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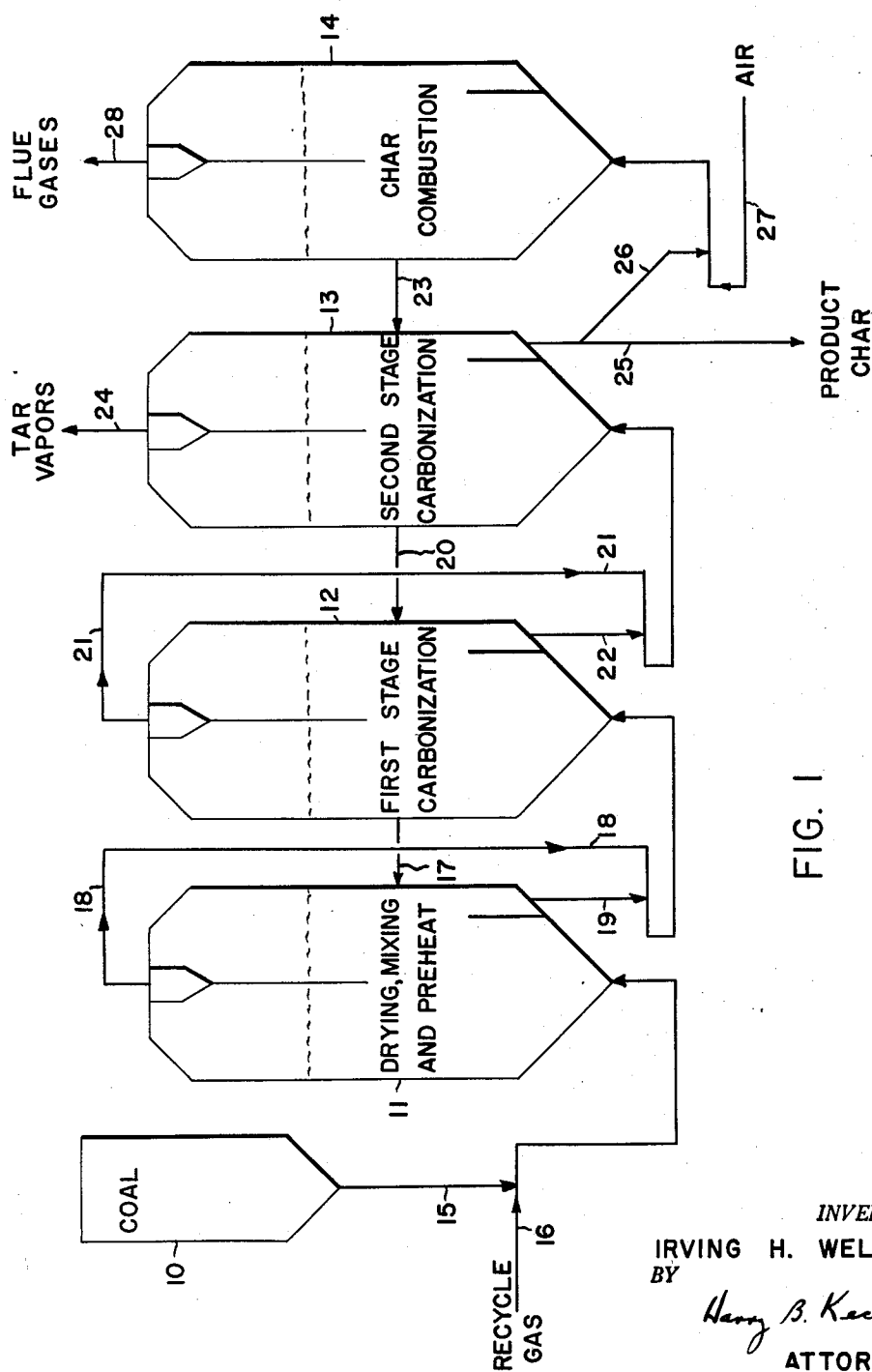


FIG. 1

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FLUIDIZED CARBONIZATION PROCESS FOR AGGLOMERATIVE COALS

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6 Claims. (Cl. 202—14)

The present invention relates to a method for effecting low temperature carbonization of agglomerative coals according to the fluidized solids contacting technique, and more particularly, to a method for conducting the carbonization process in two stages.

