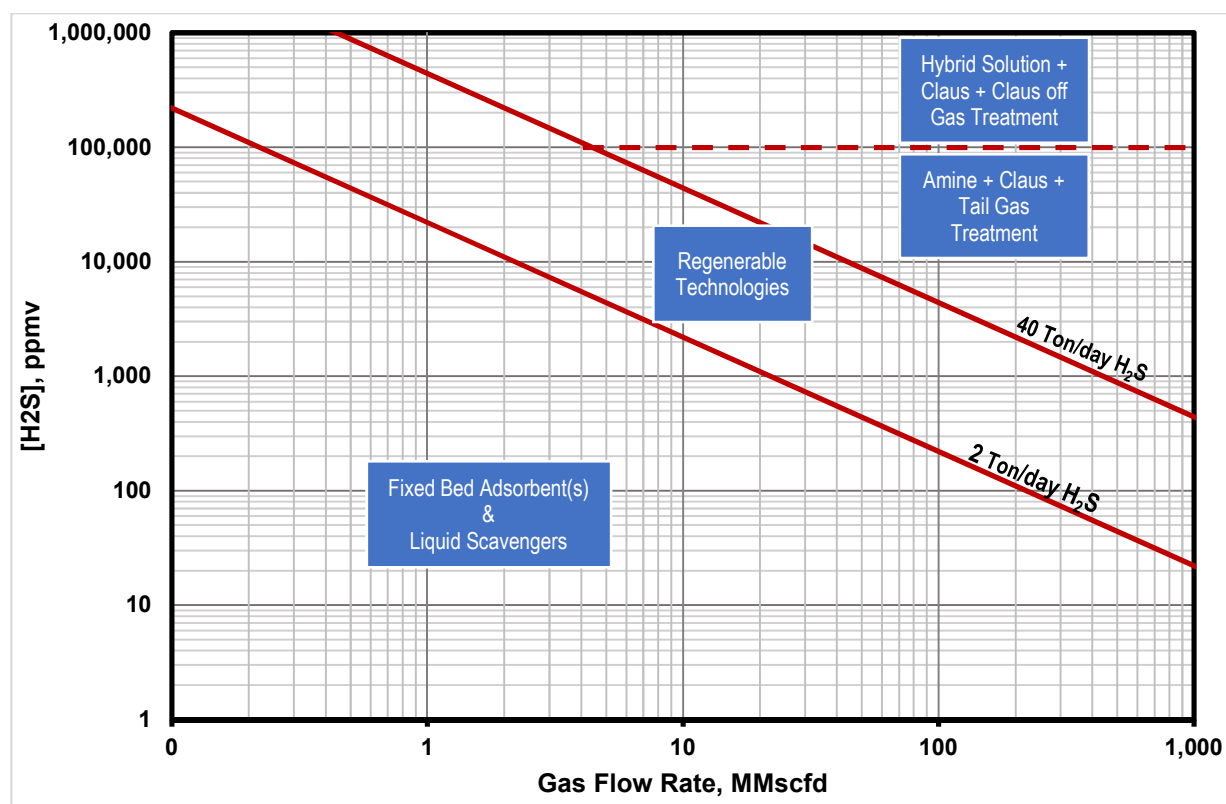


Figure 1: Typical Technology Selection by Tons Removal Per Day

Amine-Claus Process is currently the most widely used technology for recovering elemental Sulfur from H_2S [1]. Amine units use amines such as MEA and MDEA to form complexes with acid gases such as H_2S to separate them from the process gas flow. Then the Claus process uses a catalyst to convert H_2S into elemental Sulfur. Due to the relatively high capital investment and operating cost, installation of these

units is only economically viable for H₂S removal above 40 tons per day. Below 40 tons per day, it would be more feasible to use regenerative technologies; i.e. biological scrubber, amines, regenerable adsorbent, membranes and caustic scrubbers. Regenerable technologies typically work by capturing the H₂S from the feed gas and releasing it later. A user of regenerable technology will still need a mechanism to ultimately deal with the H₂S, this may include converting it to elemental Sulfur, or separating the H₂S from the gas stream prior to reinjection back into an underground reservoir cap. Therefore, it becomes uneconomical to treat H₂S below 2 tons per day removal and anything below this threshold is an opportunity for a fixed bed adsorbent or / and a liquid scavenger.

Selection of the most appropriate treatment strategy will depend on a variety of factors; H₂S concentration, gas volume, residence time, space and weight considerations, resources, process conditions, and CAPEX / OPEX sensitivity. Operating conditions will also influence the selection of treatment strategies and ultimate application locations.

When considering which type of treatment, first step is to calculate the quantity of H₂S to be removed per day. This can be done as follows (Equation 1);

$$H_2S \text{ Loading } \left(\frac{kg}{day} \right) = Flow \left(\frac{Nm^3}{hr} \right) \times 24 (hr) \times H_2S (ppmv) \times 1.52 \left(\frac{kg}{Nm^3} \right) \times 10^{-6} \quad (1)$$

This paper will concentrate on the use of liquid scavenger and fixed bed adsorbent to remove H₂S.

SCAVENGING H₂S WITH LIQUID AND FIXED BED ADSORBENT

Liquid Scavenger

The most widely used liquid scavenger for surface treatment is triazine based chemistry. This is selected due to its favorable reaction kinetics and stoichiometry between H₂S and triazine. Additionally, it is less toxic than most aldehyde based scavengers [2]. At the point of treatment natural gas has typically been separated from the hydrocarbon composition and reaction with H₂S happens in the presence of water. The atomized liquid triazine decomposes the H₂S by the nucleophilic substitution in the sulfur into the triazine ring and rapidly hydrolyzed [3]. Therefore, it is important that treatment is applied upstream of the separator as water is needed for reaction to occur. Any unreacted water soluble liquid scavenger is discharged in the water phase of the separator.

The removal rate using liquid scavenger depends upon the dissolution of H₂S into the triazine solution [3]. As a result, pressure, temperature, H₂S and CO₂ concentration, gas flow rate, contact time, and misting size and distribution contributes to the final scavenger performance.

Fixed Bed Adsorbent

Adsorption is a surface-based mildly exothermic process that leads to the transfer of a molecule from a fluid bulk to the solid surface of the adsorbent. The substance that is adsorbed to the adsorbent is called adsorbate. The process may also be classified as physical adsorption (physisorption) or chemical sorption (chemisorption), depending on the interactions between the molecules and surface. Physical adsorption is dominated by weak Van der Waals forces and electrostatic interactions, while in chemisorption, strong chemical bonds such as covalent bonds are formed between the surface and the adsorbed species [4]. Fixed bed adsorption tower units generally consist of one or more towers, filled with adsorbents. Depending on the operating condition, the type of non-regenerable adsorbents generally can either be iron oxide or mixed metal oxide. The general reaction between H₂S and a metal oxide is