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Description

The invention relates to the gasification of carbonaceous fuels containing bound water; for example low quality fuels such as sub-bituminous coal, lignite or peat. The invention has particular application as a coal feed preparation process for a coal gasification plant.

There are basically two types of coal gasification processes that are currently in commercial operation. The first type requires a dry feed and the coal is fed into the gasifier through some mechanical means, such as a screw feeder or a lock hopper system.

The second type uses a slurry feed. An example of this type is the Texaco Coal Gasification Process (TCGP) which may be practiced according to the disclosure of, for example, U.S. Patent No: 3,544,291 to which reference is directed. The TCGP operates using either oxygen or air as the oxidizing medium for the coal feed. The coal is fed as a water slurry with the water typically amounting to 50% or more of the total weight of the slurry.

The advantage of the water slurry is that it can be pumped at high pressure and eliminates the need for complicated lock hoppers or other feed systems. The water content of the slurry is a function of the desired degree of pumpability of the slurry. However, the water content of the slurry has an adverse impact on the thermal efficiency of the gasifier, the higher the water content of the slurry then the more water which must be vaporized in the gasifier, thus consuming more coal and more oxygen or air.

U.S. Patent No: 4,166,802 further describes the gasification of solid carbonaceous fuels which are introduced into the gasification zone in the form of a water slurry. Slater et al indicate that a problem arises when the solid carbonaceous fuel is of low quality, such as sub-bituminous coal, lignite, or peat, because all of these fuels contain a considerable amount of combined or bound water, a most undesirable ingredient insofar as gasification of the fuel is concerned in that although bound water is present in the solid fuel it does not play any part in the formation of the slurry vehicle and consequently has no effect on the viscosity or pumpability of the slurry. It has an adverse effect on the gasification reaction as it introduces more water into the gasifier than is necessary to form the slurry and thus has an undesirable effect on the thermal efficiency of the generator.

Patent No: 4,166,802 describes a solution to this excess water problem whereby the solid fuel, in finely-divided form, is introduced into a quench zone with water. The solid fuel and the water may be introduced separately into the quench zone or they are introduced together into the quench zone in the form of a slurry. In the quench zone, the slurry is contacted with a hot synthesis gas (comprising carbon monoxide and hydrogen) which has been prepared by the partial oxidation of a solid carbonaceous fuel, preferably the same

type of fuel as in the slurry. The hot synthesis gas, which leaves the partial oxidation zone at a temperature between about 1800° and 3200°F. (982—1760°C), is introduced substantially immediately into the quench zone and contact is made with the slurry, preferably by discharging the hot synthesis gas from a dip tube under the surface of the slurry.

United States Patent No. 3992784 discloses a process for the upgrading of solid material containing bound water and free of chemically bound carbon, in particular brown coal, which process involves a heat treatment at a temperature of at least 150°C and at a pressure that is higher than the vapor pressure of water at that temperature.

The present invention is directed to solving the problems of excess water in a partial oxidation coal gasification process when feeding a low quality solid carbonaceous fuel containing bound moisture, such as sub-bituminous coal, lignite, or peat.

As discussed above, certain types of fuel, such as sub-bituminous coal, lignite, and peat contain excessive quantities of bound moisture in terms of being useful feedstock for a slurry fed gasifier. The bound water content of lignite is typically about 35 to 50 percent by weight. Normal thermal drying processes would require a rather large heat input and would create an energy inefficiency in the overall process. This energy inefficiency should be minimized and the invention is a process which provides that benefit.

According to the present invention, there is provided a process for the gasification of a solid carbonaceous fuel containing significant quantities of bound water, which process is characterized by the combination of the following steps:—

(a) feeding the wet fuel into a dehydration apparatus in which the wet fuel is subjected to a Carver-Greenfield dehydration process in which the wet fuel is slurried in a drying oil and subjected to a plurality of sequential dehydration steps by heat evaporation whereby most of said bound water is removed and dried fuel and a dirty water stream is produced;

(b) conveying the dried fuel to a slurry preparation apparatus where it is ground and mixed with water comprising the dirty water from step (a) to form a fuel slurry and

(c) pumping the fuel slurry to a gasification plant where it is subjected to partial oxidation using oxygen or air to produce a product gas, low level heat produced in the gasification plant is conveyed to the dehydration apparatus and utilised in the Carver-Greenfield dehydration process.

The invention involves using the Carver-Greenfield dehydration process which is normally used to dehydrate sewage sludge. It has been found that by employing the Carver-Greenfield dehydration process to wet fuel a particularly advantageous energy saving system may be obtained. The Carver-Greenfield process may be practiced according to the disclosures in, for example, U.S.

