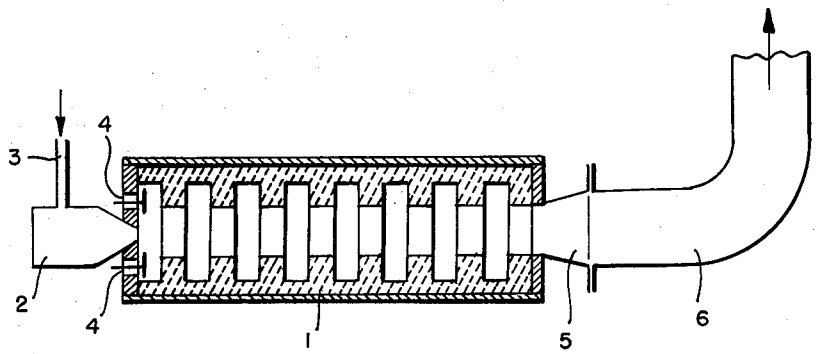
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COMBUSTION OF SULFUR WITH OXYGEN-CONTAINING GASES

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COMBUSTION OF SULFUR WITH OXYGEN-CONTAINING GASES

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This invention relates to a process for the combustion of sulfur with oxygen-containing gases. More especially, it relates to an improved process of burning sulfur in sulfur burners. The invention furthermore relates to apparatus for carrying out the said process.

It is known to react elementary sulfur in solid, liquid or gaseous state in a combustion chamber with oxygen-containing gases to form sulfur dioxide.

The known apparatus for carrying out such a combustion are provided with relatively large combustion chambers in order to achieve as long a contact time of the sulfur with the oxygen-containing gases as possible. This long contact time has been regarded as necessary in order to ensure complete conversion of the sulfur to sulfur dioxide.

In order to decrease the size of the combustion chambers, without altering the residence period of the sulfur therein, an attempt has been made to diminish the rate of flow of the gas in the chambers. At a diminished gas velocity, however, complete combustion of the sulfur is not ensured.

Apparatus are known by means of which it is possible to separate the unburnt sulfur still contained in off-gases containing sulfur dioxide. For this purpose the combustion gases are passed through a tube provided with a screw conveyor which is set in rotation by the kinetic energy of the combustion gases. A lateral outlet for withdrawal of the separated sulfur is provided at the end of the tube. Such apparatus requires careful maintenance and is naturally subject to strong wear and corrosion.

It is also a disadvantage of the said methods that the reaction is carried out adiabatically, i.e. that the combustion heat, amounting to about 70.9 kcal./mole, leads exclusively to a rise in the temperature of the system. This temperature, in a combustion chamber which is more or less run to capacity, depends merely on the concentration of sulfur dioxide in the combustion gases, i.e. on the relative proportions of sulfur and combustion medium introduced into the combustion chamber. Thus, for example, at a concentration of about 15% of sulfur dioxide in the combustion gas, a temperature of about 1500° C. is reached. Great demands are thereby made on the material of the combustion chamber. Consequently, higher sulfur dioxide concentrations in the combustion gases with correspondingly higher temperatures are impracticable in such a chamber in continuous operation.

The combustion space requirement of these combustion chambers is about 1000 to 1300 liters per day per metric ton of sulfur reacted, sulfur dioxide concentrations of about 15% being reached in the combustion gases.

According to a more recent method, the space needed for a combustion chamber per day per metric ton of sulfur reacted is decreased 40 to 50 liters by introducing the air-sulfur mixture into the combustion chamber at high rates of flow with turbulence. The problem of high gas temperatures remains unsolved in this case also, so that the technically feasible sulfur dioxide concentrations are again 14 to 15%.

It is an object of the present invention to provide a process of burning sulfur in sulfur burners, in which process the combustion is carried out in combustion chambers which are considerably reduced in size as compared with conventional apparatus.

Another object of the invention is to produce combustion gases having a higher content of sulfur dioxide.

These and other objects and advantages of the invention are achieved by intermittently injecting sulfur in liquid form into the combustion chamber, the combustion thus proceeding in the form of an explosion and the resonance frequency of the gas column oscillating in the combustion chamber being equal to or a whole multiple of the injection frequency of the sulfur.

