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Effect of the Oxygen Concentration in the inlet Air to the new Operating on the Sulfur Components in the TailGas

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Abstract
Concentrations of the H_2S and SO_2 in the TailGas in response to high concentrations of oxygen in the air oven (for the four oxygen concentrations in the air entering to the new design) have minimum amount of their own. But the SO_2 concentration in the TailGas (At high concentrations of oxygen input into the reaction furnace) is a maximum. Concentration of the CS_2 in the TailGas, in the oxygen concentration equal to 21% molar is lower with than other concentrations. Concentrations of the S_2, S_3, S_4, S_5, S_6, S_7 and S_8, in the concentration of oxygen in the air inlet to the reaction furnace above 70 mole%, were minimal.

Keywords: Oxygen Concentration, TailGas, Sulfur Components, reaction furnace, Claus unit.

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1. Introduction

Sulfur Recovery Units (SRU) in industrial scale processes is divided into two main groups based on oxidation - reduction in liquid medium (Liquid Redox) and the use of direct oxidation (Direct Oxidation) [1-3]. Process Claus (Claus Process) or processes derived from it (Modified Claus or Super Claus), are the most important of Sulfur production method that are considered a significant part of total world sulfur production processes [4, 5].

In the Claus unit, the acid gas exhaust from sweetening units, injected into the reaction furnace in the sulfur recovery process [6]. Reaction furnace, according to the reaction (1) about one third of the gas H_2S Stoichiometric amount of acid gas in the air and burned to Sulfur dioxide (SO_2) [7, 8].

$$H_2S + 3/2O_2 \rightarrow SO_2 + H_2O \qquad \Delta H = -4147.2 \text{ kj/mol} \qquad (1)$$

Then resulting SO_2 the reacts with residue H_2S and produces sulfur [8]:

$$2H_2S + SO_2 \rightarrow 3/2S_2 + 2H_2O \qquad \Delta H = -1165.65 \text{ kj/mol} \qquad (2)$$

Combustion reaction of H_2S is highly exothermic and relatively adiabatic temperature of the combustion chamber could depending on the amount of impurities in the acid gas can change between 850 to 1200 °C [8-10].

Side reactions taking place in the thermal step of the Claus reaction are [10]:

- The formation of hydrogen gas:

$$2H_2S \rightarrow S_2 + 2H_2 \qquad (\Delta H > 0) \qquad (3)$$

$$CH_4 + 2H_2O \rightarrow CO_2 + 4H_2 \qquad (4)$$

- The formation of carbonyl sulfide:

$$H_2S + CO_2 \rightarrow S{=}C{=}O + H_2O \qquad (5)$$

- The formation of carbon disulfide:

$$CH_4 + 2S_2 \rightarrow S{=}C{=}S + 2H_2S \qquad (6)$$

In this study, effect of the oxygen concentrations in the air inlet to the reaction furnace and new operating on the concentrations of the H_2S, COS, SO_2, CS_2, S_2, S_3, S_4, S_5, S_6, S_7 and S_8 will be reviewed (in a sulfur recovery unit with the new operating (Fig. 1)). Furthermore, The conditions and composition for the acid gas feed and the input air to the simulated Claus sulfur recovery unit are summarized in Table 1.

This new Operating unit consists of a reactor with an alumina catalyst, sulfur redistribution and a condenser. In this unit, the output of the condenser (3) enters into the reactor where sulfur compounds such as COS, CS_2, H_2S and SO_2 reacts with each other and produces sulfur compounds. Then the output of the reactor enters into sulfur redistribution. In the sulfur redistribution, lighter sulfur compounds is converted to heavy and high value components and then by the sulfur condenser (4) separated and enters into sulfur drain (4). Finally, the output of the condenser (4) as tailgas flow is entered into incinerator.
Oxygen concentration in the air appears to near 100 percent by several polymeric membrane systems in series mode [11].