Reissue Patent No: 26352 and U.S. Patent No.: 3323575 to which reference is directed. The Carver-Greenfield process uses a multi-stage evaporation system combined with a drying oil to produce a dry solid product, typically containing about 0.5 to 3.0 percent by weight water. In the present invention, the Carver Greenfield process is applied to certain types of coal to produce a dry solid product which is then delivered to a coal slurry preparation apparatus where it is mixed with water and subjected to a wet grinding process to produce coal particles of the final size required for the gasification process.

In order to achieve dehydration in the Carver-Greenfield system, the solids are slurried in a drying medium, typically a light gas oil, such as "ISOPAR", and then the slurry proceeds through the unit. The typical unit includes a number of stages to achieve the desired degree of dryness in the solid product. This typically would be three stages. Steam is required to operate the dryers. Alternatively, some other source of low level heat could be used. The Carver-Greenfield process offers the flexibility of varying the temperature between the various stages and through this mechanism it is possible to recover and reuse the steam from each of the subsequent stages in the evaporation train. This re-utilization of process heat results in a much higher energy efficiency than could be achieved in a single stage unit.

A by-product of the Carver-Greenfield process is the water which is driven off from the lignite or other low quality fuel that is being dried. This water is typically dirty and oily and, to prevent environmental pollution, would require treatment before disposal. One significant advantage of the present invention is that, this dirty water is used to prepare the coal slurry, thereby obviating the treatment and disposal stages normally allocated with this process. The coal slurry containing the dirty water is fed into the gasifier which conveys the environmentally harmful materials contained in the dirty water into useful products in the gasification process. Also the quantity of bound water to be removed from the lignite or other type of feedstock is normally rather large and is close to the total water requirement of the coal slurry preparation system. Thus, make-up water to the system is minimal as compared with alternative means of drying.

It was described above that a drying oil is used to assist the dehydration in the Carver-Greenfield drying process. One of the final steps in the conventional Carver-Greenfield process is the separation of the drying oil from the dried product. Oil separation is normally desirable both to minimize oil loss and also to minimize the contamination to the dried product with the drying oil. Oil removal may also be necessary for economic reasons. One advantage however, of the present invention is that it is not necessary to completely remove the drying oil from the dried fuel product. The dried fuel product containing the drying oil can be satisfactorily processed in the coal slurry preparation system and then gasified into useful

products. Tests have shown that the dried fuel material does not take up water in the slurry to achieve the same composition at the original wet feedstock going into the Carver-Greenfield process. Thus, the slurrying of the dried fuel material with water does not cause the dry fuel to revert to its original state. Therefore, the present invention allows the use of a relatively low cost wet feedstock as a feed for a coal gasification plant while still using a coal slurry preparation system.

The invention will now be described with reference to the accompanying drawings wherein:—

Figure 1 is a schematic diagram illustrating the process steps involved.

The process illustrated in Figure 1 shows the use of lignite as the feedstock, but it should be understood that the process may also be used to treat other low grade solid carbonaceous fuels containing significant amounts of bound water, such as sub-bituminous coal and peat.

Wet lignite 10 containing about 45 to 50 percent by weight bound water is introduced into the dehydration apparatus 12 which collectively performs the Carver-Greenfield dehydration process as described, for example, in U.S. Reissue Patent No: 26,352 and U.S. Patent No: 3,323,575. Wet lignite 10 is preferably crushed into particles having no cross-sectional dimension greater than about 1/2 inch (12.7 millimetres) prior to introduction into the dehydration apparatus 12.

Dried lignite 14 exists from the dehydration apparatus 12 after undergoing the Carver-Greenfield process and is conveyed to the coal slurry preparation apparatus 18. Experimental test data proves that the Carver-Greenfield process removes most of the bound moisture in the lignite so that dried lignite 14 contains about 0.5 to 3.0 percent by weight bound water. This is a particular advantage of the present invention as compared to the process disclosed in U.S. Patent No: 4,166,802 which contains no experimental data to indicate that the bound moisture in the coal has been removed.

Since dried lignite 14 is a highly reactive material, it is preferably conveyed to coal slurry preparation apparatus 18 using an enclosed conveyor system blanketed with an inert gas, such as nitrogen.

In the coal slurry preparation apparatus 18, dried lignite 14 is fed into a hopper and then into a milling apparatus where the lignite is subjected to a wet grinding process and is formed into a slurry preparation. Dirty water 16 from the Carver-Greenfield process is preferably used for this purpose and additional make-up water 20 may be used as needed. The wet grinding process produces particles of feed material which have no cross-sectional dimension greater than about 1/4 inch (6.35 millimeters). Preferably, 100 weight percent of the solid fuel will pass through a 14 mesh sieve (sieve opening 1.41 mm) and, more preferably, 100 weight percent of the solid fuel will pass through a 14 mesh sieve with not more than 30 weight percent passing through a 325 mesh sieve (sieve opening 44 μ m).

