

## DESCRIPTION

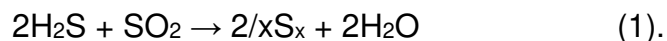
### PROCESS AND APPARATUS FOR OBTAINING SULFUR

5 [0001] The invention relates to a process for obtaining sulfur, in which a water vapor-enriched acid gas is formed from a hydrogen sulfide-containing acid gas by mixing in water, said water vapor-enriched acid gas being introduced into a Claus reactor via a burner together with an oxygen-rich gas and air, in order to be converted, by formation of a flame in a Claus process, to an elemental  
10 sulfur-comprising output stream from which elemental sulfur is separated.

[0002] Furthermore, the invention relates to an apparatus for obtaining sulfur that can be operated according to the process according to the invention.

15 [0003] The recovery of elemental sulfur from hydrogen sulfide-containing acid gas has been prior art for many years. Such an acid gas is obtained, for example, during the processing of natural gas or petroleum. In addition to the main components hydrogen sulfide and carbon dioxide, it typically also comprises further sulfur compounds, such as mercaptans, COS or CS<sub>2</sub>, as well  
20 as aromatic hydrocarbons, in particular benzene, toluene and xylenes (abbreviated to BTX).

[0004] An apparatus used for this type of sulfur recovery, referred to as SRU (Sulfur Recovery Unit), comprises a reactor (Claus reactor) which is divided  
25 into a thermal and a catalytic part. The thermal part essentially consists of a furnace (Claus furnace) into which the acid gas and an oxygen-containing oxidant, such as air, are introduced via a burner in order to react with one another to form a flame, with a portion of the hydrogen sulfide contained in the acid gas combusting to give sulfur dioxide. Adjoining the thermal part of the  
30 Claus reactor is the catalytic part consisting of two to three Claus stages where the sulfur dioxide formed during combustion reacts with hydrogen sulfide according to



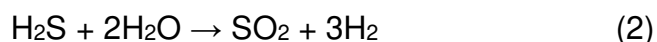
[0005] During the combustion in the Claus furnace, a third of the hydrogen sulfide used is generally converted into sulfur dioxide, which completely reacts with the remaining hydrogen sulfide in the catalytic part of the Claus reactor. A very small excess of hydrogen sulfide can also be set, in order to prevent sulfate formation on the Claus catalyst. The sulfur formed is present in the gas phase in elemental form in the output stream of the catalytic part of the Claus reactor, from which gas phase it is condensed out, particularly by cooling in the separating part of the SRU.

[0006] To increase the capacity, an oxygen-rich gas can be supplied to the Claus furnace as oxidant, wherein an oxygen-rich gas is to be understood as meaning a gas having a higher oxygen content than atmospheric air; in extreme cases, the oxygen-rich gas is technically pure oxygen, which consists of at least 95% oxygen. Corresponding processes are known to those skilled in the art as Claus processes with oxygen enrichment. Due to the increased amount of oxygen and the lower inert gas ballast, these processes make it possible to convert more hydrogen sulfide per unit time in the Claus furnace, and hence in the SRU, than when atmospheric air is used.

[0007] Since the reduction of the inert gas ballast leads to an increase in the flame temperature, the level of oxygen enrichment is limited by the maximum permissible operating temperature of the fire-resistant material used in the Claus furnace, which is typically approximately 1400°C. In order to overcome this limitation, patent application WO2015/176180A1 proposes enriching the hydrogen sulfide-containing acid gas used with water vapor upstream of the Claus furnace. By absorbing heat, on the one hand the water vapor reduces the furnace temperature and therefore the oxidant can be enriched with more oxygen. On the other hand, the authors ascribe to it the effect of enabling the

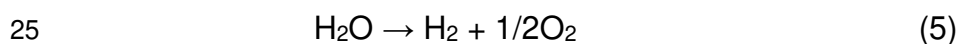
Claus reactions to take place with a lower demand for oxygen supplied in molecular form, and with additional heat absorption.