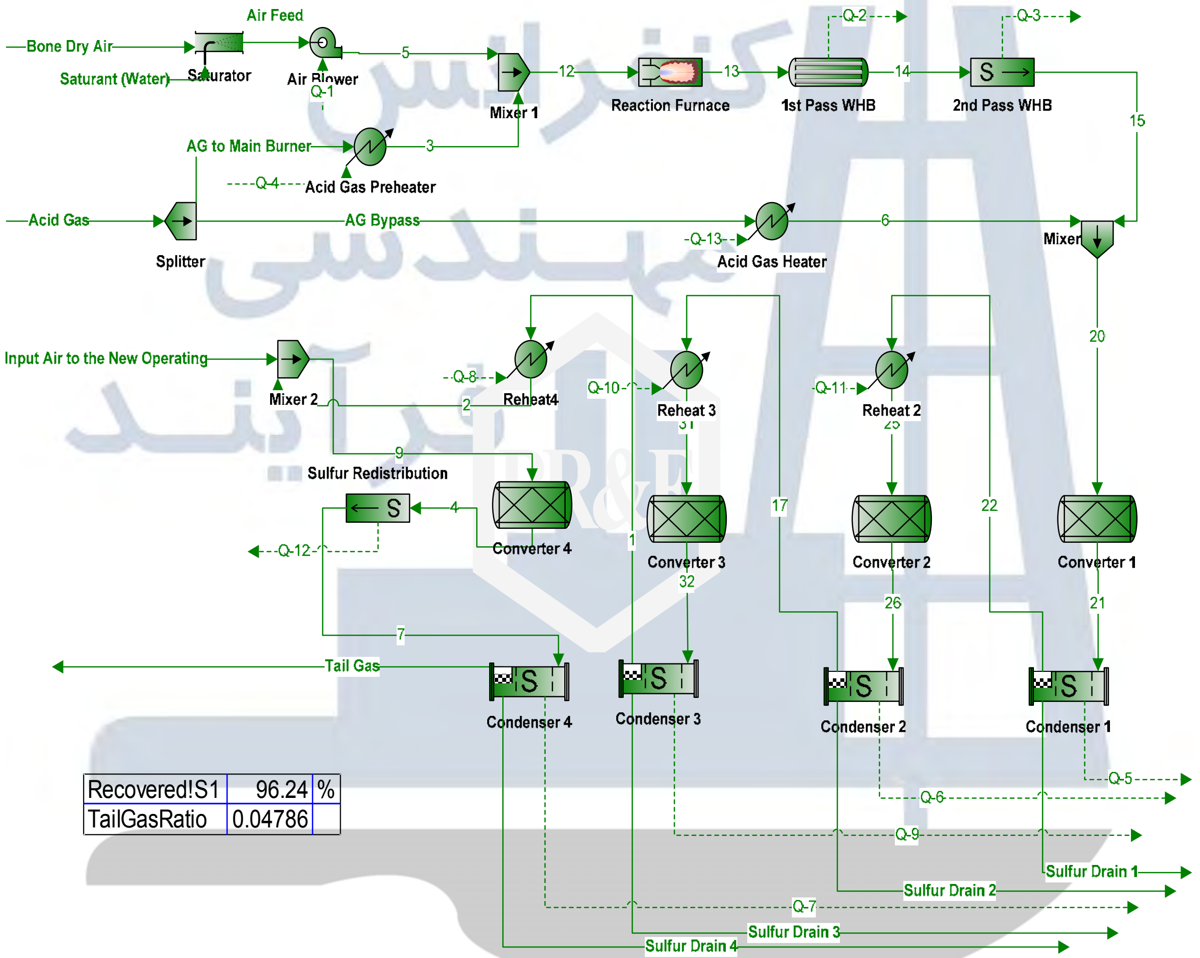

Fig. 1: A schematic of the sulfur recovery unit with the new operating.

Table 1: conditions of the acid gas feed and air input to the simulated Claus unit.

Composition/mole-%	Acid gas feed	Input air

O_2	٠	٢١
N_2	٠	٧٩
CO_2	٦٧,٧٣	٠
H_2S	٣١,٢٦	٠
CH_4	١,٠١	٠
Total	١٠٠	١٠٠
Temperature/°C	١٢٠	٧٠
Pressure/Psia	٣٠	14.7

2. Results and discussion

Sulfur recovery technology design, will take action in addition to the sulfur recovery process development, with respect to manufacturing localization to catalysts used in this unit enhanced catalytic properties and localization of the production of equipments required for this project [10].

Due to the growth of energy and global attention on clean energy, development of gas process is inevitable, therefore, one of the objectives of the process (SRU), is the removal of hydrogen sulfide from acidic gas streams effluent from the refinery sweetening units [12, 13].

Most of this gas contains hazardous substance and toxic hydrogen sulfide H_2S. That have many hazards for the human and environment, and every day, more stringent environmental regulations is set on emissions in the environment [14].

The task of Sulfur recovery unit, is to convert toxic hydrogen sulfide gas and oil refineries in acid gases, to sulfur material which is useful in many chemical industry, agriculture, health and military. For this reason, in this paper, effect of the oxygen concentrations in the air inlet to the reaction furnace and new operating on the concentrations of the H_2S, COS, SO_2, CS_2, S_2, S_3, S_4, S_5, S_6, S_7 and S_8 have been studied.

2.1 H_2S concentration in the TailGas

H_2S is highly toxic, colorless gas that dissolves easily in water and is flammable and explosive. This gas is explosive at concentrations between 4% and 44% in air and exposed to an open flame or source of ignition cause fire or explosion [8]. This gas can form acid H_2SO_4 or H_2SO_3 with water vapor in the air causes the formation of acid rain. Acidic rains cause loss of plants and organisms [12].

Fig. 2 shows the effect of oxygen concentration in the intake air to the reaction furnace on the H_2S concentration in the TailGas (Various concentration of oxygen input into the new design). As can be seen in this figure, increasing the oxygen concentration in the reaction furnace inlet in the all four oxygen concentration entrances to the new design, the H_2S concentration in the TailGas is reduced to zero from maximum value (0.02%). Therefore generally concluded that decreasing H_2S

in the TailGas and prevent environmental hazards that must be input to the furnace oxygen reaction has its maximum value.