The resulting coal slurry 22 containing between about 50 to 75 percent solids by weight on a dry basis is then pumped to a conventional coal gasification plant (CGP) 24 such as described in, for example, U.S. Patent No: 3,544,291 where the coal is partially oxidized using oxygen or air 26 to produce the desired conventional product gas 28. Low level heat 30, which may be in the form of steam or hot water, from the coal gasification plant is conveyed to the dehydration apparatus 12 where it is efficiently and economically used in carrying out the Carver-Greenfield dehydration process.

Claims

1. A process for the gasification of a solid carbonaceous fuel containing significant quantities of bound water, which process is characterised by the combination of the following steps:—

(a) feeding the wet fuel (10) into a dehydration apparatus (12) in which the wet fuel is subjected to a Carver-Greenfield dehydration process in which the wet fuel is slurried in a drying oil and subjected to a plurality of sequential dehydration steps by heat evaporation whereby most of said bound water is removed and dried fuel (14) and a dirty water stream (16) is produced;

(b) conveying the dried fuel (14) to a slurry preparation apparatus (18) where it is ground and mixed with water comprising the dirty water (16) from step (a) to form a fuel slurry (22) and

(c) pumping the fuel slurry (22) to a gasification plant (24) where it is subjected to partial oxidation using oxygen or air to produce a product gas (18), low level heat (30) produced in the gasification plant is conveyed to the dehydration apparatus (12) and utilised in the Carver-Greenfield dehydration process.

2. A process according to Claim 1 characterised in that additional make-up water (20) is added as needed.

3. A process according to any preceding Claim wherein the fuel slurry (22) formed contains fuel particles of a size wherein 100 weight percent of the solid fuel will pass through a 14 mesh sieve (sieve opening 1.41 mm) with no more than 30 weight percent passing through a 325 mesh sieve (sieve opening 44 μ m).

4. A process according to any preceding Claim wherein the fuel slurry (22) contains 50 to 75 percent solids by weight on a dry basis.

5. A process according to any preceding Claim characterised in that the wet fuel is selected from sub-bituminous coal, lignite, and peat.

6. A process according to Claim 5 characterised in that the wet solid carbonaceous fuel is lignite.

7. A process according to any preceding Claim including the step of crushing the wet solid carbonaceous fuel into particles having no cross-sectional dimension greater than 12.7 millimetres before feeding the fuel to the dehydration apparatus.

8. A process according to any preceding claim

wherein the dried fuel contains 0.5 to 3.0 percent by weight water.

9. A process according to any preceding claim wherein the dried fuel is conveyed to the slurry preparation apparatus using an enclosed conveyor system blanketed with an inert gas.

10. A process according to Claim 9 wherein the inert gas is nitrogen.

Patentansprüche

1. Verfahren zum Vergasen eines festen kohlenstoffhaltigen Brennstoffs, der beträchtliche Mengen an gebundenem Wasser enthält, gekennzeichnet durch die Kombination der folgenden Stufen:

(a) Einbringen des feuchten Brennstoffes (10) in eine Entwässerungsvorrichtung (12), in welcher der feuchte Brennstoff einer Carver-Greenfield-Entwässerung unterworfen wird, bei der der feuchte Brennstoff in einem trocknenden Öl aufgeschlämmt und durch Eindampfen in der Hitze einer Reihe aufeinanderfolgender Entwässerungsschritte unterzogen wird, wodurch der größte Anteil des gebundenen Wassers entfernt und getrockneter Brennstoff (14) sowie ein verunreinigter Wasserstrom (16) erzeugt werden;

(b) Überführen des getrockneten Brennstoffes (14) in eine Vorrichtung (18) zur Herstellung einer Aufschlämmung, wo er vermahlen und mit Wasser, daß das verunreinigte Wasser (16) von Stufe (a) enthält, unter Ausbildung einer Brennstoffaufschlämmung (22) vermischt wird, und

(c) Pumpen der Brennstoffaufschlämmung (22) in eine Vergasungsanlage (24), wo sie unter Verwendung von Sauerstoff oder Luft und unter Erzeugung eines Produktgases (18) einer partiellen Oxydation unterzogen wird und wobei geringwertige Wärme (30), die in der Vergasungsanlage erzeugt wird, der Entwässerungsvorrichtung (12) zugeführt und bei der Carver-Greenfield-Entwässerung eingesetzt wird.

2. Verfahren gemäß Anspruch 1, dadurch gekennzeichnet, daß je nach Bedarf zusätzliches Ergänzungswasser (20) zugeführt wird.

