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(54) **PROCESS AND PLANT FOR THE PRODUCTION AND FURTHER TREATMENT OF FUEL GAS**

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(57) **ABSTRACT**

A process for producing fuel gas and for carrying out a metallurgical process includes providing first and second process stages. In the first process stage, biomass is reacted with an oxygen-containing gas so as to obtain a fuel gas containing at least one of carbon monoxide, hydrogen, carbon dioxide and steam. The fuel gas is cooled to a temperature in a range from 300 to 600° C. The cooled fuel gas is subjected to a solids separation. In the second process stage, the fuel gas after the solids separation is directly supplied to at least one burner of the metallurgical process, the temperature of the fuel gas being maintained above the condensation temperature of tar and within the range from 300 to 600° C. by supplying heat.

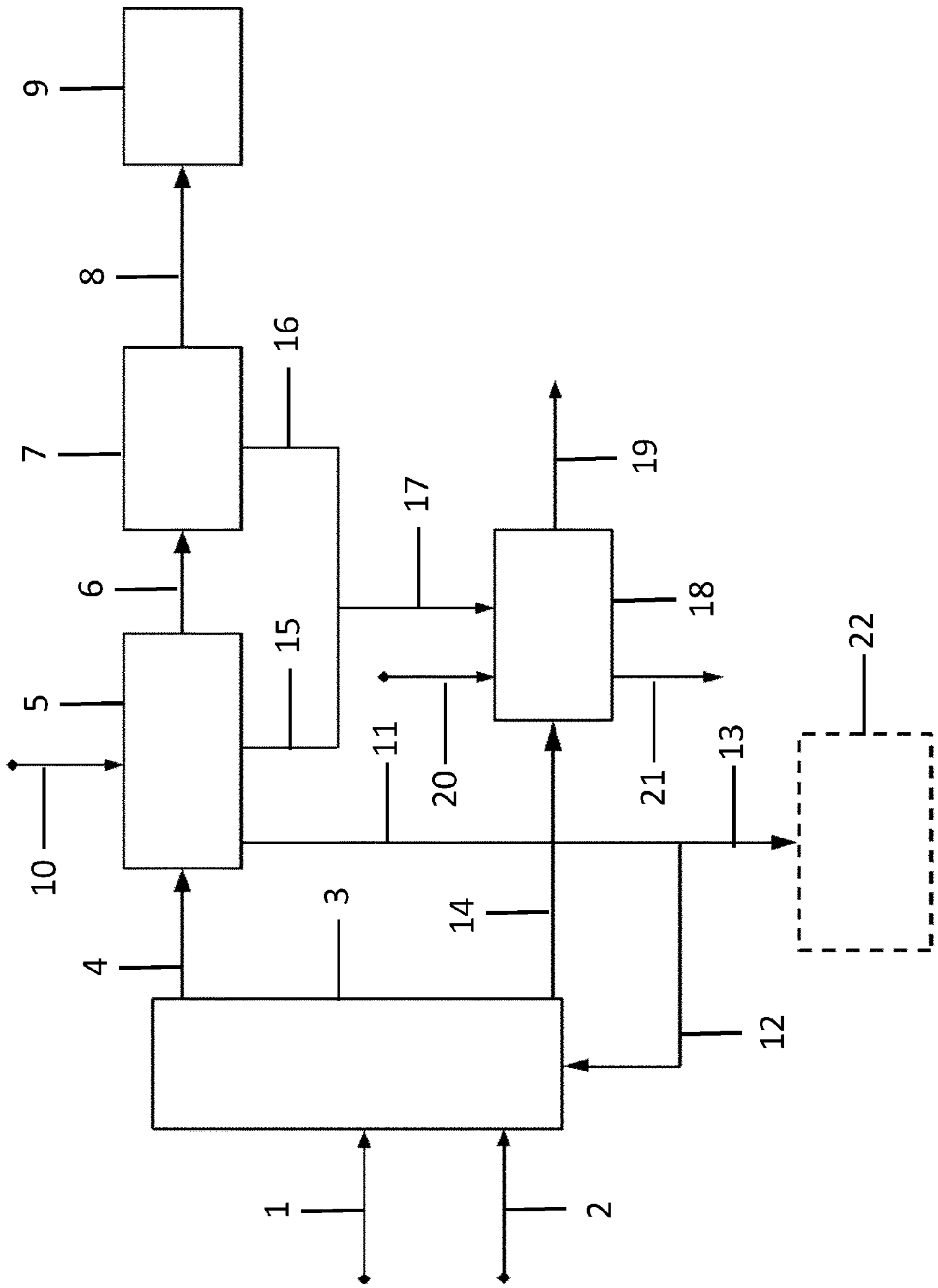

Fig. 1

PROCESS AND PLANT FOR THE PRODUCTION AND FURTHER TREATMENT OF FUEL GAS

CROSS-REFERENCE TO PRIOR APPLICATIONS

[0001] This application is a U.S. National Phase Application under 35 U.S.C. §371 of International Application No. PCT/EP2012/055599, filed on Mar. 29, 2012, and claims benefit to German Patent Application No. DE 10 2011 100 490.8, filed on May 4, 2011. The International Application was published in English on Nov. 8, 2012 as WO 2012/150097 under PCT Article 21(2).

FIELD

[0002] The present invention relates to a process for the production of fuel gas and for carrying out a metallurgical process, in which in a first process stage carbonaceous materials, preferably coal or biomass, are reacted with an oxygen-containing gas to obtain a fuel gas containing carbon monoxide, hydrogen, carbon dioxide and/or steam, wherein the fuel gas obtained is cooled to a temperature of 300 to 600° C., preferably 350 to 450° C., and subsequently supplied to a filtration means, and wherein in a second process stage the filtered fuel gas is charged to at least one burner of the metallurgical process, and to a plant for carrying out this process.

BACKGROUND

[0003] To be able to use fine iron ores for the production of pig iron or direct-reduced iron (DRI), they are mixed with water and agglomerated to pellets. The thermal energy necessary for drying and curing the pellets is provided by the combustion of natural gas or oil. Many regions in which new pellet plants are being planned are, however, not connected to a natural gas network, but often have occurrences of carbonaceous materials, such as coal or biomass.

