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D E C I S I O N
of 1 August 2000

Case Number: T 0474/97 - 3.3.5

Application Number: 92301321.3

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Language of the proceedings: EN

Title of invention:

Treatment of gases

Applicant:

The BOC Group plc

Opponent:

-

Headword:

Gas treatment/BOC

Relevant legal provisions:

EPC Art. 56

Keyword:

"Amended claims - inventive step (yes)"

Decisions cited:

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Case Number: T 0474/97 - 3.3.5

D E C I S I O N
of the Technical Board of Appeal 3.3.5
of 1 August 2000

Appellant: The BOC Group plc
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Representative: Wickham, Michael
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Decision under appeal: Decision of the Examining Division of the
European Patent Office posted 9 December 1996
refusing European patent application
No. 92 301 321.3 pursuant to Article 97(1) EPC.

Composition of the Board:

Chairman: R. K. Spangenberg
Members: M. M. Eberhard
J. H. van Moer

Summary of Facts and Submissions

- I. European patent application No. 92 301 321.3 was refused by a decision of the examining division posted on 9 December 1996. The decision was based on amended claims 1 to 13 filed on 1 March 1995.

- II. The ground for the refusal was that the process and the apparatus according to claims 1 and 9 did not involve an inventive step having regard to the teaching of EP-A-0 212 297 (hereinafter D1). According to the decision, D1 clearly indicated that all the methods described therein were conventional and that a separate water removal was quite possible and was indeed carried out in the prior art, in particular in US-A-4 138 473 referred to in D1. Consequently, the skilled person would easily have identified the drawbacks and advantages of each of the methods, such as the need for using high pressures in D1 and the risk of shifting the reversible reactions to the undesired direction if water was not removed. Performing the sulphur separation without simultaneously removing the water vapour was obvious to the skilled person since this feature was generally known in the art and the results therefrom were also predictable.

- III. The appellant lodged an appeal against this decision and filed a statement of grounds of appeal in due time. In reply to a communication of the board of appeal, five sets of amended claims were submitted on 30 June 2000, as a main request and four auxiliary requests. Oral proceedings were held on 1 August 2000. At the oral proceedings the appellant filed amended claims 1 to 8, as a sole request, by way of replacement for all the previous requests. Claim 1 of the said single

request reads as follows:

- "1. A method of recovering sulphur from a feed gas comprising hydrogen sulphide, comprising the steps of:
- (a) carrying out combustion of a part of the hydrogen sulphide content of a gas stream comprising feed gas in at least one furnace to form sulphur dioxide and water vapour;
 - (b) supplying oxygen rich gas, to support the combustion of said part of the hydrogen sulphide, at a rate such that the volumetric flow rate of oxygen into the furnace is less than half the volumetric flow rate of hydrogen sulphide into the furnace;
 - (c) allowing remaining hydrogen sulphide in the gas stream to react in the furnace with sulphur dioxide formed by the combustion of the hydrogen sulphide, thereby producing sulphur vapour and water vapour;
 - (d) separating sulphur vapour but not water vapour from a stream of gas mixture comprising hydrogen sulphide, sulphur dioxide, sulphur vapour and water vapour withdrawn from the furnace;
 - (e) reacting with oxygen-rich gas at least part of the gas stream from which sulphur has been separated, all the hydrogen sulphide in said part of the gas stream being fully oxidised to sulphur dioxide and water vapour;
 - (f) separating water vapour from the gas stream

produced by step (e);

- (g) returning to the furnace, or at least one of the furnaces, as a sole recycle gas at least part of the gas stream from which water vapour has been separated and reacting in such furnace sulphur dioxide in the returning gas stream with hydrogen sulphide in the feed gas; and
- (h) taking part of the gas stream from the end of step (d) or the end of step (f), or both, for further treatment comprising at least one catalytic stage of reaction between hydrogen sulphide and sulphur dioxide."