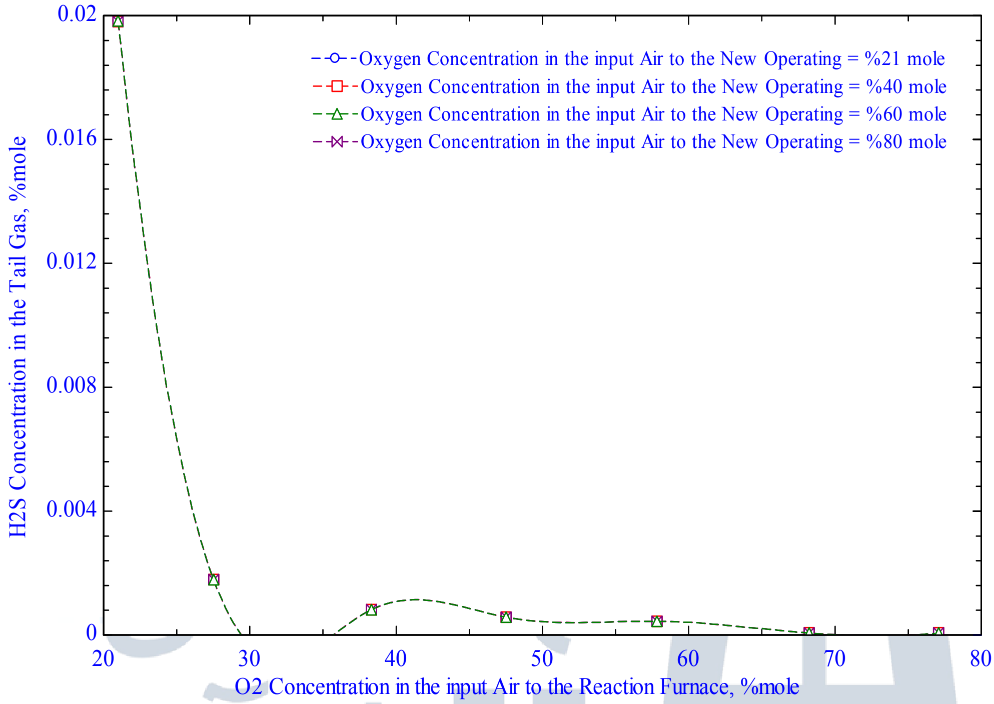

Fig. 2: Effect of the oxygen concentration in the input air to the reaction furnace on the H_2S concentration in the TailGas.

2.2 COS concentration in the TailGas

COS is Colorless and toxic gas. If inhaled can cause fatal accidents and affects the central nervous system, respiratory system, may cause disability [2]. Nausea, vomiting, unconsciousness and death are the effects of exposures. Despite the nature of the dissolved acid gas in water and the resulting acid rain is formed [5].

Increasing the oxygen concentration in the intake air into the reaction furnace, the COS concentration can increase the maximum value and then decreases with a relatively steep slope (Fig. 3). Moreover, in this figure can be seen that the concentration of oxygen in the air to the reaction furnace between 70-75 mole percent of their value is minimal.

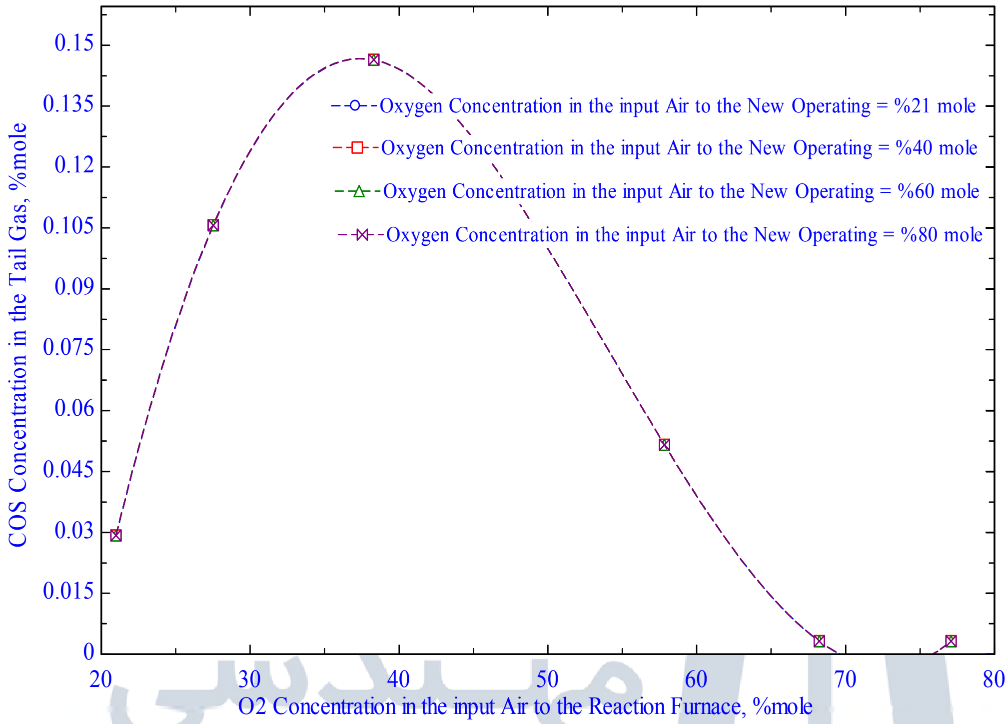

Fig. 3: Effect of the oxygen concentration in the input air to the reaction furnace on the COS concentration in the TailGas.

2.3 SO_2 concentration in the TailGas

Increasing the oxygen concentration in the intake air into the reaction furnace (for the four oxygen concentration in the intake air to the new design) SO_2 concentration in the TailGas is increased until it reaches a constant value (Fig. 4). Moreover, this figure can be concluded that to reduce the amount of SO_2 in the TailGas, the oxygen content of the air entering the reaction furnace is less than 50 mole percent.