[0004] Similar conditions of the local infrastructure, in particular the availability of carbonaceous materials such as coal or biomass as the only energy source, can also be found at sites for other metallurgical processes such as the calcination of alumina earth.

[0005] As a consequence, it is economically expedient to convert the existing carbonaceous materials (e.g. coal or biomass) to fuel gas, so that they are energetically usable for the succeeding metallurgical process.

[0006] DE 102 60 734 A1 describes a process for the production of carbonization coke and fuel gas in a fluidized-bed reactor, wherein the fluidized bed is an annular fluidized bed. The gas velocities of the first gas and of the fluidizing gas for the annular fluidized bed are adjusted in a certain ratio relative to each other, so that solids from the stationary annular fluidized bed are introduced into an upper region, the mixing chamber region, and mixed there intensively, before the particles fall back into the annular fluidized bed.

[0007] EP 0 062 363 A1 describes a process for the production of fuel gas, in which the by-products obtained can be reduced. First, gasification is carried out in the presence of steam in a fluidized bed, the gas formed then is liberated from sulfur compounds, cooled and dedusted, and then the residue from the gasification is burnt.

[0008] The gasification of carbonaceous materials—in particular of coal—to a fuel gas, which substantially consists of carbon monoxide, hydrogen, carbon dioxide and steam, results in the formation of tar. The tars contained in the hot gases involve the risk that they are deposited in plant sections and harden there. This would first of all lead to a reduction of the conduit cross-sections and as a result to changed flow conditions, which renders a regulation and control of the plant much more difficult. Further deposits might lead to a complete clogging of plant sections, which represents a considerable safety risk.

[0009] WO 2009/074170 A1 therefore describes that the fuel gas produced in the gasification of coal first is supplied to a solids separation and subsequently transferred to a further wash, by means of which the tar can be removed.

