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(54) Process and equipment for burning gases containing H_2S to form sulphur

(57) The invention relates to a process for the burning of H_2S-containing gases with air and/or oxygen to elementary sulphur and for the separation of the sulphur from the reaction gas, and is carried out in a burner-equipped combustion zone (1a), a subsequent reaction zone (1b) and several cooling zones. When the H_2S-containing gases contain $\geq 25\%$ H_2S, they are passed into the combustion zone essentially by one or several main burners (3), and when they contain $< 25\%$ H_2S the gases are passed to the combustion zone by a by-pass burner (4). In the low-load range heating gas is additionally burned by a separate burner (5) and the cooling surfaces in the cooling zones, to which reaction gas is admitted, are reduced.

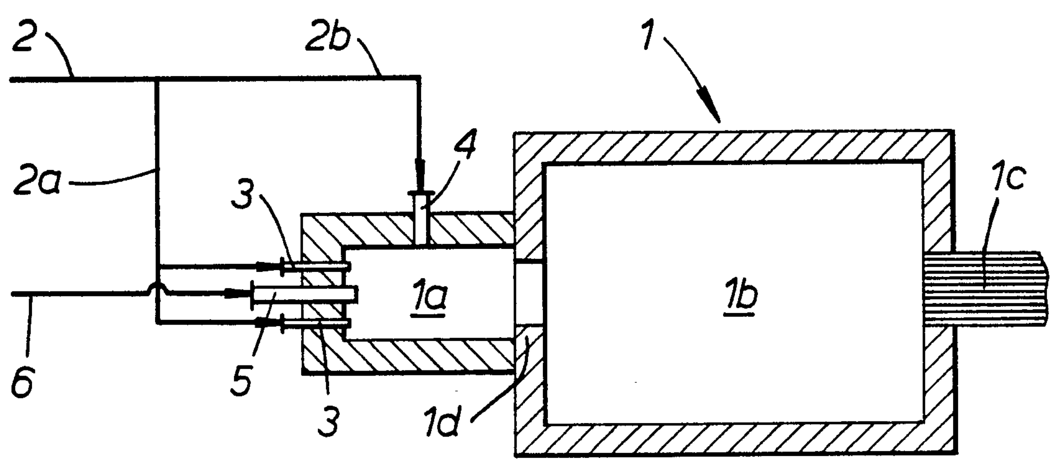

FIG. 1.

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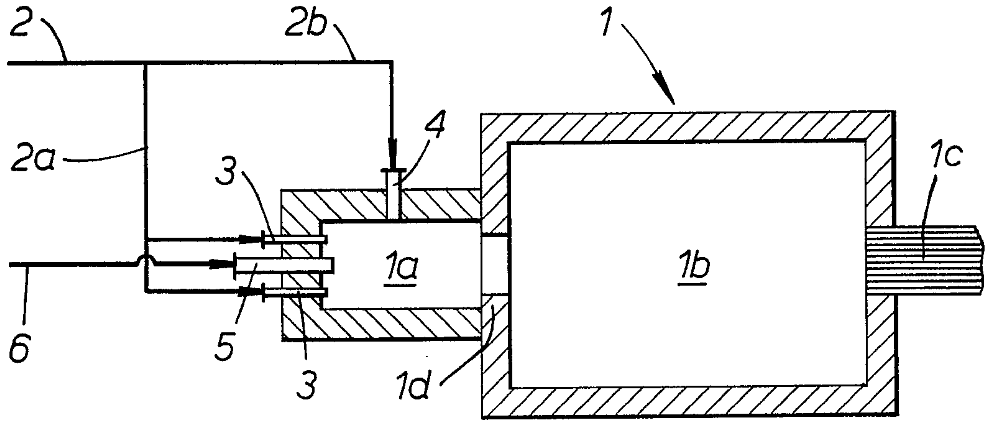

FIG. 1.