[0008] The described effect could be caused by reverse sulfur dioxide  
5 hydrogenation:



which, however, does not significantly contribute to the oxidation of hydrogen  
10 sulfide at the maximum permissible operating temperature of a Claus furnace.

[0009] From the prior art, as described, for example, in *Ullmann's Encyclopedia of Industrial Chemistry 2012, vol. 35, Sulfur, Chapter 6.6*, it is known to introduce a portion of the acid gas used together with technically pure oxygen  
15 into the inner region, referred to as the inner cone, of the flame formed, while the remaining acid gas is introduced together with air into the outer region, referred to as the outer cone, of the flame. The flame therefore consists of a comparatively cold outer cone which protects the fire-resistant lining of the Claus furnace from the extreme heat of the flame inner cone. Due to the high  
20 temperatures, elemental sulfur and oxygen are produced in the flame inner cone via the decomposition reactions:



[0010] The combination of this technique with the teaching of WO2015/176180A1 results in a high-capacity Claus process with a significantly reduced demand for supplied elemental oxygen. Particularly when  
30 an acid gas is used with a low hydrogen sulfide concentration, as is obtained, for example, from the desulfurization of natural gas, only very low temperatures of less than 1100°C can be reached within the flame outer cone due to the

nitrogen entrained by the combustion air, which temperatures do not allow effective destruction of BTX when the residence times are shortened. Since, even at low concentrations, BTX lead to deactivation of the Claus catalysts, this is to be regarded as very problematic.

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[0011] The object of the present invention is to specify a process of the generic type and an apparatus for carrying out said process, by means of which it is possible to obtain sulfur more effectively than is possible according to the prior art.

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[0012] This object is achieved in terms of the process according to the invention by a first portion of the hydrogen sulfide-containing acid gas being mixed with water to give the water vapor-enriched acid gas and then introduced together with the oxygen-rich gas into the inner region of the flame, while the remaining second portion of the hydrogen sulfide-containing acid gas is fed together with the air to the outer region of the flame.

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[0013] The process according to the invention makes it possible to produce high temperatures in the flame inner cone and to largely fully utilize the advantages described above, which result from enriching the acid gas with water vapor. Due to omitting the addition of water, the second portion of the hydrogen sulfide-containing acid gas has a higher calorific value than the acid gas generated from the first portion and enriched with water vapor. This makes it possible, despite the nitrogen ballast introduced with the air, to reach temperatures of more than 1100°C in the outer cone of the flame, at which temperatures BTX contained in the acid gas is reliably destroyed. At the same time, however, the flame outer cone is cold enough to effectively protect the Claus reactor from the heat of the flame inner cone.

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[0014] Preferably, the first portion of the hydrogen sulfide-containing acid gas, present at a first pressure, is fed to a steam jet pump known from the prior art in order to be enriched with water vapor, in which steam jet pump water vapor

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is used as propellant at a pressure higher than the first pressure. The acid gas is sucked in through the water vapor and mixed therewith, and therefore a mixture of substances consisting of water and the hydrogen sulfide-containing acid gas leaves the steam jet pump. This mixture of substances is guided to the burner, either directly or after separation of any liquid water that may be present, as water vapor-enriched acid gas in order to be fed to the inner flame region.

[0015] The invention further relates to an apparatus for obtaining sulfur, having a mixing device for forming a water vapor-enriched acid gas by mixing water into a hydrogen sulfide-containing acid gas, a Claus reactor having a burner via which the water vapor-enriched acid gas can be introduced into the Claus reactor together with an oxygen-rich gas and air, in order to be converted, by formation of a flame in a Claus process, to an elemental sulfur-comprising output stream and also to a separation portion for separating elemental sulfur from the output stream.