[0010] U.S. Pat. No. 4,461,629 also teaches that after the gasification of coal the tars present must urgently be removed from the fuel gas, as otherwise tar deposits and the involved risks will occur. For this purpose, the fuel gas is introduced into a fluidized-bed reactor and cooled there. Impurities present, in particular the tars, are deposited on the particles of the fluidized bed, while the fuel gas can be cleaned and after cooling be supplied to the next process step.

[0011] U.S. Pat. No. 4,563,195 on the one hand describes the possibility of tar removal by washing with cold water, which however involves the disadvantage that this produces large amounts of waste water. As an ecologically more expedient variant of tar removal, on the other hand, a wash with a rather small amount of water therefore is described, which is effected in that the fuel gases are passed through a water spray. This has the advantage of a distinctly lower moisture content of the tars removed in this way, which allows a burn-off of the tars.

[0012] Various possibilities of the wash, e.g. a RECTISOL wash, are also known from the general scientific literature, for example from Joerg Schmalfeld, "Die Veredelung und Umwandlung von Kohle-Technologien und Projekte 1970 bis 2000 in Deutschland", Urbanverlag, Hamburg 2008.

[0013] All processes have in common that a use of the resulting hot fuel gas for a downstream metallurgical process only is possible when the fuel gas is subjected to an expensive and ecologically not unproblematic tar removal.

SUMMARY

[0014] The present invention advantageously allows for the coupling of a fuel gas production with a metallurgical process, without first having to remove the tar from the fuel gas.

[0015] In an embodiment, the present invention provides a process for producing fuel gas and for carrying out a metallurgical process. In a first process stage, biomass is reacted with an oxygen-containing gas so as to obtain a fuel gas containing at least one of carbon monoxide, hydrogen, carbon dioxide or steam. The fuel gas is cooled to a temperature in a range from 300 to 600° C. The cooled fuel gas is subjected to a solids separation. In a second process stage, the fuel gas after the solids separation is directly supplied to at least one burner of the metallurgical process, the temperature of the fuel gas being maintained above the condensation temperature of tar and within the range from 300 to 600° C. by supplying heat.

BRIEF DESCRIPTION OF THE DRAWING

[0016] The present invention will be described in even greater detail below based on the exemplary figure. The invention is not limited to the exemplary embodiments. All features described and/or illustrated herein can be used alone or combined in different combinations in embodiments of the invention. The features and advantages of various embodiments of the present invention will become apparent by reading the following detailed description with reference to the attached drawing which illustrates the following:

[0017] FIG. **1** shows a schematic diagram of the process according to an embodiment of the invention.

DETAILED DESCRIPTION

[0018] In accordance with an embodiment of the invention, in a first process stage, carbonaceous materials, in particular coal or biomass, are reacted with an oxygen-containing gas, which in particular can be oxygen, air, compressed air or industrial air (80 vol-% nitrogen, 20 vol-% oxygen), to obtain a fuel gas containing carbon monoxide, hydrogen, carbon dioxide and/or steam. The fuel gas thus obtained subsequently is cooled to a temperature of 300 to 600° C., preferably 350 to 450° C., more preferably 380 to 420° C., and in particular 400±5° C. and supplied to a solids removal. Such solids removal in particular can be at least one cyclone or a filter device, wherein the use of candle filters here is particularly useful, since ceramic candle filters are quite useful for hot gas filtration, because they hardly show wear phenomena despite the relatively high temperatures of gas and particles.

[0019] In the sense of this description, the term "carbonaceous material" means a material whose carbon content preferably corresponds to at least 25 wt-% of its dry matter, more preferably at least 30 wt-% of its dry matter, even more preferably at least 35 wt-% of its dry matter, most preferably at least 40 wt-% of its dry matter, and in particular to at least 45 wt-% of its dry matter. In a further preferred embodiment, the carbon content in the carbonaceous material corresponds to at least half its dry matter.

[0020] In a particularly preferred embodiment, the carbonaceous materials are coal or biomass (preferably solid biomass) or any mixture thereof.

