Cheap and Zero-Sources CCU Processing: What about the CO_2 Reduced by Other Emissions?

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Acid gases are common pollutants in the process industry. Their removal and abatement is mandatory from environmental, safety, and operational standpoints. H_2S is typically decomposed in Sulfur Recovery Units (SRU) through the Claus process. Even if effective for H_2S neutralization, Claus process does not exploit the hydrogen content of the gas. The Acid Gas to Syngas (AG2S™) technology is a novel alternative that aims to replace the Claus unit by converting acid gases into syngas (H_2 and CO), the building block for base chemicals synthesis, through the innovative overall reaction defined, validated and industrially implemented by the authors:

$$2\ H_2S + CO_2 \rightarrow H_2 + CO + H_2O + S_2$$

This work investigates the modeling of a dedicated AG2S™ unit. The process is composed by three main reactive sections in series: a burner, a reactive thermal reactor (RTR), and a waste heat boiler (WHB). In the burner, a part of H_2S is combusted with sub-stoichiometric pure oxygen to reach the high operating temperatures (above 1200 °C) required for endothermic reactions and decomposition of unwanted species such as ammonia. The AG2S™ reaction occurs in the adiabatic RTR, generating syngas, while in the WHB the effluents are rapidly cooled to limit reverse reactions. Recovered heat is used to preheat the feed; the unconverted gases are recycled to ensure the complete H_2S abatement.

A preliminary analysis is conducted to identify optimal operating conditions, focusing on the H_2S/CO_2 feed ratio required to produce a syngas with an H_2/CO molar ratio close to 1. The study is based on detailed process simulations combining a dedicated suite for kinetic modeling of sulfur species (developed at Politecnico di Milano) with conventional process modeling in Aspen HYSYS v.11. This approach allows to investigate composition and temperature profiles along the unit allowing to the consequent reactor design.

Preliminary results highlight that syngas quality, in terms of SN, improves with higher H_2S/CO_2 ratios. Specifically, with a feed ratio of 4 and an RTR temperature of 1200 °C, an H_2S conversion of approximately 60% per pass is achieved, and the resulting syngas has an SN between 0.9 and 1.0. The analysis shows that approximately 0.5 kmol of CO_2 are sequestered and utilized per kmol of syngas (H_2 + CO) generated. Even if preliminary, these results demonstrate the feasibility of recovering high-value products from typical waste streams. Further studies are required to assess the integration of AG2S™ as a viable alternative to SRUs from technical, economic, and environmental perspectives.

Keywords: *Acid Gas; Syngas, H2S, Process Simulation; Reactor Design*