IV. The appellant put forward inter alia the following arguments:

The closest prior art was the process according to Figure 6 of D1. The problem addressed by the invention was to find a process that made it possible to achieve a high or even higher effective percentage conversion of hydrogen sulphide to sulphur in the combustion furnace while avoiding the difficulties arising from the use of elevated pressures and hence from the co-condensation of sulphur vapour and water vapour. Furthermore, the claimed process made it possible to use a much smaller recycle stream than in Figure 6 of D1 without having a detrimental effect on the effective conversion in the combustion furnace. The disclosure of D1 did not render obvious the claimed process. The co-condensation of water vapour and sulphur vapour lay at the heart of D1 and was a key feature of the embodiment shown in Figure 6. Therefore, the skilled person would not have thought of dispensing with this

co-condensation step. If the front end of the process according to Figure 6 had been operated without co-condensation of the water vapour, the acid gas recycle stream would have been rich in water vapour and an enhanced recovery of sulphur vapour would not have been realised. It seemed that unless the amount of gas fed to the incinerator was very small, or unless the conversion in the combustion furnace was very high, there would have been a build up of sulphur dioxide in the embodiment of Figure 6. Therefore, a skilled person seeking to modify this process would have eliminated the recycle of liquid sulphur dioxide and adopted the process of Figure 7 in preference to Figure 6. Indeed, according to Table 3 on page 22, the sulphur conversion in the combustion furnace was 68.3% with the liquid sulphur dioxide recycle, but 94.3% without such recycle. Furthermore, D1 taught that the acid gas recycle was the main recycle stream, not the sulphur dioxide recycle. The skilled person would not have omitted the acid gas recycle and kept the sulphur dioxide recycle because to do so would have increased the amount of sulphur dioxide recycled and thereby exacerbated the problems. In view of the much greater sulphur conversion in the case of Figure 7, he would have formed the view that the sulphur dioxide recycle was of less importance than the acid gas recycle and would not therefore have been led to consider using a recycle from downstream of the incinerator in any other process, for example an ambient pressure Claus process.

- V. The appellant requested that the decision under appeal be set aside and that a patent be granted on the basis of claims 1 to 8 filed during the oral proceedings.

Reasons for the Decision

1. The appeal is admissible.

2. The amended claims 1 to 8 meet the requirements of Article 123(2) EPC. Concerning the amendments in claim 1, it can be unequivocally derived from the application as filed, in particular the data in Tables 1 and 3, that no water vapour is separated from the gas stream in step (d). It is also directly and unambiguously derivable from the original application that the gas stream from which water vapour has been separated in step (f) is the sole recycle gas which is returned to the combustion furnace (see in particular page 7, lines 3 to 6; page 16, the last five lines in combination with page 17, lines 15 to 16; page 19, first paragraph; Figures 1 and 2). The additional feature in step (h), namely that the further treatment comprises at least one catalytic stage of reaction between hydrogen sulphide and sulphur dioxide, is disclosed in the description as filed: see in particular page 7, lines 3 to 6; page 9, lines 4 to 5 and 18 to 22; page 15, lines 13 to 18. Dependent claims 2 to 8 correspond to claims 2 to 8 originally filed.

3. Claim 1 differs from the process according to Figure 6 of D1 in that (i) the sulphur separation in step (d) is carried out without simultaneous removal of the water vapour, (ii) the gas stream from which water has been separated in step (f) is the sole recycle gas which is returned to the combustion furnace, and (iii) part of the gas stream from the end of step (d) or from the end of step (f) is subjected to further treatment comprising at least one catalytic stage of reaction

between hydrogen sulphide and sulphur dioxide. Therefore, the claimed process is novel with respect to the embodiment according to Figure 6 of D1. It also meets the requirement of novelty over the other processes disclosed in D1 and over the disclosure of the remaining documents cited in the search report.

4. At the oral proceedings the appellant considered that the process according to Figure 6 of D1 represents the closest prior art even with respect to amended claim 1. Although the processes disclosed in D1 are performed under high pressure so that the water vapour produced by the Claus reactions is condensed concurrently with the sulphur vapour, the board can follow this approach.