[0021] In the sense of this description, the term "biomass" means organic substances which can also be referred to as "renewable raw materials". The carbon content of the biomass (preferably solid biomass) preferably corresponds to at least 25 wt-% of its dry matter, more preferably at least 30 wt-% of its dry matter, even more preferably at least 35 wt-% of its dry matter, most preferably at least 40 wt-% of its dry matter, and in particular to at least 45 wt-% of its dry matter. In a particularly preferred embodiment, the carbon content in the biomass, preferably solid biomass, corresponds to at least half its dry matter.

[0022] In a second process stage, the filtered fuel gas then is charged to at least one burner of the metallurgical process and used as fuel for this burner. The injection of the fuel gas from the filtration into at least one burner is effected directly, i.e. in particular without interconnection of further process/cleaning stages, wherein the temperature of the fuel gas between filtration and burner inlet is maintained in the range from 300 to 600° C., preferably 350 to 450° C.

[0023] The adjustment of the temperature loss is effected by minimizing the heat losses and/or heat supply. The conduit design on the one hand is a suitable means for minimizing the heat losses. In accordance with the invention, the connecting line between filtration and burner therefore is insulated. On the other hand, the heat losses can be reduced in that the conduit has a rather small heat-exchange surface, which can be effected both by a suitable guidance of the conduit and by a reduction of the conduit cross-section.

[0024] A heat supply is possible via a direct or indirect heating of the conduit. A combination of these two measures also is conceivable.

[0025] By adjusting the temperature of the fuel gas to 300 to 600° C., preferably 380 to 420° C., and particularly preferably to a value of 400±5° C., the temperature lies above the condensation temperature of tar. The condensation of tar detrimental to a stationarily and safely operated process thereby can reliably be prevented.

[0026] Since the fuel gas subsequently is supplied to a burner, temperatures are produced by the combustion of the gas at which the tars are also burnt, so that a purification of the fuel gas no longer is necessary even in a future process stage. Thus, at least one cleaning stage of the fuel gas is saved and in addition the ecological burden is reduced, which in particular in the conventional washes occurs due to the resulting polluted water.

[0027] As metallurgical process, pelletizing is particularly useful, for example for iron, or the calcination, as it is used for example in the production of alumina.

[0028] Furthermore, it was found in an embodiment of the present invention to be advantageous to gasify the carbonaceous materials in a fluidized bed, as in this way a sufficiently long retention time of the solids in the system can be ensured for a high gas yield and low production of tar. The use of a circulating fluidized bed is particularly favorable, as the same is characterized by a very good heat and mass transfer. What has been discovered in an embodiment of the present invention to be quite particularly advantageous are systems in which the advantages of a stationary fluidized bed and a circulating fluidized bed are combined with each other. Such process is described for example in DE 102 60 734 A1.

[0029] To be able to supply the fuel gas to a filtration at all, it is necessary to at least partly cool the gas. An energetically attractive design can herein be achieved in that by cooling the fuel gas steam is generated and this steam is at least partly utilized for power generation and/or as moderator in the first process stage. It is particularly advantageous to utilize a part of the energy thus generated in the first process stage, in particular for temperature moderation, and to use the remaining residual amount of steam for power generation.

[0030] A use in the first preheating stage in particular can consist in that the steam generated by cooling the fuel gas is at least partly utilized as fluidizing gas in the fluidized bed of the first process stage. This has the advantage that the use of a further gas as fluidizing gas can be omitted.

[0031] The invention furthermore comprises, in an embodiment, a plant which is suitable for carrying out the process according to embodiments of the invention. Such a plant includes a first and a second process stage, wherein the first process stage consists of at least one reactor for producing fuel gas containing carbon monoxide, hydrogen, carbon dioxide and/or steam and at least one supply conduit each for carbonaceous materials and an oxygen-containing gas. The second process stage contains at least one reactor for carrying out a metallurgical process, such as pelletizing or calcination, and at least one burner. Furthermore, between the first and the second process stage at least one cooling device and an adjoining solids separating device, in particular a filtering device, are provided. Via a direct conduit, the solids separating device is connected with at least one burner of the second process stage. Heat losses can already be minimized by this direct conduit.