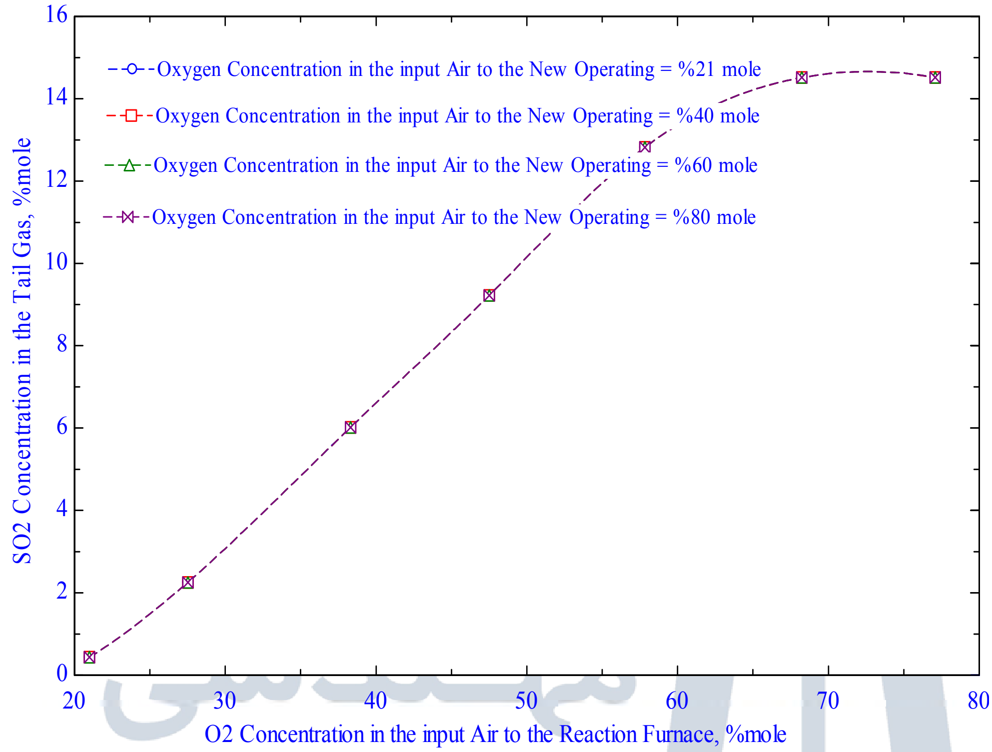

Fig. 4: Effect of the oxygen concentration in the input air to the reaction furnace on the SO_2 concentration in the TailGas.

2.4 CS_2 concentration in the TailGas

Fig. 5 Studies the effect of oxygen concentration in the intake air to the reaction furnace on the CS_2 concentration in the TailGas (for the four oxygen concentration equal to 21 mole %, 40 mole %, 60 mole % and 80 mole %). Generally seen in the form of a 21% molar concentration of oxygen in the air to the new design, the CS_2 in the present TailGas has lower oxygen concentrations than the other input is the new design. As well as it can be seen in this figure that by increasing the oxygen concentration of the air entering the reaction furnace, the CS_2 concentration initially increases to maximum concentration and then by different gradient (depending on the oxygen concentration of the air entering the new design) is reduced.

Concentration of oxygen in the air to the new design equal to 21% molar, the CS_2 concentration available at TailGas is increased from zero percent Value to 0.005035 mole percent and then decreases to 0.004990 percent value. Whereas in the oxygen concentrations equal to 40 mole%, 60 mole% and 80 mole%, CS_2 concentration in the TailGas increases from 0.004995 to 0.005070 mole percent and then decreases to a value of 0.004990 mole percent.

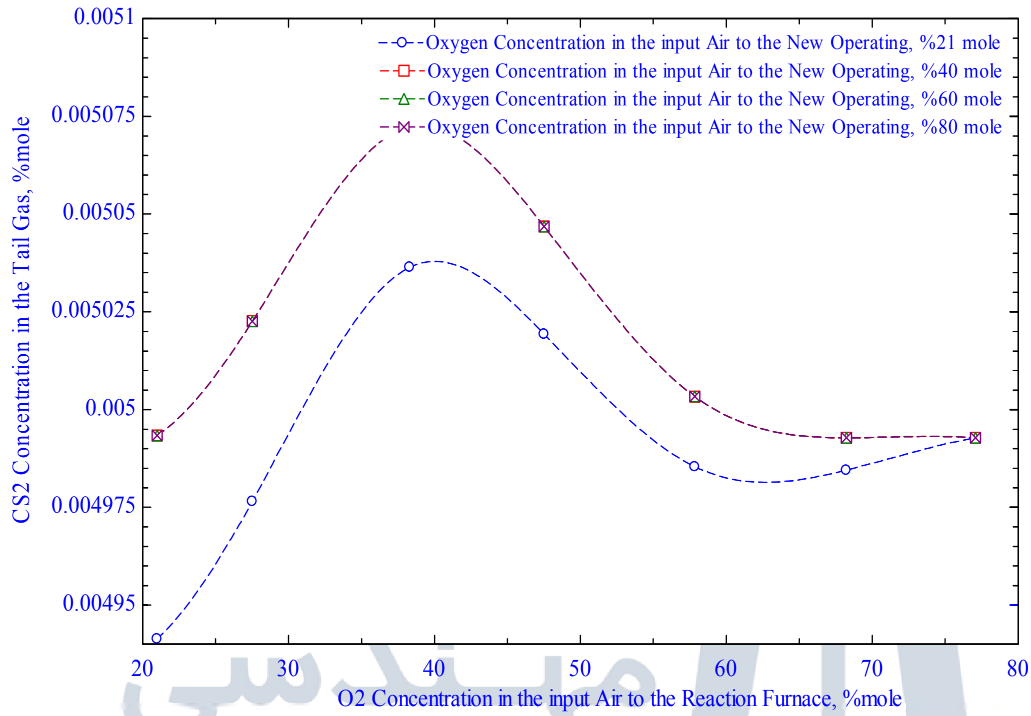

Fig. 5: Effect of the oxygen concentration in the input air to the reaction furnace on the CS_2 concentration in the TailGas.

2.5 S_2 concentration in the TailGas

S_2 is among the major sulfur compounds contained in TailGas, which whatever the value of the TailGas becomes less, more sulfur recovery rates can be achieved [6]. In addition S_2 easily dissolved in water vapor in the air to form sulfuric acid and so does these acids can be found in nature associated with the rain coming down and the plants and creatures to life is disrupted. Thus reducing the amount of the effective parameters of S_2 in the TailGas is investigated.