3. Verfahren gemäß einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die gebildete Brennstoffaufschlämmung (22) Brennstoffteilchen mit einer derartigen Größenverteilung enthält, daß 100 Gew.-% des festen Brennstoffs durch ein 14-mesh-Sieb (Sieböffnung 1,41 mm) hindurchgehen, jedoch nicht mehr als 30 Gew.-% durch ein 325-mesh-Sieb (Sieböffnung 44 μ m) hindurchgehen.

4. Verfahren gemäß einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß die Brennstoffaufschlämmung (22) 50 bis 75 Gew.-% Feststoffe, bezogen auf das Trockengewicht, enthält.

5. Verfahren gemäß einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß der feuchte Brennstoff aus sub-bituminöser Kohle, Lignite oder Torf besteht.

6. Verfahren gemäß Anspruch 5, dadurch gekennzeichnet, daß der feuchte, feste,

kohlenstoffhaltige Brennstoff Lignit ist.

7. Verfahren gemäß einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß es die Stufe des Zerkleinerns des feuchten, festen, kohlenstoffhaltigen Brennstoffs zu Teilchen, die keinen größeren Querschnitt aufweisen als 12,7 mm, umfaßt, bevor der Brennstoff der Entwässerrungsvorrichtung zugeführt wird.

8. Verfahren gemäß einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß der getrocknete Brennstoff 0,5 bis 3,0 Gew.-% Wasser enthält.

9. Verfahren gemäß einem der vorhergehenden Ansprüche, dadurch gekennzeichnet, daß der getrocknete Brennstoff der Vorrichtung zur Herstellung der Aufschlammung zugeführt wird, indem man ein geschlossenes Conveyersystem verwendet, das von einem Inertgas umhüllt ist.

10. Verfahren gemäß Anspruch 9, dadurch gekennzeichnet, daß das Inertgas Stickstoff ist.

Revendications

1. Procédé pour la gazéification d'un combustible carboné solide dans lequel de l'eau est retenue en quantités importantes, ce procédé étant caractérisé par la combinaison des étapes suivantes;

(a) amené du combustible humide (10) dans un appareil de déshydratation (12) dans lequel le combustible humide est soumis à un procédé de déshydratation de Carver-Greenfield au cours duquel il est placé en suspension dans une huile siccative et subit une série d'étapes de déshydratation séquentielles par évaporation thermique, pour ainsi éliminer la majeure partie de ladite eau retenue et obtenir un combustible déshydraté (14) et un courant d'eau souillée (16);

(b) acheminement du combustible déshydraté (14) jusqu'à un appareil de préparation de suspension (18) dans lequel il est broyé et mélangé à de l'eau contenant l'eau souillée (16) provenant de l'étape (a) pour former une suspension de combustible (22); et

(c) pompage de la suspension de combustible (22) en direction d'une usine de gazéification (24) où elle est soumise à une oxydation partielle à l'aide d'oxygène ou d'air pour produire un gaz de

consommation (18), la chaleur peu élevée (30) produite dans l'usine de gazéification étant acheminée jusqu'à l'appareil de déshydratation (12) et utilisée au cours du procédé de déshydratation de Carver-Greenfield.

2. Procédé selon la revendication 1, caractérisé en ce que de l'eau d'appoint supplémentaire (20) est ajoutée suivant les besoins.

3. Procédé selon l'une quelconque des revendications précédentes, dans lequel la suspension de combustible (22) formée contient des particules de combustible d'une taille selon laquelle 100 pour cent en poids du combustible solide passe à travers un tamis de 14 meshes (ouverture de tamis 1,41 mm), avec un maximum de 30 pour cent en poids passant à travers un tamis de 325 meshes (ouverture de tamis 44 µm).

4. Procédé selon l'une quelconque des revendications précédentes, dans lequel la suspension de combustible (22) contient 50 à 75 pour cent en poids de particules solides sur une base sèche.

5. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce que le combustible humide est sélectionné à partir de charbon sous-bitumineux, de lignite, et de tourbe.

6. Procédé selon la revendication 5, caractérisé en ce que le combustible carboné solide, humide est du lignite.

7. Procédé selon l'une quelconque des revendications précédentes, comprenant, avant l'amenée du combustible jusqu'à l'appareil de déshydratation, l'étape de broyage du combustible carboné solide, humide en particules dont aucune dimension en coupe transversale n'est supérieure à 12,7 millimètres.

8. Procédé selon dans l'une quelconque des revendications précédentes, dans lequel le combustible déshydraté contient 0,5 à 3 pour cent en poids d'eau.

9. Procédé selon l'une quelconque des revendications précédentes, dans lequel le combustible déshydraté est acheminé jusqu'à l'appareil de préparation de suspension au moyen d'un système d'acheminement fermé, enveloppé d'un gaz inerte.

10. Procédé selon la revendication 9, dans lequel le gaz inerte est de l'azote.

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FIG. 1