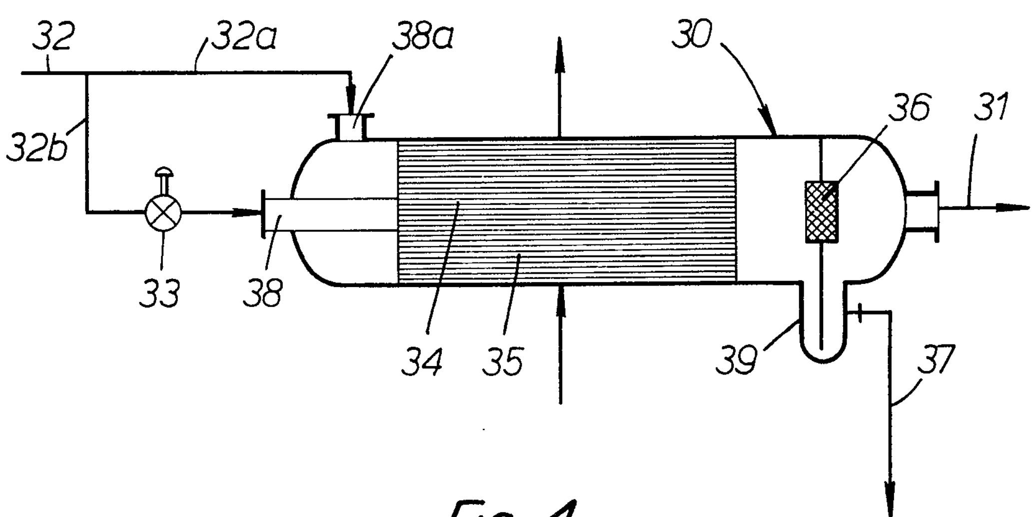

FIG. 4.

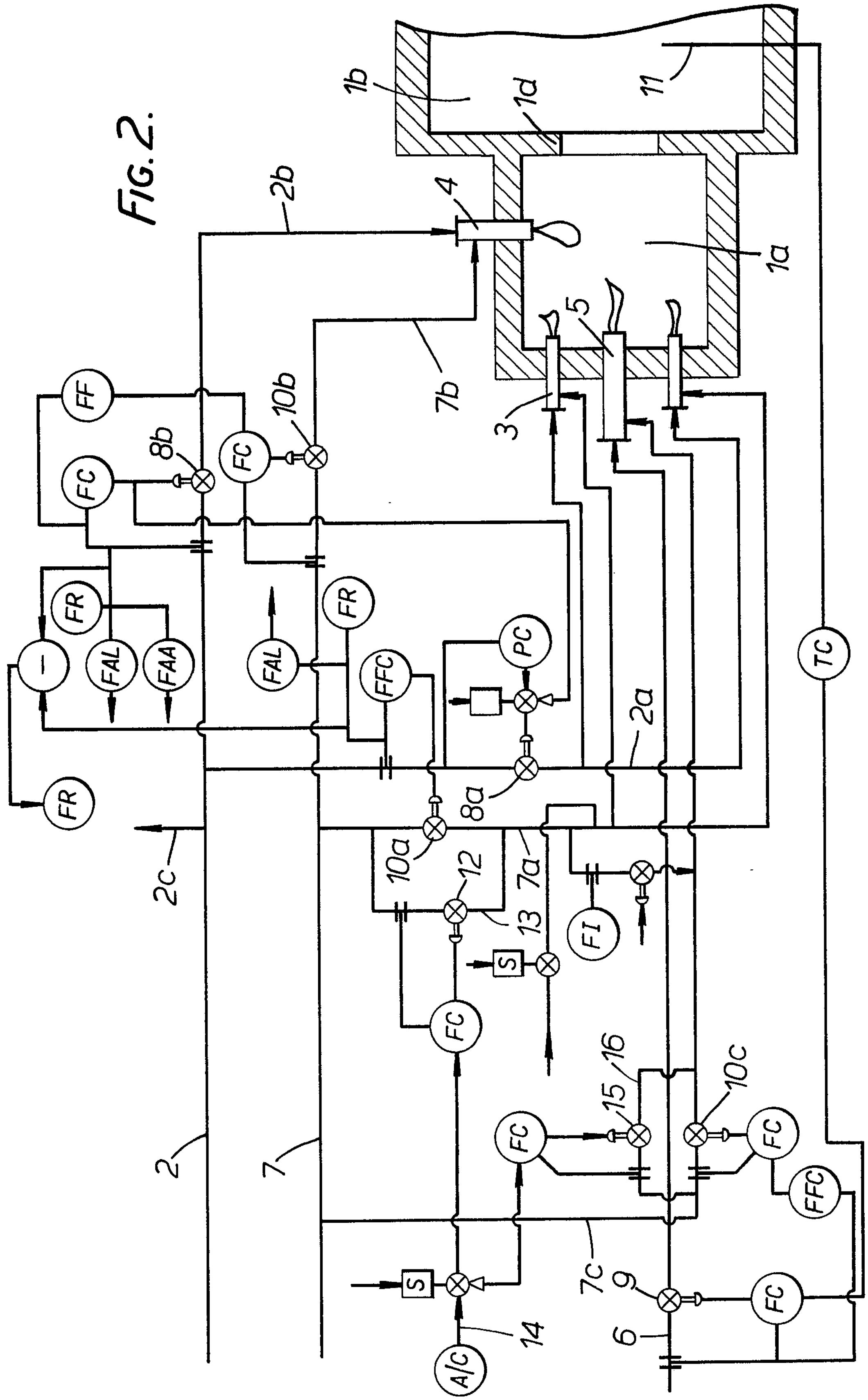
1b
1d
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FIG. 2.

