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(54) Title: PROCESS AND PLANT FOR PRODUCING SYNTHESIS GAS AND PYROLYSIS PRODUCTS FROM COAL OF DIFFERENT GRAIN SIZE

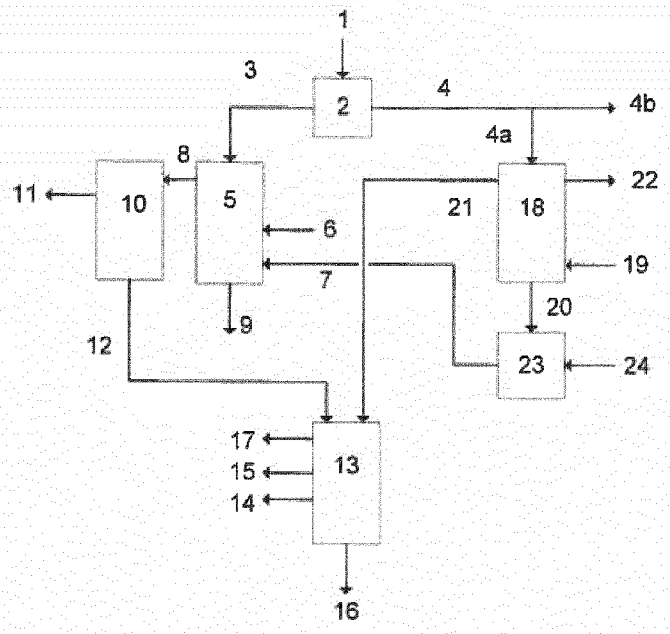

Fig. 1

(57) Abstract: A process for converting coal into synthesis gas and by-products, such as for instance tar and oil, wherein the coal is separated into a coarse and a fine fraction, the coarse fraction is processed in a fixed-bed pressure gasification, the fine fraction is processed in a pyrolysis, and the respectively obtained products containing tar, oil and naphtha are combined and mixed.

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Process and Plant for Producing Synthesis Gas and Pyrolysis Products from Coal of Different Grain Size

Field of the Invention

This invention relates to a process and a plant for converting coal into synthesis gas, tar, oil, naphtha, gas condensate and ash, comprising the process steps:

a) providing coal,

b) separating the coal into a coarse-grained and a fine-grained part by application of a mechanical separation process,

c) converting the coarse-grained part of the coal into synthesis gas, tar, oil, gas condensate and ash in a plant comprising a first plant section with a fixed-bed pressure gasification reactor in which the coal is gasified to a raw synthesis gas chiefly comprising carbon monoxide and hydrogen by using oxygen and steam, and wherein ash is produced, a second plant section which comprises a unit connected to the reactor for cooling and scrubbing the raw synthesis gas, which produces cooled synthesis gas and gas condensate loaded with tar and oil, and a third plant section for mechanically separating tar and oil from the gas condensate, wherein a chiefly tar-containing product stream, a chiefly oil-containing product stream, a chiefly dust- and tar-containing product stream and a gas condensate stream depleted of tar and oil is discharged from the third plant section for further processing.

Prior art

Such process is known. It is described in principle in Ullmann's Encyclopedia of Industrial Chemistry, Sixth Edition, Vol. 15, Gas Production, Chapter 4.4. The plant section which in specialist jargon is called "tar separator" for mechanically separating tar and oil from the gas condensate is described in Ullmanns Encyklopädie der technischen Chemie, 4th Edition, Vol. 14, Kohle, Gaserzeugung, Chapter 6.1.1.

It is a prerequisite for the trouble-free function of the process that the bed of the fixed-bed pressure gasification reactor can be traversed by the process gases oxygen and steam to a sufficient extent and uniformly distributed. To achieve this, the fine-grained fraction must be separated from the coal before use in the reactor. The separated fine-grained fraction of the coal in many cases is used as combustible material for the generation of process steam. It occurs, however, that the fine-grained fraction of the coal is so large that it amounts to up to 50 wt-%, so that it exceeds the coal demand for the generation of process steam and it is difficult to economically use the excess of fine-grained coal for other purposes. A further disadvantage of this use as combustible material consists in that it is not possible to obtain valuable products, such as tar and oil, from this part of the coal.

Description of the Invention

In the process according to the invention as described in detail below, the disadvantages of the prior art are overcome in that at least a part of the fine-grained fraction of the coal is converted into coke as well as tar, oil and naphtha vapors by pyrolysis, wherein the coke is supplied to a further use and the tar and oil vapors are condensed and the tar is admixed to the chiefly tar-containing product stream from step c) and the oil is admixed to the chiefly oil-containing product stream from step c) and the naphtha vapor for the one part is supplied to another use and for the other part is condensed and the liquid naphtha obtained thereby is admixed to the chiefly oil-containing product stream from step c).