[0016] On the apparatus side, the stated object is achieved by the apparatus comprising a separating device, which makes it possible to separate the hydrogen sulfide-containing acid gas into a first portion and a second portion, of which the first portion can be introduced into the mixing device in order to form the water vapor-enriched acid gas, and the burner has at least four concentrically arranged supply channels, wherein the oxygen-rich gas can be introduced into the reactor via the innermost supply channel, the water vapor-enriched acid gas can be introduced into the reactor via the supply channel adjacent to the innermost supply channel, air can be introduced into the reactor via the outermost supply channel and the second portion of the hydrogen sulfide-containing acid gas can be introduced into the reactor via the supply channel adjacent to the outermost supply channel.

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[0017] The supply channels are preferably formed by straight tubes having a circular cross-section, the walls of which delimit the supply channels from one

another. The diameter of one or more of the tubes can change along the longitudinal axis so that, for example, one or more of the supply channels terminate in a nozzle on the reactor side.

- 5 [0018] The separating device that is arranged upstream of the mixing device and connected thereto and to the burner preferably comprises a tube branch designed, for example, as a Y-branch tube or a T-branch tube, to which one or more control members are connected, via which the proportional ratio between the first and second portions of the hydrogen sulfide-containing acid gas can  
10 be adjusted.

[0019] One variant of the apparatus according to the invention provides that the mixing device is designed with a mixing element. This mixing element, to which the first portion of the hydrogen sulfide-containing acid gas and water  
15 can be supplied, can consist, for example, of a tube part with a cross section which is constant or variable along the axis thereof. Furthermore, the tube part may contain one or more static mixers. However, the mixing element is preferably designed as a steam jet pump in which water vapor can be used as propellant in order to suck the first portion of the hydrogen sulfide-containing  
20 acid gas and mix it with the water vapor.

[0020] The mixing device can furthermore comprise a phase separator arranged downstream of the mixing element, by means of which phase separator liquid water can be separated from the mixture of substances  
25 generated by the mixing element in order to obtain the water vapor-enriched acid gas.

[0021] Hereinafter, the invention is to be explained in more detail based on two exemplary embodiments schematically illustrated in **Figures 1** and **2**.

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[0022] Figure 1 shows an SRU with a Claus reactor which is operated according to a preferred variant of the process according to the invention.

[0023] Figure 2 shows a part of the head of a burner, which can be operated according to the invention, for the Claus reactor of an SRU.

5 [0024] In the exemplary embodiment in Figure 1, a hydrogen sulfide-containing acid gas 11 is separated by means of the separating device T into a first portion 12 and a second portion 13, of which the first portion 12 is mixed in the mixing device M with water 14 supplied in liquid form or in vapor form, in order to  
10 obtain a water vapor-enriched acid gas 15, which is subsequently introduced via the burner B into the Claus reactor R and combusted in the Claus furnace O, forming the inner cone K of a flame F, with an oxygen-rich gas 16, which is, for example, technically pure oxygen. The second portion 13 of the hydrogen sulfide-containing acid gas 11 is likewise fed to the Claus furnace O via the burner B and combusted with air 17, wherein the flame outer cone A is formed  
15 in which temperatures of more than 1100°C, which in particular ensure reliable BTX decomposition, are achieved due to the lack of water vapor. At the same time, the flame outer cone A is sufficiently cold to prevent damage to the Claus furnace O due to the extreme heat of the flame inner cone K. The mixture of substances, in particular BTX-free mixture of substances, generated during  
20 combustion in which hydrogen sulfide and sulfur dioxide are present in a ratio of 2:1 is fed via line 18 to the catalytic part D of the Claus reactor R. Elemental sulfur 20 is separated, in the separation portion Z, from the output stream 19 comprising elemental sulfur obtained here.

25 [0025] The burner head shown in longitudinal section in Figure 2 comprises the four concentrically arranged burner tubes O, H, G and L, each of which has a circular cross section and forms four supply channels 21, 22, 23 and 24 which are open toward the reaction chamber R of the Claus furnace C.