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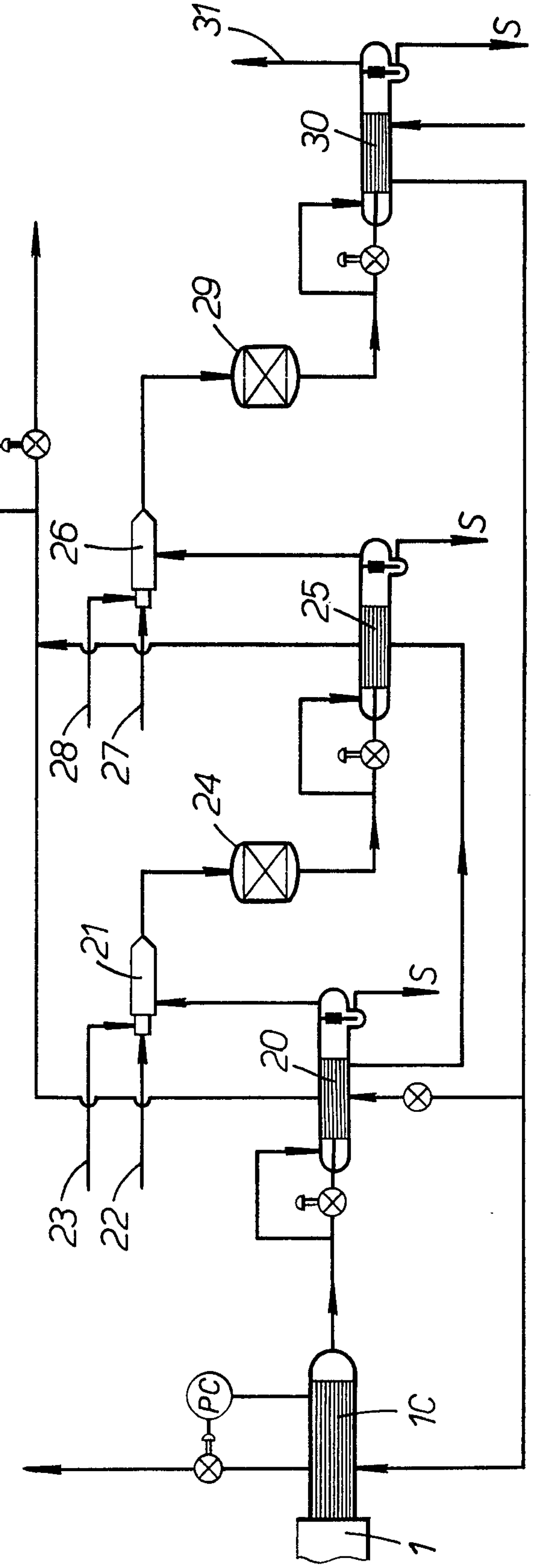

FIG. 3.