4.1 D1 discloses a high pressure oxygen-based non-catalytic process for recovering sulphur from a feed gas comprising hydrogen sulphide: see the process configuration of Figure 6 and the corresponding description on page 18, line 32, to page 23, line 22. This process comprises all the features stated in steps (a) to (g) of claim 1 except that the water vapour is condensed concurrently with the sulphur vapour in the first condenser (16) and that the recycling of the sulphur dioxide stream (60) to the combustion furnace (7) is not the sole recycle to the furnace. In the process according to Figure 6 not only gaseous sulphur dioxide is recycled back to the front-end Claus combustion furnace (7) but also a part of the acid gas stream obtained after co-condensation of the water vapour and sulphur vapour in the first condenser (see acid gas recycle (63) in Figure 6). Furthermore, the process according to Figure 6 does not comprise any catalytic stage of reaction between hydrogen sulphide and sulphur dioxide (see page 18, line 32, to page 19,

line 3; title at the bottom of Figure 6; page 23, lines 18 to 22). According to page 21, the overall sulphur recovery from the gas is near 100% for the process of Figure 6. Table 3 on page 22 shows that under the operating conditions stated on pages 20 to 22 the sulphur conversion in the combustion surface is 68.3%. According to the appellant, this seems to be the actual conversion and not the effective feed conversion (which is higher) taking into account the value of 94.3% stated in the right-hand column of Table 3 for the process according to Figure 7 of D1.

- 4.2 As pointed out by the appellant in the letter dated 1 March 1995, a number of disadvantages are associated with the co-condensation of water vapour and sulphur vapour in the first condenser (16) since the simultaneous condensation has to be performed at elevated pressure. As a result, special construction materials are required because of a potential corrosion problem arising from the enhanced solubility of sulphur dioxide at elevated pressure.

Starting from this prior art, the technical problem underlying the claimed process can be seen in the provision of a process for recovering sulphur from a hydrogen sulphide-containing feed gas, which makes it possible to overcome this drawback while obtaining a high effective percentage conversion of hydrogen sulphide to sulphur in the front-end combustion furnace.

It is proposed that this problem be solved by the process as defined in claim 1, which differs from the process of D1 in that (i) the sulphur separation in step (d) is carried out without simultaneous removal of

the water vapour, (ii) the gas stream from which water has been separated in step (f) is the sole gas which is recycled back to the combustion furnace (ie the acid gas recycle (63) according to Figure 6 of D1 is omitted), and (iii) part of the gas stream from the end of step (d) or from the end of step (f) is subjected to further treatment comprising at least one catalytic stage of reaction between hydrogen sulphide and sulphur dioxide. In view of the high effective sulphur conversion obtained in the combustion furnace in the examples of the description and taking into account the further information on page 9 that a high effective conversion of the hydrogen sulphide upstream of any catalytic reactors is still obtained when two furnaces receive hydrogen sulphide feed in parallel, it is credible that the technical problem has actually been solved by the claimed process.

- 4.3 D1 discloses that a basic problem with a low pressure Claus process is the fact that the water vapour produced either from the combustion furnace or from subsequent catalytic Claus converters remains in the gas stream throughout the process, which seriously limits the sulphur conversion due to the reversible nature of the reactions between hydrogen sulphide and sulphur dioxide (see reactions (3) and (4) on page 2, lines 20 and 35). This inherent low pressure limitation thus results in an incomplete sulphur recovery, and a large gas volumetric flowrate and equipment size resulting in increased capital and operating costs in the Claus plant, the tail gas clean-up unit and the incinerator (see page 3, lines 17 to 25). This problem is solved in D1 by condensing the water vapour produced by the Claus reactions concurrently with the sulphur vapour at a temperature above the sulphur melting point