In this way, the yield of valuable products, such as tar and oil, from the coal is increased, as the fine-grained fraction of the coal no longer merely is fired or discarded, as it is common practice according to the prior art. By targeted selection from the pyrolysis processes known to the skilled person, which in the literature occasionally also are referred to as carbonization processes, and by targeted process management well-known to the skilled person, the quality of the pyrolysis products tar, oil and naphtha can be influenced. By mixing the tars and oils originating from the gasification and from the pyrolysis according to the invention, the quality of the tar and oil produced by the process according to the invention thus can also be influenced selectively.

What is suitable for the invention for example is the LURGI-RUHRGAS carbonization process, cf. Ullmanns Encyklopädie der technischen Chemie, 4th Edition, Vol. 3, p. 463.

In the sense of this invention, carbonization is understood as pyrolysis. Pyrolysis conditions are understood to be physico-chemical conditions which provide for a thermochemical decomposition of organic compounds under largely non-oxidative conditions. They are known per se from the prior art and comprise the setting of high temperatures and largely the absence of oxidizing agents, i.e. for example heating under the exclusion of air. The skilled person will suitably select the pyrolysis conditions in dependence on the feedstock to be treated.

Preferred Aspects of the Invention

A particular aspect of the invention is characterized in that the fine-grained part of the coal mentioned in step b) of claim 1 is defined by a particle size of below 5 mm. The particle size is adjusted by sieving with a sieve having a mesh width of 5 mm. At this boundary between fine-grained coal part which is pyrolyzed and coarse-grained part which is processed in the fixed-bed pressure gasification reactor, a good throughflow of the fixed bed in the gasification reactor is given with many types of coal.

Another particular aspect of the invention is characterized in that the tar, oil and naphtha vapors obtained by pyrolysis are cooled such that the tar and oil vapors are condensed completely and the naphtha vapor is condensed in part, and wherein the liquid tar, oil and naphtha phases obtained thereby are introduced into the third plant section mentioned in step c) and in the same are introduced into the gas condensate loaded with tar and oil, and wherein the non-condensed part of the naphtha vapor is supplied to another use. The advantage of this aspect consists in that the condensation of the pyrolysis products can be effected close to the pyrolysis apparatus, whereby a transport of the vapors over larger distances through conduits is avoided.

Another particular aspect of the invention is characterized in that the tar, oil and naphtha vapors obtained during the pyrolysis in the third plant section mentioned in step c) are introduced into the gas condensate phase contained therein, which is loaded with tar and oil, wherein tar and oil vapors are condensed completely and together with the tar and oil obtained in step c) are separated from the gas condensate, and wherein the naphtha vapor is condensed in part and together with the oil separated from the gas condensate and the non-condensed part of the naphtha vapor is supplied to another use. The advantage of this aspect consists in that no separate unit is required for the condensation of the vapors.

Another particular aspect of the invention is characterized in that the coke produced in the pyrolysis according to step d) of claim 1 is at least partly used as heat carrier for the production of the steam used for the gasification carried out in the fixed-bed pressure gasification reactor according to step c) of claim 1. Due to this use of the coke within the plant, costs for the sale and transport to more remote sites of use are avoided.

Another particular aspect of the invention is characterized in that the non-condensed part of the naphtha vapor is used as heat carrier in the pyrolysis of the fine-grained part of the coal. This measure increases the energy efficiency of the process.

Exemplary embodiment

Further features, advantages and possible applications of the invention can also be taken from the following description of an exemplary embodiment and numerical example as well as the drawing. All features described and/or illustrated form the subject-matter of the invention per se or in any combination, independent of their inclusion in the claims or their back-reference.

In the only Figure

Fig. 1 shows a schematic block diagram of the process according to the invention.

The process according to the invention will be explained below with reference to Fig. 1 of the drawing.

In a mechanical separating device 2, e.g. a screening machine, the provided coal 1 is separated into a coarse-grained fraction 3 and a fine-grained fraction 4. In a first plant section 5, the coarse-grained fraction 3 of the coal is gasified to raw synthesis gas 8 by using oxygen 6 and steam 7, wherein ash 9 is produced. The raw synthesis gas 8 is transferred from the first plant section 5 into a second plant section 10 and cooled and scrubbed there and is supplied to a further treatment as synthesis gas 11. During the treatment in the second plant section 10 gas condensate 12 loaded with tar, oil and dust is obtained.