SPECIFICATION

Process and equipment for the burning of gases containing H_2S

The invention relates to a process for the burning of H_2S-containing gases with air and/or oxygen to elementary sulphur and for the separation of the sulphur formed from the reaction gas. The invention also relates to equipment for carrying out this process.

Processing of hydrogen-sulphide-containing gases by the Claus method is effected in plants which may be operated in a load range between 100 and 20%. Often, however, it becomes necessary to keep the plant operating at loads below 20%. This may be the case in refineries, for example, where from time to time very-low-suphur crude oils are processed and/or only a fraction of the capacity is utilized.

This invention is based on the need to provide a process and equipment for the transformation of H_2S-containing gases into elementary sulphur in a load range from 100 down to 5%, which ensures reliable trouble-free operation even in the low-load range. In the load range from 20 to 5% in particular, the invention seeks to provide reliable burning of the H_2S-containing gas and mist-free separation of the formed sulphur.

The invention is based on a process for the burning of H_2S-containing gases with air and/or oxygen to elementary sulphur and the separation of the formed sulphur from the reaction gas in a burner-equipped combustion zone, a subsequent reaction zone and several cooling zones, in which the formed sulphur, optionally after previous re-heating and catalytic further transformation into sulphur, is condensed and then separated from the reaction gas. In a high-load range, the H_2S-containing gases are passed into the combustion zone essentially by one or several main burners, and, in a low-load range, the gases are passed into the combustion zone by a by-pass burner with heating gas being additionally burned by a separate burner in the low-load range and with the cooling surfaces in the cooling zones, to which reaction gas is admitted, being reduced. Because in the low-load range, the H_2-containing gas is passed into the combustion chamber by a separate by-pass-burner designed for this load range, and because due to the burning of heating gas in this load range a reaction temperature sufficient for transforming the H_2S into sulphur is maintained, a reliable H_2S conversion of more than 90% into elementary sulphur is achieved even for a load range from 20 to 5%. By reducing the cooling surface acted upon by reaction gas in the low-load range, the formation of sulphur mists in the cooling zones is avoided thus achieving mist-free condensation of the sulphur. Where the reaction gases leaving the cooling zones are re-heated in in-line burners, the reduction in cooling surface in the low-load range has the added advantage of saving on heating gas, if the in-line burners are operated with heating gas, or of increasing the sulphur recovery level of the whole process, if the in-line burners are operated with acid gas.

In the preferred embodiment of the process according to the invention the switch-over between high-load and low-load operation is effected at a load in the 15–40% range, preferably at a load of approximately 25%. In the high-load range for example, the main burner may take 95 to 20% of the load, whilst the by-pass-burner is supplied constantly with 5% of the nominal load. When in the downward direction the load has reached 25%, the switch-over may be made by switching the main burner off and keeping only the by-pass-burner running, whose load will increase from 5 to 25% as the switch-over is made.

Preferably the heating-gas burner is switched in or out as a function of the temperature in the reaction zone or the combustion zone. In this way the temperature in the reaction zone may be maintained at the optimum value required for the formation of sulphur even in the low-load range, which optimum value cannot be achieved in the low-load range solely by burning the H_2S. This temperature in the reaction zone achieved by burning heating gas is generally 900 to 1150°C in the low-load range. The supply of heating gas to the heating-gas burner is conveniently controlled by the temperature in the reaction zone. In general, the heating-gas burner is switched on, when the load has dropped to 40% or less, preferably to 25% or less.

With the preferred embodiment of the process according to the invention the change in the admission of the reaction gas to the cooling surfaces is effected at a load in the approximately 40 to 60% range. If the load drops below a value in this range, the cooling surfaces acted upon by the reaction gas are reduced. This has the effect of preventing an excessive drop in the speed of the gas in the cooler and the formation of elementary sulphur mists which are difficult to separate in the usual sulphur condensers.

Furthermore provision should preferably be made for the air supply to the combustion zone to be controlled by a process chromatograph, in the high-load range via the amount of air flowing to the main burner(s) and in the low-load range via the amount of air flowing to the heating-gas burner. The command variable for controlling the air supply is the H_2S/SO_2 ratio in the reaction gas at the exit of the plant, that is after the last sulphur condensation before the entry of the end gas into a thermal or catalytic post-burning stage.

