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Effect of O_2 Concentration on the Reaction Furnace Temperature and Sulfur Recovery Using a TSWEET® Process Simulator

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Abstract

In the present study, effect of a parameter for increasing the reaction furnace temperature and sulfur recovery of Claus sulfur recovery units (SRUs) is investigated by TSWEET process simulator based on Gibbs free minimization. The effect of oxygen enrichment on the reaction furnace temperature and sulfur recovery has been studied by proposed simulator. In the case of the effect of O_2 concentration, temperature of main burner increased monotonically. It is found that sulfur recovery (in the O_2 high concentrations) increases up to a maximum value and then decreases with increase of O_2 concentration, while this is not the case for O_2 low concentrations.

Keywords: Sulfur recovery; O_2 concentration; Reaction Furnace; Claus unit

Introduction

Sulfur recovery unit (SRU) is an important unit in natural gas processing units. It removes H_2S from acid gas feed before they can be released into the environment [1]. H_2S exists mainly as an undesirable by-product of gas processing units [2]. Different processes are applied to recover sulfur from H_2S. The most widely used process is Claus process [1,3]. It should be noted that several modifications were developed on the main Claus process in order to increase the overall sulfur recoveries.

The sulfur recovery requirements range from 97.5 to 99.8% for gas processing units and refining facilities processing 10 LT/d and greater of natural gas [4]. By increasing the number and type of beds in the case of rich acid gas feed, the sulfur recovery increases from 96.1% to 99.3%. In the case of lean acid gas feed, the sulfur recovery increases from 96.1% to 96.6%.

Recently, a number of studies have been studied the reaction furnace of Claus units. As the fraction of the AG splitter flow to main burner increased, initially the temperature of the main burner increased to a maximum temperature but it then decreased sharply as the flow was further increased. This was true for all three concentrations of oxygen [5]. However, if the concentration of H_2S, the H_2S/CO_2 ratio and the flow rate of air are increased, the temperature of the main burner increased [5].

In this paper, the simulation of Claus process was done, and Also effect of O_2 concentration on the reaction furnace temperature and sulfur recovery is investigated. For these purposes, intake air and acid gas feed are classified into three different categories in terms of their composition. The first type of intake air and acid gas feed contains 21 mol% of O_2 and 30 mol% of H_2S (usual feed and input air). The second type includes 50 mol% of O_2 and 50mol% of H_2S. The last type contains 85 mol% of O_2 and 90 mol% of H_2S (O_2 enriched air-H_2S reach feed).

Methodology

Research methodology consists of a review on O_2 concentration (in the tail gas ratio of 2.0) effect on the reaction furnace temperature and sulfur recovery of Claus unit using a process simulator called TSWEET.

Figure 1 shows the flow diagram of the Claus unit. In this process, the acid gas (acid gas + fuel gas) enters SRU and is divided into two streams in the AG splitter. A part of the feed stream is sent to the main burner, and another part is sent to the acid gas heater (for hydrolyzing sulfur components to H_2S). 1/3 of H_2S in the acid gas is oxidized to SO_2 at the main burner using outlet air of air blower.

$$H_2S+3/2O_2 \leftrightarrow SO_2 + H_2O \quad (1)$$

This combustion generates a large amount of heat. Further, the combustion products undergo Claus reaction between H_2S and SO_2.

$$2H_2S+ SO_2 \leftrightarrow 3/nS_n + 2H_2O \quad (2)$$

Where n is in the range of 6-8. Reaction (2) is exothermic and reversible, thus, processing under adiabatic conditions increases temperature.

The effluent gas from the main burner (reaction furnace) passes through the first pass waste heat boiler (1st pass WHB) to recover heat and produce high pressure steam [1,6]. The second pass of the waste heat boiler is where the redistribution of S_2 to S_8 is the primary reaction. It should be noted that, side reactions involving hydrocarbons and CO_2 in the acid gas feed can result in the formation of carbonyl sulphide (COS) and carbon disulfide (CS_2) in the main burner [7]. The effluent streams from the 2nd pass WHB and acid gas heater is cooled in condenser 1 to condense and recover the liquid sulfur. The effluent gas of the condenser 1 is preheated in the reheater 1 and is sent to the catalytic converters where Claus reaction occurs at lower temperatures. This leads to higher equilibrium conversion because Claus reaction is exothermic.

Typically, COS and CS_2 are also hydrolyzed in the first catalytic converter according to the following exothermic reactions [2]:

$$COS+H_2O \rightarrow CO_2+H_2S \quad (3)$$

$$CS_2+2H_2O \rightarrow CO_2+2H_2S \quad (4)$$

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