under a sufficiently high pressure. The higher conversion in subsequent reaction steps, which results from the removal of water, increases sulphur recovery (see page 6, lines 24 to 31; page 8, lines 11 to 16). Therefore, the co-condensation of water vapour and sulphur vapour under high pressure is clearly a key feature of the processes disclosed in D1. In these circumstances, the skilled person faced with the problem stated above and hence wishing to avoid high pressures, would have sought suggestions in prior art documents concerning low pressure Claus processes rather than trying to modify the high pressure process of Figure 6 of D1. However, if it were assumed for the sake of argument that the skilled person would have considered reducing the pressure in the process of Figure 6 in an attempt to solve the problems associated with the co-condensation step, then he would not have contemplated omitting the acid gas recycle (recycle stream 63) and keeping only the sulphur dioxide recycle (recycle stream 60), for the following reasons:

The process according to Figure 6 includes two recycles to the combustion furnace, the acid gas recycle (63) and the gaseous SO₂ recycle (60). According to page 19, lines 13 to 17, the bulk of the process gas stream (20) is recycled to the combustion furnace while the remaining process gas stream is incinerated, cooled, dehydrated, liquefied and recycled to the combustion furnace. Therefore, the acid gas recycle (63) is the **main** recycle stream. It is not indicated in D1 what the purpose of the acid gas recycle in the embodiment of Figure 6 is. However, an acid gas recycle is also used in the sulphur recovery process of Figure 3 which is a high pressure oxygen-based sulphur recovery process with concurrent sulphur and water condensation further

including three catalytic stages. D1 teaches that the acid gas recycle stream (77) in Figure 3 aims at moderating the furnace temperature and provides for additional sulphur conversion in the invention of D1 wherein the water content of the stream (16) is substantially reduced (see page 17, lines 9 to 15, and Figure 3). D1 further discloses values of the sulphur conversion in the combustion furnace for both the processes of Figure 6 and Figure 7 (see page 22, Table 3). As emphasised by the appellant, Table 3 shows that a very high sulphur conversion (94.3%) can be obtained in the combustion furnace when the acid gas recycle is kept and the sulphur dioxide recycle dispensed with. Therefore, the skilled person faced with the problem stated above would not have been encouraged to omit the acid gas recycle, ie the main recycle in Figure 6 and the sole recycle in Figure 7 and Figure 3, and to keep the sulphur dioxide recycle since, in view of the teaching of D1 about the purposes of those recycles, he would not have expected this modification to enable the achievement of high effective sulphur conversion in the combustion furnace.

- 4.4 The remaining documents cited in the search report do not contain information which could point towards the claimed process. EP-A-0 252 497 (D3) discloses introducing externally supplied sulphur dioxide into the combustion furnace of a low pressure oxygen-enriched Claus process to moderate the furnace temperature, reduce oxygen consumption and increase sulphur conversion (see claim 1). However, this document does not suggest that the externally supplied sulphur dioxide might be replaced by a recycle gas as defined in the claimed process, ie a recycle gas which is obtained by oxidation of the process gas stream from

the first sulphur condenser followed by water vapour separation according to steps (e) and (f) of claim 1. Taking into account the fundamental differences between the process of D3 and the process of Figure 6 of D1 on the one hand, and the teaching of D1 about the function of the acid gas and sulphur dioxide recycles on the other hand, the board considers that a combination of these two documents in order to arrive at the claimed process would be based on a hindsight approach.

- 4.5 It follows from the above that the process according to claim 1 meets the requirements of inventive step set out in Articles 52(1) and 56 EPC.
5. Claim 1 being allowable, the same applies to dependent claims 2 to 8, whose patentability is supported by that of claim 1.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.
2. The case is remitted to the first instance with the order to grant a patent with the following documents:

Claims: 1 to 8 filed at the oral proceedings,

Description: to be adapted accordingly,

Figures: 1 to 6 filed on 11 March 1992.

The Registrar:

The Chairman:

S. Hue

R. Spangenberg