The control may be effected by means of by-pass lines with control valves provided on the main air valves of the air lines to the mains burners/the heating gas burner, with the control valves opening to a greater or lesser extent depending upon the control commands coming from the chromatograph. To ensure that the H_2S-containing gas is reliably burned even at very low load, the process air is conveniently controlled on the air line to the heating-gas burner. Conveniently the air supply to the by-pass-burner is limited to a load range from 8 to 25%. If the reaction gas is re-heated after condensation of the sulphur by means of in-line-burners, the supply of air to the by-pass-burner is omitted for loads below 8%, whilst in cases not employing in-line-burners the supply of air to the by-pass-burner is maintained down to 5%. The air supply to the by-pass-burner is set to a constant ratio in relation to the H_2S-containing gas, whereby the control is effected, as explained above, by the air supply to the heating gas burner, which is always operating in the low-load range.

The equipment for carrying out the process according to the invention comprises a combustion furnace including a combustion chamber, a reaction chamber and burners for H_2S-containing gas and heating gas, further a reaction gas cooler and at least one sulphur condenser/separator. At least one main burner for the high-load range and a by-pass-burner and a heating-gas burner for the low-load range are provided in the wall of the combustion chamber, and the cooling surfaces of the sulphur condenser/separator are divided enabling part of the cooling surfaces to be shut off. Whilst with the previous Claus furnaces a heating-gas burner was only used for the start-up, its purpose with the equipment according to the invention is to prevent the reaction temperature from dropping in the low-load range due to insufficient heat generation from the burning of the H_2S. The heating-gas burner thus has a permanent function in the low-load range. Shutting-down a part of the cooling surfaces ensures that in the low-load range, the mass speed in the cooling tubes does not drop below a certain value, thus avoiding the formation of sulphur mists in the gas phase. If the sulphur condenser/separator comprises a bank of tubes surrounded by a coolant, separate gas inlet pipes are preferably provided for the central tubes and for the tubes of the outer circumferential area, and a shut-off device is arranged in the gas line supplying the central tubes. In the low-load range the central tubes may be disconnected from the gas flow by means of the shut-off device. Shutting-off the central (inner) tubes ensures that the central (shut-off) tubes are surrounded by a sufficiently heated coolant (water), so that the sulphur is prevented from consolidating in these tubes not acted upon by the reaction gas.

The invention will now be described in detail by way of example with reference to the drawings in which:

Figure 1 is a schematic illustration of the combustion furnace with the burners for acid gas and heating gas;

Figure 2 is an enlarged illustration of part of the combustion furnace showing the gas feeds and the associated control devices;

Figure 3 is a schematic illustration of that part of the equipment according to the invention which is arranged downstream of the combustion furnace, and

Figure 4 is an enlarged illustration of one of the sulphur condensers built into the equipment according to the invention.

Fig. 1 shows the combustion furnace 1 comprising a combustion chamber 1^a and a reaction chamber 1^b, attached to which is the first stage of the process gas cooler 1^c. A restriction has been created between chambers 1^a and 1^b by means of a baffle plate. The acid gas advanced through line 2 may be passed to the main burner 3 via line 2^a, whereby main burner 3 is shaped as a multi-jet burner. The acid gas may also be passed to a by-pass-burner 4 via the by-pass-line 2^b. Furthermore the combustion chamber 1^a has a central heating-gas burner 5 which is supplied with heating gas via line 6.

As shown in Fig. 2, the acid gas lines 2^a and 2^b and also the heating-gas line 6 contain control valves 8^a, 8^b and 9 respectively, the importance of which will be described further on. Oxygen and air are passed to the burners 3, 4, 5 from the line 7 via the part lines 7^a, 7^b and 7^c respectively, also equipped with control valves 10^a, 10^b and 10^c respectively. Acid gas to the in-line-burners is supplied via line 2^c.