The fine-grained fraction 4 of the coal 1 for the one part 4a is supplied to a pyrolysis treatment 18 and for the other part 4b is supplied to another use, e.g. the use as combustible material. In the pyrolysis treatment 18 the coal is converted into coke 20, carbonization products 21 and waste gases 22 by dosed addition of air 19. The coke 20 produced is supplied to a plant for steam generation 23, which is fed with water 24. The generated steam 7 is introduced into the first plant section 5. The waste gases 22 produced in the pyrolysis 18, which also contain naphtha, are supplied to a further treatment. During the pyrolysis treatment there are furthermore obtained carbonization products 21 which chiefly consist of tar, oil

and naphtha and, in dependence on the process conditions applied during the pyrolysis and cooling treatment, are present in gaseous or liquid form.

The loaded gas condensate 12 and the carbonization products 21 liquefied by cooling are transferred into the plant section 13 and mixed therein. In this plant section 13, a chiefly tar-containing product stream 14, a chiefly oil-containing product stream 15 which also contains naphtha, and a dust-containing and tar-containing product stream 16 are separated from the gas condensate in a mechanical way, e.g. by means of a settling tank, which often is referred to as tar separator. The purified gas condensate 17 is supplied to a further treatment.

Industrial Applicability

The invention provides a process for converting coal into synthesis gas and valuable by-products such as tar, in which the fine fraction of the coil also is used effectively for the production of the by-products.

List of Reference Numerals

1	coal
2	separating device
3	coarse-grained fraction of the coal
4	fine-grained fraction of the coal, a for pyrolysis, b for other purposes
5	first plant section, e.g. fixed-bed pressure gasification
6	oxygen
7	steam
8	raw synthesis gas
9	ash
10	second plant section, cooling and scrubbing
11	raw synthesis gas
12	loaded gas condensate
13	third plant section, e.g. tar separator
14	tar-containing product stream
15	product stream containing oil and naphtha
16	product stream containing dust and tar
17	gas condensate
18	pyrolysis
19	air
20	coke
21	carbonization products
22	waste gases, also containing naphtha
23	steam generation
24	water

Claims:

1. A process for converting coal into synthesis gas, tar, oil, naphtha, gas condensate and ash, comprising the process steps:

a) providing coal,

b) separating the coal into a coarse-grained and a fine-grained part by application of a mechanical separation process,

c) converting the coarse-grained part of the coal into synthesis gas, tar, oil, gas condensate and ash in a plant comprising a first plant section with a fixed-bed pressure gasification reactor in which the coal is gasified to a raw synthesis gas chiefly comprising carbon monoxide and hydrogen by using oxygen and steam, and wherein ash is produced, a second plant section which comprises a unit connected to the reactor for cooling and scrubbing the raw synthesis gas, which produces cooled synthesis gas and gas condensate loaded with tar and oil, and a third plant section for mechanically separating tar and oil from the gas condensate, wherein a chiefly tar-containing product stream, a chiefly oil-containing product stream, a chiefly dust- and tar-containing product stream and a gas condensate stream depleted of tar and oil is discharged from the third plant section for further processing, characterized in that

d) at least a part of the fine-grained part of the coal obtained in step b) is converted into coke as well as tar, oil and naphtha vapors by pyrolysis, wherein the coke is supplied to a further use and the tar and oil vapors are condensed and the tar is admixed to the chiefly tar-containing product stream from step c) and the oil is admixed to the chiefly oil-containing product stream from step c) and the naphtha vapor for the one part is supplied to another use and for the other part is condensed and the liquid naphtha obtained thereby is admixed to the chiefly oil-containing product stream from step c).

2. The process according to claim 1, characterized in that the fine-grained part of the coal mentioned in step b) of claim 1 is defined by a particle size of below 5 mm.

3. The process according to claim 1 or 2, characterized in that the tar, oil and naphtha vapors obtained are cooled such that the tar and oil vapors are condensed completely and the naphtha vapor is condensed in part, and wherein the liquid tar, oil and naphtha phases obtained thereby are introduced into the third plant section mentioned in step c) of claim 1 and in the same are introduced into the gas condensate loaded with tar and oil, and wherein the non-condensed part of the naphtha vapor is supplied to another use.

4. The process according to claim 1 or 2, characterized in that the tar, oil and naphtha vapors obtained during the pyrolysis in the third plant section mentioned in step c) of claim 1 are introduced into the gas condensate phase contained therein, which is loaded with tar and oil, wherein tar and oil vapors are condensed completely and together with the tar and oil obtained in step c) of claim 1 are separated from the gas condensate, and wherein the naphtha vapor is condensed in part and together with the oil is separated from the gas condensate and the non-condensed part of the naphtha vapor is supplied to another use.

