Recycling Of SO_2: Its Conversion Into Elemental Sulfur

Harutyunyan H., Mantashyan A.

14apt. 1\16, Avan-Arindj, RA

Paruyr Sevaki St., 5/2 Building Yerevan, 0014, Armenia,

E-mail: harhasmik@mail.ru

Abstract

The environmental pollution by the industry and thermal power plants with adverse gas emissions is considered to be one of the most important ecological issues nowadays.

The project is aimed at the SO_2 utilization and its conversion into elemental sulfur. The hunting of SO_2 with the existing mechanisms is based on the chemical conversion of the oxide into solid compound. The new approach of the alteration of inorganic compounds is preseneted in the project bypassing the traditional ways of chemical alteration realization. It gives an opportunity to utilize SO_2 by recovering the elemental sulfur from its oxide. The innovation is based on the realization of the sulfur dioxide conversion coupled process by the effect of the hydrogen oxidation branched chain reaction.

As revealed in the researches, the hydrogen-oxygen mixtures containing SO_2 implement regular flaming mode in which SO_2 is converting into elemental sulfur (low temperature burning) in the low pressure and temperature and flow conditions. It's obvious that in these conditions (T = 450-510°C, P≤ 200 Torr) molecular hydrogen separately does not interact with the sulfur dioxide.

In the result the coupled full chain process is fulfilled, when inorganic compounds as well as primary reagents are complied into intensive chemical conversion.

Keywords: environmental pollution, recycling, emissions, utilization, elemental sulfur, conversion, chain reaction

1. Introduction

About 99% of the sulfur dioxide in air comes from human sources. The main source of sulfur dioxide in the air is industrial activity that processes materials that contain sulfur, eg the generation of electricity from coal, oil or gas that contains sulfur. Some mineral ores also contain sulfur, and sulfur dioxide is released when they are processed. In addition, industrial activities that burn fossil fuels containing sulfur can be important sources of sulfur dioxide. Sulfur dioxide is also present in motor vehicle emissions, as the result of fuel combustion. In the past, motor vehicle exhaust was an important, but not the main, source of sulfur dioxide in air. However, this is no longer the case.

Sulfur dioxide affects human health when it is breathed in. It irritates the nose, throat, and airways to cause coughing, wheezing, shortness of breath, or a tight feeling around the chest. The effects of sulfur dioxide are felt very quickly and most people would feel the worst symptoms in 10 or 15 minutes after breathing it in. Those most at risk of developing problems if they are exposed to sulfur dioxide are people with asthma or similar conditions [1].

The problem of utilizing sulfur dioxide emitted into the atmosphere with the flue gases of thermal power plants and metallurgical plants motivates the search for rational pathways of its chemical conversion to harmless compounds. The chemical conversion of SO_2 in the chain oxidation of hydrogen in low temperature and low-pressure flames [2-4] is of practical interest in particular for conversion of this gas into useful product- elemental sulfur. The new phenomenon of "Intermittent flames" and origin of elemental sulfur from hydrogen-oxygen mixtures containing SO_2 will bring new theories of chemical conversions probably creating new processes.

2. Methods and Results

Some experiments has been carried out in the vacuum equipment, quartz reactor (Fig.1) and with H_2:N_2:O_2:SO_2 :N_2 mixtures as well as with different compounds of this gas to find out the optimal conversion of the latter.

Besides, chromatographic analysis (T= 470-510°C) of SO_2 and H_2 have been implemented. The chain reaction takes place when gas mixture passes through the reactor where sulfur is produced.

We are aimed to study the kinetic mechanism of the SO_2 conversion into elemental sulfur in the coupled process comparing the experiment with the mathematical modeling. Different chemical conversions of coupled process have been discussed. Thus, thermodynamic analysis of all expected elementary reactions has been carried out, revealing the probability of their processing. The mathematical modeling of the coupled process chemical mechanism has been implemented based on the known constant speed of the elementary reactions.

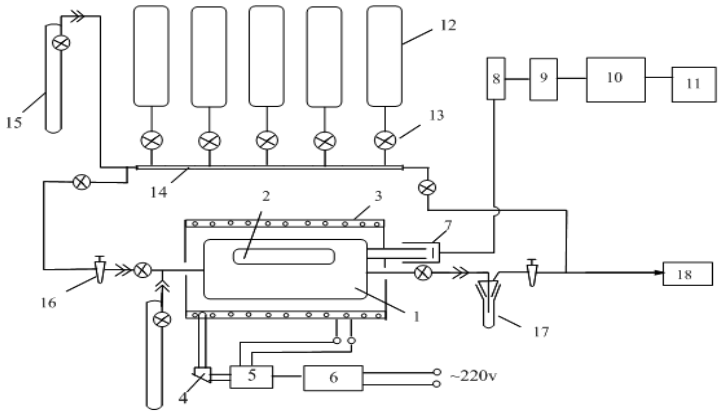

Figure 1. Equipment scheme

The calculations of thermal effects and Gibbs free energy change for the possible and probable elematary reactions has been carried out with the H,O and OH atoms and free radicals in the coupled process.

We have hunted speed constant of elemenary reactions from the base data of NIST (National Institute of Standards and Technology). As well as we've studied the probability of the elementary reactions processing. Besides, we've formed different kinetic models of coupled chain process, thus presenting the branched reaction of hydrogen oxidation with the same elementary reactions, during which all possible reactions producing H_2, O_2, SO_2 and sulfur has been discussed. Reacting with SO_2, hydrogen takes the oxygen from the latter, thus producing sulfur (Fig.2).

The modeling showed that hydrogen-oxygen mixture is necessary for the initiation phase:

$$H_2+O_2 \rightarrow HO_2 + H \quad (1)$$

In the result H free radical has been created that goes on to react with SO_2:

$$H_2+SO_2 \rightarrow SO+OH \quad (2)$$

$$H+SO \rightarrow S+OH \quad (3)$$

Conclusion

In the result we have determined the chemical mechanism of the conversion of the SO_2 into sulfur as well as discovered the optimal conditions for the process realization.

The experiment and modeling resulted in forming the same product-sulfur.

It has been found out from mathematical modeling , that if we can find another source of H radical, that will replace the reaction (1) the interchange of initiation phase will be possible

Thus, solving ecological contemporary problem by recycling of SO_2, we get elemental sulfur-useful product.

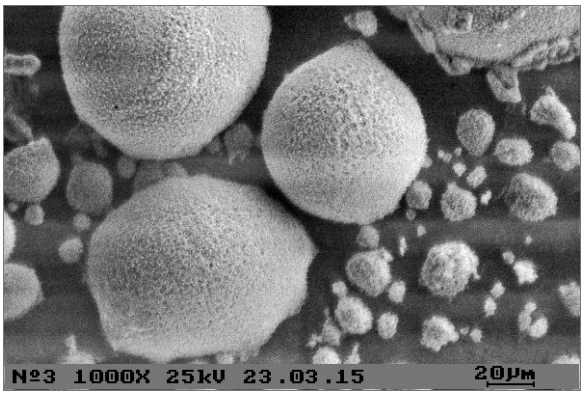

Figure 2. Elemental sulfur

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