As can be seen from Fig. 2, valves 8^a, 8^b, 9 and 10^a to 10^c form part of an integrated control system allowing the controlled supply of acid gas, heating gas and air to the burners 3 to 5. Actuation of the heating gas valve 9 is controlled by a temperature sensor 11 in the reaction chamber 1^b of the furnace, and similarly air valve 10^c in the associated air line 7^c is controlled via a ratio control. The combustion air is controlled by a process chromatograph (not shown), which detects the H_2S/SO_2-ratio in the reaction gas at the exit, i.e. after the last sulphur condensation before entry of the gas into a thermal or catalytic post-burning stage. The purpose of this command variable is to control the amount of combustion air flowing through line 7^a to valve 10^a by means of a valve 12 in the by-pass-line 13 in the load range between 25 and 100%. For loads below 25% the supply of combustion air to the heating-gas burner 5 is controlled by the process chromatograph via control line 14 by means of valve 15 which is arranged in a by-pass 16 to the air valve 10^c.

According to Fig. 3 the reaction gas flows from the furnace 1 initially through a first reaction cooler 1^c, in which it is cooled to a temperature of at least 10 to 20°C above the sulphur melting point, thus substantially avoiding any sulphur condensation. The cooling of the gas is effected by generating medium-pressure steam. The reaction gas is then cooled down to a temperature below the sulphur melting point in a cooler/condenser/separator 20. During this process a large part of the formed sulphur is separated. The temperature of the cooled reaction gas will be in the range between 180 and 220°C for example. Subsequently the gas is heated in a combination chamber 21 to 220–300°C for example, by means of an in-line burner. This is achieved by burning acid gas supplied through line 22 with air supplied through line 23 in the combustion chamber 21. The gas is then further transformed at a Claus contact 24, followed by a cooler/condenser 25, where it is freed from the sulphur which has formed. The gas, cooled down to 140–180°C, is re-heated in a further combustion chamber 26 to 180–250°C for example, by burning acid gas (line 27) with air (line 28), it is then further transformed at the Claus contact 29 and finally cooled down in the cooler/condenser 30 to allow the sulphur to condense. When it has cooled to 120–150°C and the sulphur has separated out, the gas reaches a third and possible fourth Claus contact stage and/or a post-burning facility.

The cooler/separator 20, 25, 30 illustrated in Fig. 3 can be seen dimensionally enlarged in Fig. 4. It has a bank of tubes between tube plates with central tubes 34 to which gas may be admitted through a pipe socket 38^b, and tubes 35 in the annular area surrounding the central tubes 34, to which gas may be admitted through a pipe socket 38^a. The gas is supplied to the condenser 30 through line 32, whereby the central tubes 34 are supplied by line 32^b containing the shut-off device 33, whilst the tubes 35 in the annular area are supplied via partial line 32^a. Downsteam of the bank of tubes is the separator, where the sulphur droplets which have formed are separated. The liquid sulphur collects in the trap 39 and is drawn off by line 37. The reaction gas leaves the separator through line 31. This design permits the cooling surface to be reduced to the tubes 35 in the annular area by shutting off line 32^b, when the load has dropped to a certain value, for instance to 50%.

Operating methods

1. Operation in a load range from 100 to 25%.

5% of the H_2S-containing gas are advanced at a controlled rate to the by-pass-burner 4 and directed into combustion zone 1^a without combustion air. The remaining 20 to 95% are burned together with the required quantity of air at a controlled pressure in the main burner 3, whereby the quantity of acid gas required for the in-line burners 21, 26 may be deducted from this quantity. The heating-gas burner 5 which is not in operation is purged with part of the combustion air or an inert gas, in order to prevent the intrusion of sulphur vapours into the burner. When the reaction temperature, in general approximately 1000°C, drops below this value in the combustion chamber 1^a or the reaction chamber 1^b, the heating-gas burner 5 is ignited and the purging stops. The process chromatograph controls the air quantity admitted to the main burner 3.

2. Operation in the load range from 25 to 5%.

When a load of 25% is reached, i.e. 20% to the main burner 3 and 5% to the by-pass burner 4, the main burner 3 is switched off and purging with an inert gas begins. The acid quantity is burned at a controlled pressure in the by-pass burner 4 with the quantity of air required for the process. If the heating-gas burner is not in operation, it is ignited at this stage at the latest, in order to ensure reliable operation down to a load of 5%. The process air quantity from the process chromatograph is controlled by valve 15 in the by-pass 16 to the air valve 10^c of air line 7^c to burner 5.