It is preferable to use for carrying out the process according to this invention a cylindrical combustion chamber the dimensions of which naturally depend on the amount of sulfur reacted per unit of time. The ratio of diameter to length may be varied substantially, but advantageously is between 1:6 and 1:15. To achieve the most complete reaction possible it may also be advantageous to constrict and widen the diameter alternately in the direction of the longitudinal axis of the cylinder. The combustion chamber is provided with an attached pipe through which the combustion gases are supplied to a plant for further processing. The combustion air is supplied at the opposite end through a pipe capable of being closed by one or more check valves. The air may however also flow through the valves direct from the surrounding air space. The nozzle for the intermittent injection of liquid sulfur conveyed by means of an injection pump is advantageously arranged centrally so that it is surrounded concentrically by the check valves. The frequency with which the injection pump feeds the sulfur into the combustion tube can be adjusted by means of a variable gear to accord with the resonance frequency of the combustion tube, and when the tube is started up can be determined empirically by variation of the speed of the injection pump. When the two frequencies are in phase, this becomes evident by explosions of uniform strength and occurring at equal intervals. It is only under these conditions that combustion of the sulfur takes place completely.

After an explosion shock, a strong acceleration is imparted to the gas column in the combustion chamber in the direction of the outlet from the combustion chamber, so that a negative gauge pressure occurs at the point where the air enters. The check valves thus open and fresh combustion air is drawn into the chamber. The explosion wave is in the meantime reflected at the other end of the combustion chamber so that the combustion air freshly drawn in its compressed adiabatically. At the moment of maximum compression, fresh sulfur is injected through the nozzle into the combustion chamber, and a fresh combustion is released in the form of an explosion by the high temperature produced by the adiabatic compression.

By working in accordance with this invention, rapid and complete combustion of the sulfur introduced into the combustion chamber is achieved, so that a combustion gas mixture is obtained which contains 18 to 20% by volume of sulfur dioxide. A further advantage of the process according to this invention results from the fact that the temperatures are lower than in the known methods in spite of the higher concentrations of sulfur dioxide. The following table shows the course of the temperature (A) in dependence on the sulfur dioxide concentration in the combustion gases in a continuously operated sulfur burner, compared with the course of the temperature (B) in a sulfur burner according to the invention into which the sulfur is injected intermittently; in order that the results obtained should be comparable, burners having com-

bustion chambers of equal size and operated with the same throughput are used.

Concentration of sulfur dioxide in combustion gas	Temperature in ° C	
	A	B
10%	925	710
12%	1100	829
14%	1300	930
16%	1490	1020
18%	1670	1100

It is found that the volume of the combustion chamber operated according to this invention may be considerably smaller than combustion chambers operated by the known methods. Thus one metric ton of sulfur per day may be reacted according to this invention in a combustion chamber having a volume of only 15 liters.

The process according to this invention may be carried out especially advantageously in an apparatus such as is illustrated diagrammatically by way of example in the accompanying drawing.

The combustion chamber 1 is lined with fireclay and is provided with successive constrictions and enlargements of the cross-section at equal intervals. A nozzle 2 is provided centrally at one end of the combustion chamber 1 for the intermittent injection of liquid sulfur. The liquid sulfur is supplied to the nozzle 2 through a pipe 3. The nozzle 2 is surrounded by air valves 4 arranged concentrically at equal distances. The necessary combustion air is intrdouced into the combustion chamber through the said valves 4. The combustion gases leave the combustion chamber through a diffuser 5 and a pipe 6 connected thereto.

The invention is illustrated by, but not limited to, the following example.

Example

A cylindrical combustion chamber is used having a capacity of about 15,000 cc., a length of 100 cm. and ten equidistant alternate constrictions and enlargements of the cross-section, the narrow portions having a diameter of 10 cm. and the wide portions a diameter of 16 cm. 50 kg. of liquid sulfur is injected into the combustion chamber in the course of an hour. The amount of air supplied is 180 m.^{3} (S.T.P.)/hour. Frequency of explosions is regulated to 480 explosions per minute.

When starting up the combustion chamber, the explosions are initiated by an igniting flame or an incandescent wire arranged in the combustion chamber in front of the injection nozzle. This auxiliary ignition is unnecessary after about five minutes operation.

The combustion gas leaving the combustion chamber has a sulfur dioxide concentration of 18 to 20%.

What we claim is:

1. In a process for the combustion of sulfur with an oxygen-containing gas in the combustion chamber of a sulfur burner, the improvement which comprises: injecting said sulfur intermittently in liquid form into said combustion chamber for explosive combustion with said oxygen-containing gas, the frequency of said liquid sulfur injection being adjusted to be in phase with the resonance frequency of the gas column oscillating in the combustion chamber.

2. A process as claimed in claim 1 wherein the frequency of said liquid sulfur injection is equal to the resonance frequency of the gas column oscillating in the combustion chamber.

3. A process as claimed in claim 1 wherein the resonance frequency of the gas column oscillating in the combustion chamber is a whole multiple of the frequency of said liquid sulfur injection.

4. A process as claimed in claim 1 wherein the combustion is carried out in a combustion chamber having a ratio of diameter to length between about 1:6 and 1:15.

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