[0032] To furthermore be able to ensure that the temperature of the fuel gas does not decrease to a value at which tars condensate out, the conduit can be equipped with at least one means for minimizing the heat losses and/or with at least one device for heat supply. Means for minimizing the heat losses include any form of insulations or variations of the heat-exchange surface. As heat supply, any form of direct or indirect heating can be provided, in particular double-walled tubes with the passage of a heating medium are recommended for example, or also a conduit design in which the waste heat of adjacent components is utilized.

[0033] To utilize the energy released in the process during cooling, it is expedient to design the cooling device as steam generator, in particular as waste heat boiler.

[0034] The steam thus generated can be supplied from the steam outlet of the steam generator via a conduit to a power generation and/or to the first process stage. As a result, the energy released in the process can be utilized in the process itself either as heat carrier or as energy carrier.

[0035] It is particularly advantageous when the conduit which leads from the steam generator to the first process stage includes a valve for regulating or controlling the steam quantity, as in this way the temperature within the first process stage can be adjusted with a simple control variable, namely the steam quantity supplied.

[0036] Referring to FIG. **1**, via conduit **1** carbonaceous materials, preferably comminuted coal or biomass, in particular solid biomass is fed into the gasification reactor **3**, which in a non-illustrated manner preferably includes a circulating fluidized bed, and is gasified there with oxygen or air enriched with oxygen supplied via conduit **2** in a manner known to the skilled person. The fuel gas obtained during the gasification is withdrawn from the reactor **3** via conduit **4**. Conduit **4** opens into the steam generator **5**, which via conduit **6** is connected with a hot-gas filtration **7**, e.g. by ceramic candle filters. Via conduit **8**, the filtered fuel gas subsequently is transferred into a pelletizing plant **9** with a temperature of about 400° C.

[0037] Via conduit **10**, the steam generator **5** is supplied with water. The steam obtained due to the heat exchange is withdrawn via conduit **11**. Conduit **11** is split into conduits **12** and **13**, wherein conduit **12** opens into the gasification reactor **3** in which the steam preferably is used as fluidizing gas. Conduit **13** is the supply conduit of a turbine **22** for power generation.

[0038] Furthermore, ash is withdrawn via conduit **14** from the reactor **3**, via conduit **15** from the steam generator **5**, and via conduit **16** from the hot gas filtration **7**. The ash removed from the reactor **3** via conduit **14** is the bottom product obtained in the reactor **3**, whereas the two conduits **15** and **16**, which each transport fly ash, open into conduit **17**. The collected ash is cooled in the cooling device **18** and subsequently discharged via conduit **19**. As cooling medium of the cooling device **18** water preferably is used, which is supplied via conduit **20** and discharged via conduit **21**.

[0039] Due to the direct coupling of the gasification with the metallurgical process, an expensive and cost-intensive wet gas cleaning and the related disposal of the tar-loaded waste waters or residual substances can be avoided.

EXAMPLE

[0040] To the coal gasification, 13 t/h of ground coal (grain size >6 mm) are charged with the following composition:

Proximate analysis		Elemental analysis
C_{fix}:	33 wt-% (dry)	C: 78%
Volatile components:	27 wt-% (dry)	H: 5%
Ash:	40 wt-% (dry)	S: 0.5%
Moisture:	6.7%	O: 16.5% (calculated)
Upper calorific value	17 MJ/kg	
Ash softening temperature:	1400-1500° C.	

[0041] In the fluidized bed gasification 21,000 Nm^3/h of fuel gas (coal gas) with a calorific value of 7.0 MJ/Nm^3 are formed. The fuel gas is composed as follows: Molar gas composition

CO	23.4
CO_2	22.1
H_2	29.0
H_2O	21.4
CH_4	2.5
O_2	0.0
N_2	1.4
H_2S	0.1
COS	0.007
Tars	0.003
Rest	0.09

[0042] In ceramic candle filters, the gas is filtered to a dust content of >20 mg/Nm^3, preferably 5 mg/Nm^3, and fed into the burners of the pelletizing plant with a temperature of 420±5° C.