3. Load range from 25 to 5% employing in-line burners operated with acid gas.

The burning of acid gas in the in-line burners 21, 26 and possibly further in-line burners is effected in the range between the stoichiometric air quantity for burning to SO_2 ($\lambda = 0.9$ to 0.95) and that for burning to sulphur for the purpose of avoiding an O_2 surplus. In order to prevent the air/acid gas ratio going to the by-pass burner 4 from dropping below the minimum value (maintaining the flame), this ratio is preset and used to operate the by-pass burner 4 at a value below the stoichiometric value. The fine adjustment of the process air quantity is effected as indicated in 2. When a minimum quantity of acid acid is reached, e.g. 10 to 15% (as a function of the acid gas concentration and the acid gas quantity to the in-line-burners) the air supply to the by-pass burner 4 is switched off. Air control is effected as previously, via the combustion air for the heating gas. The transformation into elementary sulphur is then effected, in the main, in the reaction zone 1^b of the combustion furnace 1.

With the process according to the invention the variations in the load may be caused by changes in the gas throughput, and also by fluctuations in the H_2S-concentration.

CLAIMS

1. Process for the burning of H_2S-contain-

ing gases with air and/or oxygen to elementary sulphur and the separation of the sulphur from the reaction gas, within a load range from 100 to 5%, in a burner-equipped combustion zone, a subsequent reaction zone and several cooling zones, in which the formed sulphur, optionally after previous re-heating and catalytic further transformation into sulphur, is condensed and then separated from the reaction gas, wherein in a high-load range, the H_2S-containing gases are passed into the combustion zone essentially by one or several main burners, and, in a low-load range, the gases are passed into the combustion zone by a by-pass burner, with heating gas being additionally burned by a separate burner in low-load range and with the cooling surfaces in the cooling zones, to which reaction gas is admitted, being reduced.

2. Process according to claim 1, wherein the switch-over from high-load to low-load operation is effected at a load in the 15–40% range.

3. Process according to claim 2, wherein the switch-over is effected at a load of about 25%.

4. Process according to claim 1, 2, or 3 wherein the heating-gas burner is switched in or out as a function of the temperature in the reaction zone or combustion zone.

5. Process according to any one of claims 1 to 4, wherein the heating gas is burned at a load of 40% or less.

6. Process according to claim 5, wherein the heating-gas is burned at a load of 25% or less.

7. Process according to any one of claims 1 to 6, wherein the change in the admission of the reaction gas to the cooling surfaces takes place at a load in the range between 40 and 60%.

8. Process according to any one of claims 1 to 7, wherein the air supply to the combustion zone is controlled by a process chromatograph, in the high-load range via the amount of air flowing to the main burner or burners and in the low-load range via the amount of air flowing to the heating-gas burner.

9. Process according to any one of claims 1 to 8, wherein the air supply to the by-pass-burner is limited to a load range between 8 and 25%.

10. Equipment for carrying out the process according to any one of claims 1 to 9, comprising a combustion furnace with a combustion chamber, a reaction chamber and burners for H_2S-containing gas and heating gas, the equipment further comprising a reaction gas cooler an at least one sulphur condenser/separator, at least one main burner for the high-load range and one by-pass-burner and one heating burner for the low-load range being provided in the wall of the combustion chamber, and the cooling surfaces of the sulphur condenser/separator being divided enabling part of the cooling surfaces to be shut off.

11. Equipment according to claim 10, in which the sulphur condenser/separator comprises a bank of tubes, with separate gas inlet pipes being provided for the central tubes and for the tubes of the outer circumferential area of the bank of tubes and with a shut-off device being arranged in the gas line supplying the central tubes.

12. Process for the burning of H_2S-containing gases with air and/or oxygen to elementary sulphur and the separation of the sulphur from the reaction gas substantially as described herein with reference to the accompanying drawings.

13. Equipment for carrying out a process for the burning of H_2S-containing gases with air and/or oxygen to elementary sulphur and the separation of the sulphur from the reaction gas, substantially as shown in the accompanying drawings and described herein with reference thereto.

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