30 [0026] In burner operation, an oxygen-rich gas can be introduced into the reaction chamber R via the innermost supply channel 21 and air can be introduced into the reaction chamber R via the outermost supply channel 24.

Here, the oxygen-rich gas 21 predominantly mixes with the water vapor-enriched acid gas which can be fed via the adjacent channel 22 in order to combust therewith to form the hot flame inner cone K. Acid gas can be introduced into the reaction chamber R via the supply channel 23 adjacent to  
5 the outermost channel 24, where it predominantly mixes with the air 24 and combusts therewith, wherein the comparatively cold flame outer cone A is formed.

## Claims

1. A process for obtaining sulfur (20), in which a water vapor-enriched acid gas (15) is formed from a hydrogen sulfide-containing acid gas (11) by mixing  
5 in water (14), said water vapor-enriched acid gas being introduced into a Claus reactor (R) via a burner (B) together with an oxygen-rich gas (16) and air (17), in order to be converted, by formation of a flame (F) in a Claus process, to an elemental sulfur-comprising output stream (19) from which elemental sulfur (20) is separated, **characterized in that** a first portion (12) of the hydrogen  
10 sulfide-containing acid gas (11) is mixed with water (14) to give the water vapor-enriched acid gas (15) and then introduced together with the oxygen-rich gas (16) into the inner region (K) of the flame (F), while the remaining second portion (13) of the hydrogen sulfide-containing acid gas (11) is fed together with the air (17) to the outer region (A) of the flame (F).  
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2. The process according to claim 1, characterized in that the first portion (12) of the hydrogen sulfide-containing acid gas (11) is fed to a steam jet pump (M) in order to be enriched with water vapor, in which steam jet pump water vapor (14) is used as propellant in order to suction the hydrogen sulfide-  
20 containing acid gas (12) mix with water.
3. An apparatus for obtaining sulfur (20), having a mixing device (M) for forming a water vapor-enriched acid gas (15) by mixing water (14) into a hydrogen sulfide-containing acid gas (11), a Claus reactor (R) having a burner  
25 (B) via which the water vapor-enriched acid gas (15) can be introduced into the Claus reactor (R) together with an oxygen-rich gas (16) and air (17), in order to be converted, by formation of a flame (F) in a Claus process, to an elemental sulfur-comprising output stream (19) and also to a separation portion (Z) for separating elemental sulfur (20) from the output stream (19),  
30 **characterized in that** it comprises a separating device (T), which makes it possible to separate the hydrogen sulfide-containing acid gas (11) into a first portion (12) and a second portion (13), of which the first portion (12) can be

introduced into the mixing device (M) in order to form the water vapor-enriched acid gas (15), and the burner (B) has at least four concentrically arranged supply channels (21, 22, 23, 24), wherein the oxygen-rich gas can be introduced into the reactor (R) via the innermost supply channel (21), the water vapor-enriched acid gas (15) can be introduced into the reactor (R) via the supply channel (22) adjacent to the innermost supply channel, air can be introduced into the reactor (R) via the outermost supply channel (24) and the second portion (13) of the hydrogen sulfide-containing acid gas (11) can be introduced into the reactor (R) via the supply channel (23) adjacent to the outermost supply channel.

4. The apparatus according to claim 3, characterized in that supply channels (21, 22, 23, 24) of the burner (B) are formed by straight tubes (O, H, G, L) having a circular cross-section, the walls of which delimit the supply channels (21, 22, 23, 24) from one another.

5. The apparatus according to any of claims 3 or 4, characterized in that the mixing device (M) comprises, as mixing element, a steam jet pump in which water vapor (14) can be used as propellant in order to suck the first portion (12) of the hydrogen sulfide-containing acid gas (11) and mix it with the water vapor (14).

6. The apparatus according to any of claims 3 to 5, characterized in that the mixing device (M) comprises a phase separator arranged downstream of the mixing element, by means of which phase separator liquid water can be separated from the mixture of substances generated by the mixing element in order to obtain the water vapor-enriched acid gas (15).