Fig. 6 examines the effect of oxygen concentration in the intake air oven at four concentrations of oxygen in the air reacts to the new design on the S_2 concentration in the TailGas. As can be seen in this figure, increasing the oxygen concentration in the intake air into the reaction furnace, the oxygen concentration of the air entering the new design, the concentration S_2 in the TailGas, first stabilized and then declined with a steep slope to zero.

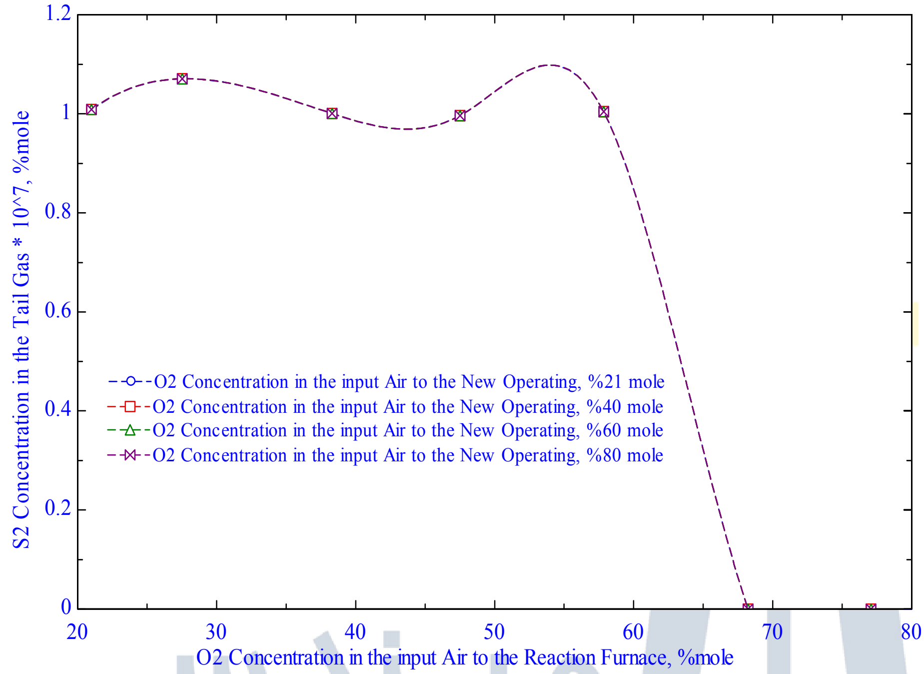

Fig. 6: Effect of the oxygen concentration in the input air to the reaction furnace on the S_2 concentration in the TailGas.

2.6 S_3 concentration in the TailGas

Elemental sulfur S_3 in nature combines with oxygen and forms sulfur oxides [14, 15]. These mainly include sulfur oxides, sulfur dioxide and sulfur trioxide can be shown that these oxides are the main cause's disruption in living life [16]. Therefore the impact of these two parameters oxygen concentration in the intake air into the reaction furnace and the new design reduces the amount of S_3 in the TailGas is investigated (Fig. 7). As can be seen in this figure, the concentration of oxygen in the air to new design changes S_3 concentration in the TailGas with than the oxygen in the air to the furnace is different. Moreover, from this figure it can be seen that the S_3 concentration in the TailGas (21% molar concentration of oxygen in the air to new design) increases the maximum value and then decreased with a relatively steep slope. However, in the concentration of 40 mole% oxygen, S_3 concentration in the TailGas Initially decreased to the minimum value and then increased to 3×10^-9 Mole percent. Later S_3 concentration in the TailGas relatively has reduced with steep slope. Changes S_3 concentration in the TailGas at concentrations of 60 and 80mole percent of the oxygen in the air to new design new changes are sinusoidal. Moreover, from this figure it can be seen that in 60% mole oxygen in the air to new design, S_3 concentration in the TailGas is Maximum (3×10^-9 mole %) of its value.

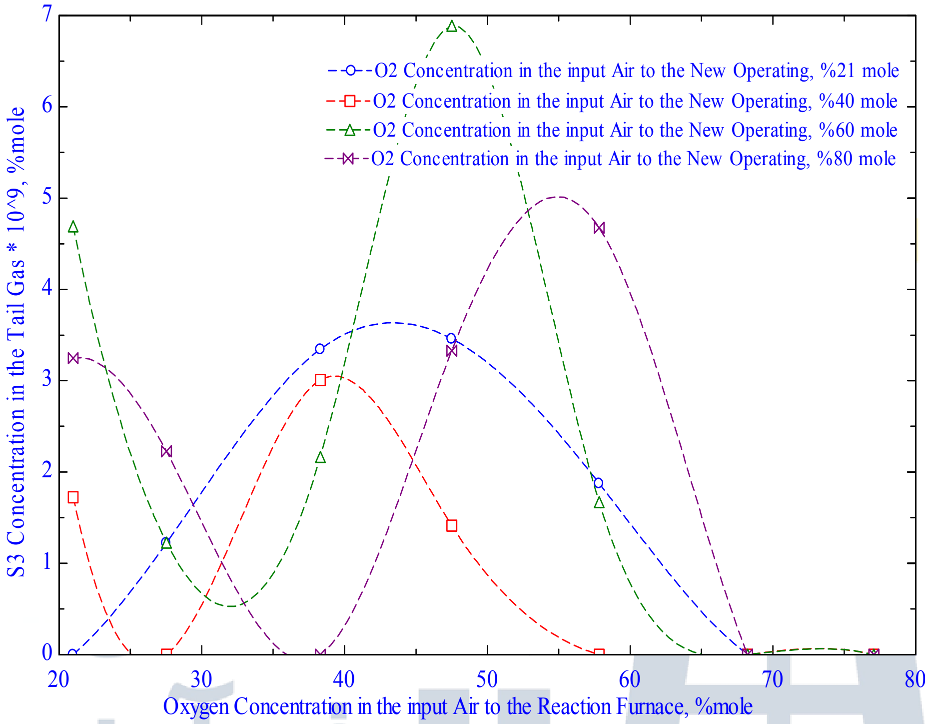

Fig. 7: Effect of the oxygen concentration in the input air to the reaction furnace on the S_3 concentration in the TailGas.