[0043] While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive. It will be understood that changes and modifications may be made by those of ordinary skill within the scope of the following claims. In particular, the present invention covers further embodiments with any combination of features from different embodiments described above and below. Additionally, statements made herein characterizing the invention refer to an embodiment of the invention and not necessarily all embodiments.

[0044] The terms used in the claims should be construed to have the broadest reasonable interpretation consistent with the foregoing description. For example, the use of the article "a" or "the" in introducing an element should not be interpreted as being exclusive of a plurality of elements. Likewise, the recitation of "or" should be interpreted as being inclusive, such that the recitation of "A or B" is not exclusive of "A and B," unless it is clear from the context or the foregoing description that only one of A and B is intended. Further, the recitation of "at least one of A, B and C" should be interpreted as one or more of a group of elements consisting of A, B and C, and should not be interpreted as requiring at least one of each of the listed elements A, B and C, regardless of whether A, B and C are related as categories or otherwise. Moreover, the recitation of "A, B and/or C" or "at least one of A, B or C" should be interpreted as including any singular entity from the listed elements, e.g., A, any subset from the listed elements, e.g., A and B, or the entire list of elements A, B and C.

LIST OF REFERENCE NUMERALS

[0045] 1, 2 conduit

[0046] **3** reactor (first process stage)

[0047] **4** conduit
[0048] **5** cooling device
[0049] **6** conduit
[0050] **7** hot gas filtration
[0051] **8** conduit
[0052] **9** pelletizing plant (second process stage)
[0053] **10-17** conduit
[0054] **18** ash cooling
[0055] **19-21** conduit
[0056] **22** turbine

1-9. (canceled)

10. A process for producing fuel gas and for carrying out a metallurgical process, the process comprising:

reacting, in a first process stage, biomass with an oxygen-containing gas so as to obtain a fuel gas containing at least one of carbon monoxide, hydrogen, carbon dioxide or steam;

cooling the fuel gas to a temperature in a range from 300 to 600° C.;

subjecting the cooled fuel gas to a solids separation; and

directly supplying, in second process stage, the fuel gas after the solids separation to at least one burner of the metallurgical process, the temperature of the fuel gas being maintained above the condensation temperature of tar and within the range from 300 to 600° C. by supplying heat.

11. The process according to claim **10**, wherein the fuel gas is cooled to a temperature in a range from 350 to 450° C. and maintained in the range from 350 to 450° C. in the second process stage.

12. The process according to claim **10**, wherein the biomass is gasified in a fluidized bed.

13. The process according to claim **10**, further comprising at least partly utilizing steam generated by cooling the fuel gas for power generation or in the first process stage.

14. The process according to claim **12**, further comprising at least partly utilizing steam generated by cooling the fuel gas as fluidizing gas in the fluidized bed.

15. A plant for producing fuel gas and for carrying out a metallurgical process, the plant comprising:

a first process stage including at least one first reactor configured to produce a fuel gas containing at least one of carbon monoxide, hydrogen, carbon dioxide or steam and having at least one supply conduit each for biomass and an oxygen-containing gas;

at least one cooling device disposed downstream from the first process stage;

at least one solids separating device disposed downstream from the at least one cooling device;

a second process stage including at least one second reactor configured to carry out the metallurgical process and at least one burner; and

a direct conduit from the at least one solids separating device into the at least one burner of the second process stage, the conduit being equipped with at least one device configured to supply heat and maintain a temperature of the fuel gas above a condensation temperature of tar.

16. The plant according to claim **15**, wherein the at least one cooling device includes a steam generator.

17. The plant according to claim **16**, wherein a steam outlet of the steam generator is connected, via a conduit, with a power generation stage or the first process stage.

18. The plant according to claim **17**, wherein the conduit extends from the steam generator to the first process stage, and further comprising a valve disposed in the conduit and configured to regulate or control a steam quantity.

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