5. The process according to any of the preceding claims, characterized in that the coke produced in the pyrolysis according to step d) of claim 1 is at least partly used as heat carrier for the generation of the steam used for the gasification carried out in the fixed-bed pressure gasification reactor according to step c) of claim 1.

6. The process according to any of the preceding claims, characterized in that the non-condensed part of the naphtha vapor is used as heat carrier in the pyrolysis of the fine-grained part of the coal.

7. A plant for converting coal into synthesis gas, tar, oil, naphtha, gas condensate and ash, comprising the plant sections:

- apparatus for the mechanical separation of the coal into a coarse-grained and a fine-grained fraction,
- apparatus for the fixed-bed pressure gasification of the coarse-grained fraction of the coal to a raw synthesis gas with the formation of ash,
- apparatus for cooling and scrubbing the raw synthesis gas with the formation of gas condensate,
- tar separator for the mechanical separation of product streams from the gas condensate,
- apparatus for the pyrolysis of the fine-grained fraction of the coal,
- apparatus for steam generation, which is operated with the coke produced in the apparatus for the pyrolysis,
- furthermore comprising the apparatuses for the transfer of the intermediate products between the plant sections,

characterized in that the apparatus for the pyrolysis with a transfer device for carbonization products is connected with the tar separator, and the apparatus for steam generation with a transfer device for the vapor is connected with the apparatus for the fixed-bed pressure gasification.

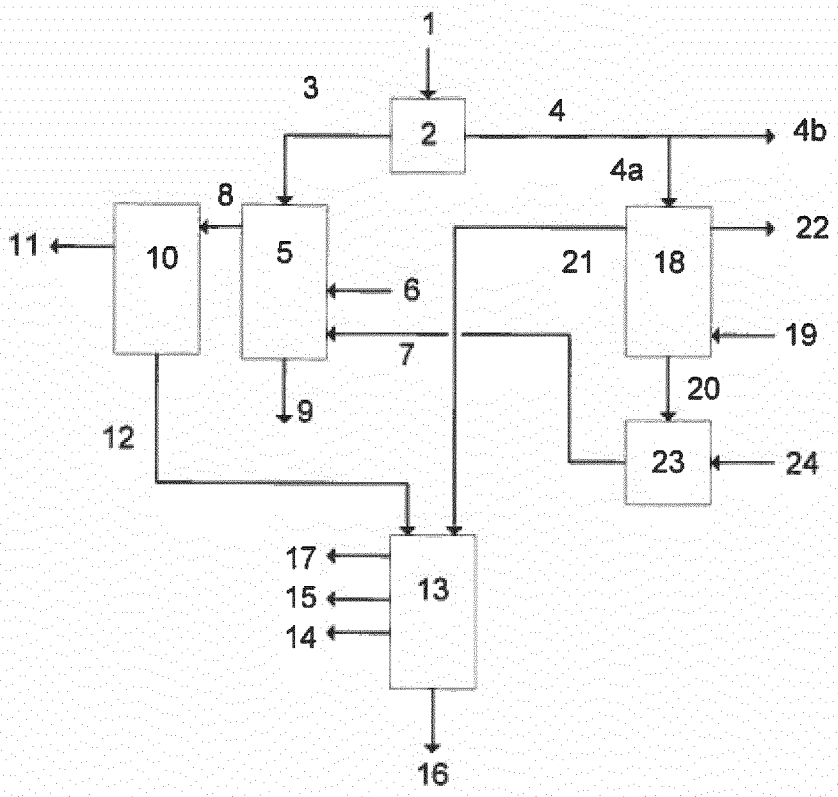

Fig. 1

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/025037

A. CLASSIFICATION OF SUBJECT MATTER
INV. C10J3/02 C10K1/00 C10K1/10 C10B49/02 C10B53/04
C10C1/00
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C10J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	DE 39 13 894 A1 (METALLGESELLSCHAFT AG [DE]) 31 October 1990 (1990-10-31) column 1, line 3 - column 2, line 63; figure 1	1-7
X	EP 0 119 648 A2 (METALLGESELLSCHAFT AG [DE]) 26 September 1984 (1984-09-26) page 4, paragraph 3 - page 5, paragraph 3; figure 1	1-7
X	EP 0 075 972 A1 (METALLGESELLSCHAFT AG [DE]) 6 April 1983 (1983-04-06) page 2, paragraph 5 - page 5, paragraph 2; figure 1	1-7
A	WO 80/00974 A1 (KAISER ENG INC [US]; HURNEY R [US]; HEMPILL H [US]) 15 May 1980 (1980-05-15) the whole document	1-7

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2016/025037

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