7.2 S_4, S_5, S_6, S_7 and S_8 concentrations in the TailGas

Sulfur is an element, pale yellow, odorless, brittle solid that is insoluble in water but soluble in carbon disulfide. Sulfur is an essential element for life and exists with small amounts on fat and body fluids, and skeletal structure [13-17].

In 1839, Charles Goodyear accidentally dropped a mixture of rubber and sulfur, into the fire that led to the discovery of vulcanized rubber [7]. Invention to respect his tires Vulcan, the Roman god of fire, to be named. In the Eighteenth century, most English children's mothers mix one tablespoon of sulfur and molasses as a spring booster fed.'s Sulfur-containing drugs is used to fight bacterial meningitis. The Sulfur oils to treat infections of skin [6, 9].

History of sulfur and sulfur use is back to thousands of years [4]. Egypt ancient using sulfur color Constructed or used for bleaching (the SO_2) Chinese people also use sulfur to make gunpowder. Ancient Greeks have used sulfur as medicine and disinfectant [4,5].

Much of the sulfur is used to produce sulfuric acid (H_2SO_4). Sulfuric acid often used to make fertilizers (nearly 40 million tons per year), battery Lead - Acid is used in many other industries [12, 13]. Quantities of sulfur is used for the manufacture of rubber, vulcanized, insect cache (Homer, the Greek poet nearly 2800 years ago as a pest of sulfur Cache has learned), the powder and pigments is used [15].
Majority section of sulfur is used for the production of the sulfuric acid [13]. To create a more interesting composition, hydrogen sulfide (H_2S) is the composition of the gas that smells of rotten eggs. Sulfur dioxide (SO_2) is resulting from the burning of sulfur in the air as a bleaching agent, solvent, disinfectant, refrigerant material. If sulfur dioxide combines with water to produce acid, sulfur (H_2SO_3) is the main component of acid rain that was weak [13-16]. Thus, as has been described in many applications, but the sulfur emissions in the environment as an environmental problem arises and is not a natural phenomenon. Sulfur is non-toxic element and the risk of the molten sulfur is due to the high temperature [17]. Under certain conditions of heat, both solid and liquid forms are able to produce hydrogen sulfide and sulfur dioxide. In high concentrations of these gases cause allergy in eyes and respiratory tract and slow breathing, unconsciousness, and death. smell of hydrogen sulfide should be a warning sign of confidence [1].
Sulfur is insoluble in the water, in certain circumstances at long run will produce acidic waste. Dangerous in high concentrations for aquatic ecosystems, anaerobic conditions elemental sulfur and hydrogen sulfide produce restoring biochemical and sulfide ions [4].
If the element is a breakdown, the product of sulfur oxides into water bodies because sulfuric acid is a threat to the marine environment [14].
Figs. (8-12) investigates on the parameters of the oxygen concentration in the reaction furnace and the oxygen concentration in the intake air into the newly designed air intake on serum concentrations of S_4, S_5, S_6, S_7 and S_8 in the TailGas. As can be seen in the form of concentrations S_4, S_5, S_6, S_7 and S_8 the sinusoidal variations are negligible and the steep decline is reached. Moreover, it can be seen that in the higher concentration of oxygen in the air inlet to the reaction furnace, concentrations of the S_4, S_5, S_6, S_7 and S_8 in the TailGas are zero. Therefore generally it can be concluded that the concentrations of S_4, S_5, S_6, S_7 and S_8 in the TailGas, in the concentration of oxygen in the air to the reaction furnace between 70-80 mole percent (at all levels of oxygen in the air entering the new design), are the minimum value for themselves.

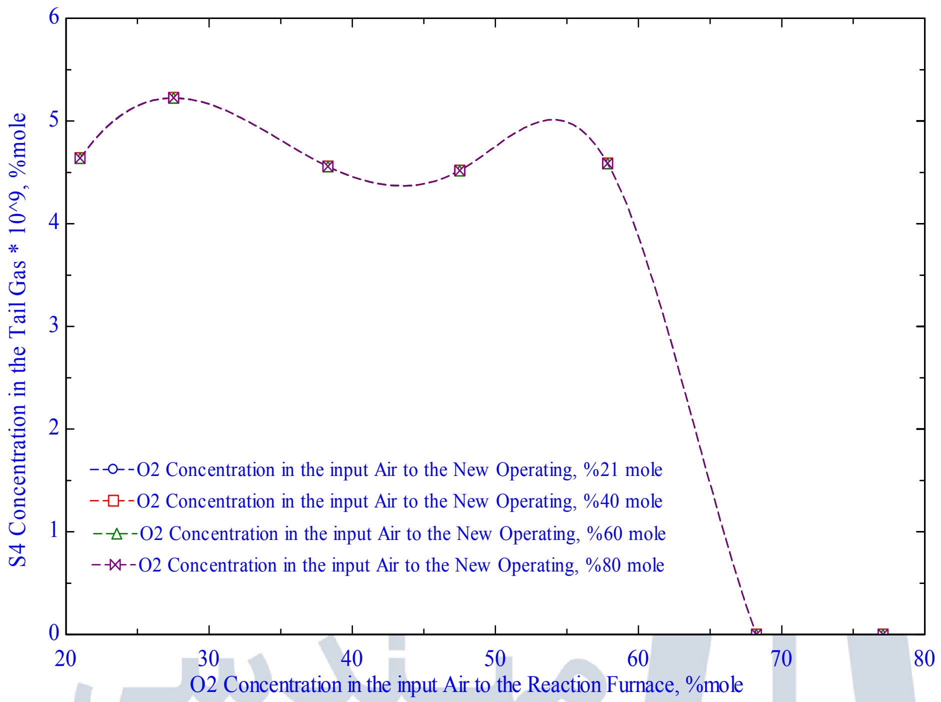

Fig. 8: Effect of the oxygen concentration in the input air to the reaction furnace on the S_4 concentration in the TailGas.

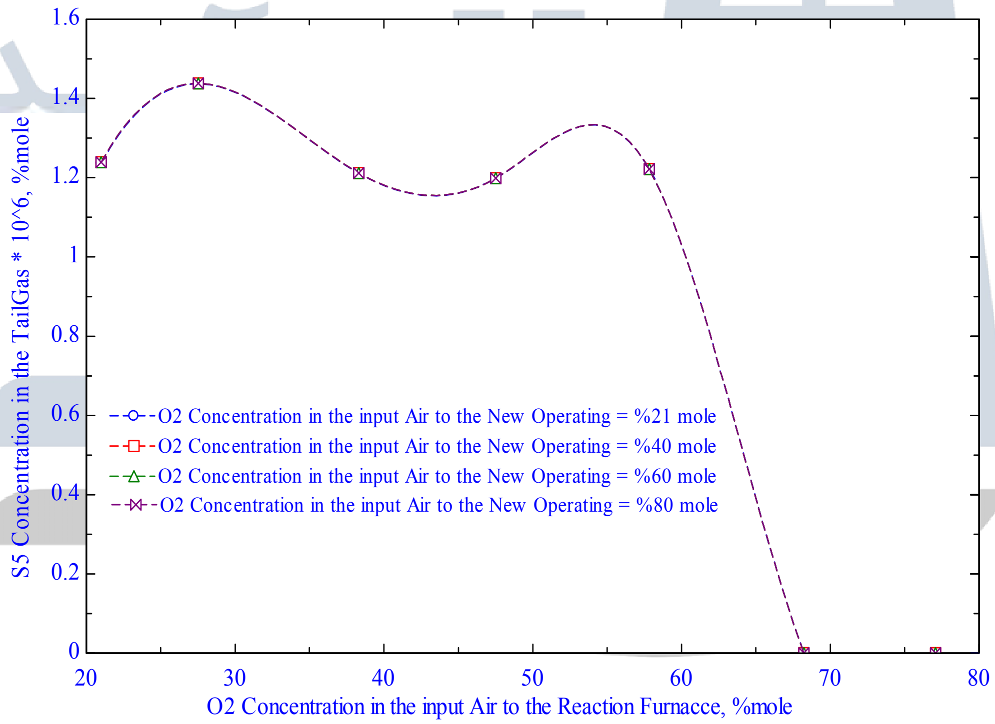

Fig. 9: Effect of the oxygen concentration in the input air to the reaction furnace on the S_5 concentration in the TailGas.

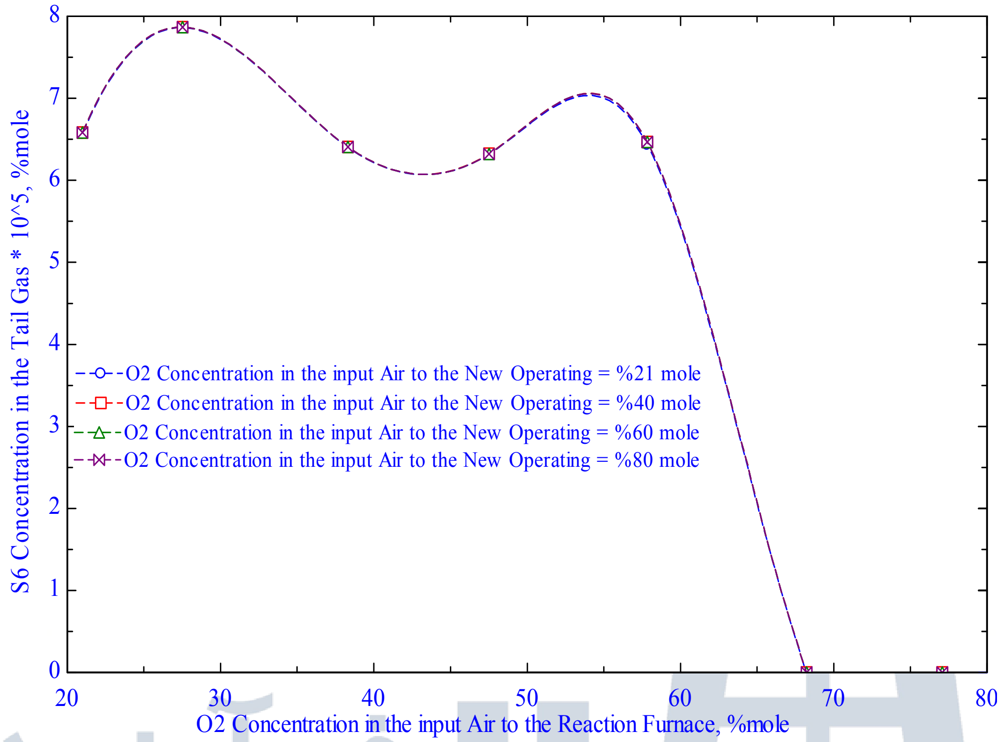

Fig. 10: Effect of the oxygen concentration in the input air to the reaction furnace on the S_6 concentration in the TailGas.

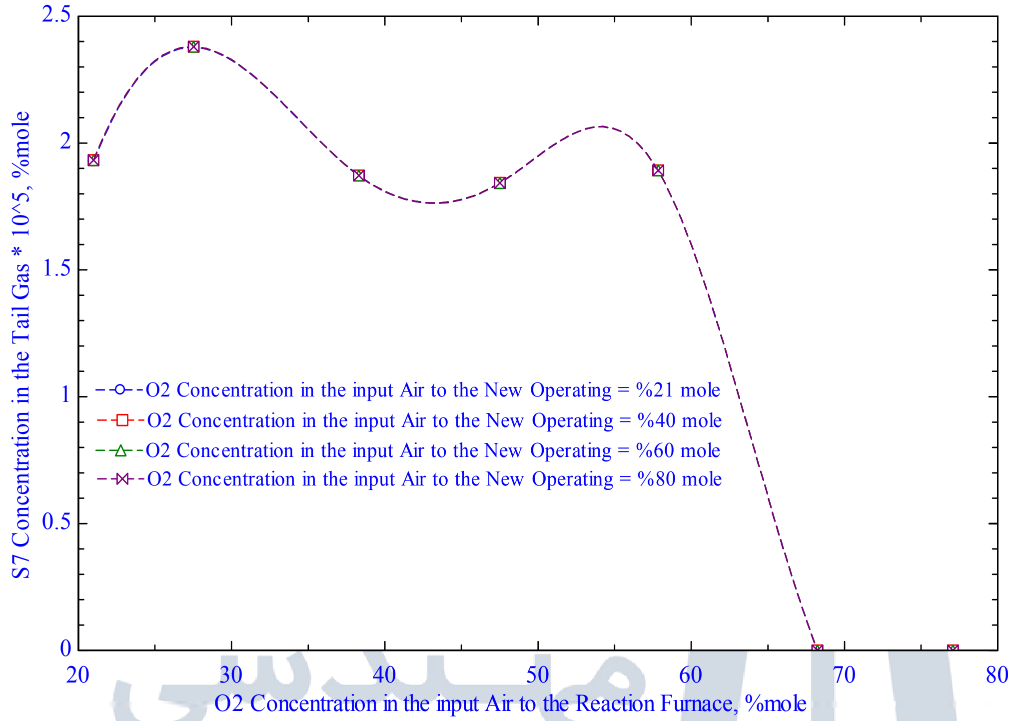

Fig. 11: Effect of the oxygen concentration in the input air to the reaction furnace on the S_7 concentration in the TailGas.

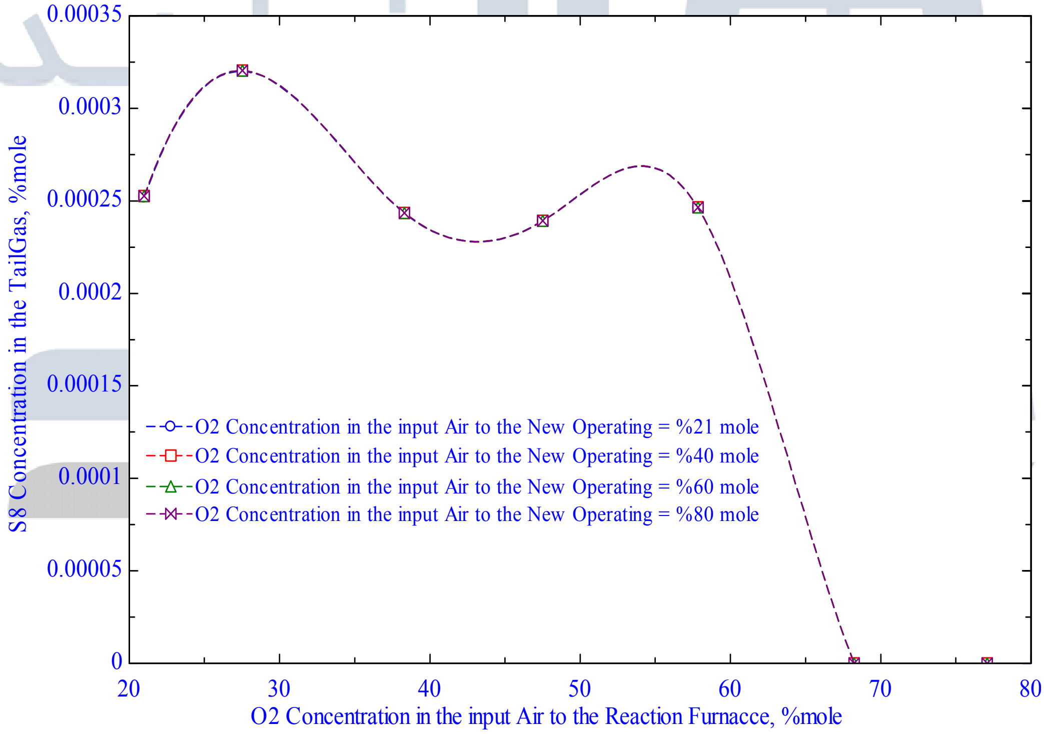

Fig. 12: Effect of the oxygen concentration in the input air to the reaction furnace on the S_8 concentration in the TailGas.

3. Conclusions

The general conclusion reached is that the high concentrations of oxygen in the air inlet to the reaction furnace, concentrations of the H_2S, COS, CS_2, S_2, S_3, S_4, S_5, S_6, S_7 and S_8 in the TailGas with its minimum requirements. In the case of high concentrations of oxygen in the air to the reaction furnace, the maximum concentration SO_2 in the TailGas has been made. Therefore the oxygen concentrations in the intake air to the reaction furnace above 70% molar concentration of the oxygen in the air to a new design with a 21% molar are optimal.

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