In my prior U.S. Patent No. 2,677,650, I described a method for reducing the amount of inert solids required to maintain an agglomerative coal in an operable condition in a fluidized carbonization zone. I accomplished this reduction by mixing the inert solids with the agglomerative coal at a temperature between 450° and 750° F. As soon as the mixture was effected and the desired temperature reached, the resulting hot mixture of solids was passed to the fluidized carbonization zone where the coal was distilled.

In accordance with the present invention, I provide a still further reduction of the amount of inert solids required, which reduction is substantially greater than any hitherto accomplished. I have found that when the agglomerative coal is held in the first stage carbonization zone at a temperature within the plastic range of the coal, i.e., about 725° to about 825° F., for at least 5 minutes under non-agglomerating conditions, that the amount of inert solids required to maintain the thus treated coal in an operable fluidized condition in a second stage carbonization zone at a temperature above 825° F., is substantially lessened. In order to hold the agglomerative coal in the first stage carbonization zone under non-agglomerating conditions, only a relatively small amount of inert solids is required. The coal softens and assumes a rounded form. At the same time substantial distillation of the coal in this first stage is effected, that is up to about 50% of the total volatile content of the coal is distilled depending upon the time it is held in this zone. In effect, the process is a two stage distillation process with the first stage being in the plastic range itself. The improved results of my present invention will be demonstrated by examples in the following detailed description.

The caking tendency of agglomerating coals in the plastic range may be obviated by treatment aimed at reducing the tendency or by treatment aimed at rendering the tendency ineffective. Examples of the former treatment of agglomerating coal are partial oxidation and treatment with chemicals such as calcium chloride. An example of the latter treatment is the dilution of the coal with non-agglomerative solids whereby the coal particles are dispersed to prevent their sticking. My present discovery is that retention of the agglomerative coal in the plastic range from about 725 to about 825° F. under fluidized conditions for at least five minutes effects a reduction in the agglomerating tendency of the coal and permits its subsequent carbonization under fluidized conditions at temperatures above the plastic range with a relatively small quantity of non-agglomerative solids being required to render the agglomerating tendency ineffective therein.

For a clear understanding of the present invention,

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its objects and advantages reference should be had to the accompanying description and drawing in which Figure 1 is a schematic illustration of apparatus adapted for carrying out the preferred embodiment of the present invention.

Referring to Figure 1 which illustrates the preferred embodiment of the present invention, five vessels are shown as follows:

Numeral 10 refers to a coal supply vessel containing an agglomerative coal which is to be subjected to low temperature carbonization in the present process.

Numeral 11 refers to a mixing, drying and preheating vessel adapted to confine a fluidized bed of finely divided solid particles at a temperature below the plastic range of the coal undergoing treatment.

Numeral 12 refers to a first stage carbonization vessel adapted to confine a fluidized bed of finely divided solid particles at a temperature within the plastic range of the coal undergoing treatment.

Numeral 13 refers to a second stage carbonization vessel adapted to confine a fluidized bed of finely divided solid particles at a temperature above the plastic range of the coal undergoing treatment.

Numeral 14 refers to a char combustion vessel adapted to confine a fluidized bed of finely divided solids under oxidizing conditions at a temperature above that of the second stage carbonization vessel 13.

Caking coal in the supply vessel 10 is ground to a fluidizable size consist, preferably such that the entire coal feed stream will pass through a 14 mesh Tyler standard screen. Fluidizable size coal is withdrawn from the coal supply vessel 10 through a conduit 15 whence it is picked up, suspended and conveyed by process recycle gas flowing through a conduit 16 and carried into the mixing, drying and preheating vessel 11.

Within the mixing, drying and preheating vessel 11, the coal is maintained at a temperature above about 250° F. to assure dehydration and below the plastic temperature to avoid agglomeration. A temperature of about 450 to 700° F. is preferred. Heat may be supplied to the vessel 11 by any convenient means although I prefer to supply heat by introducing sufficient hot finely divided solid particles through a conduit 17 from the first stage carbonization vessel 12. The amount of hot solid particles required may be determined by simple heat balance calculation. Fluidizing gases are recovered along with evaporated moisture from the mixing, drying and preheating vessel 11 through an overhead conduit 18 and are re-employed as the fluidizing gas in the first stage carbonizing vessel 12. Dried, preheated coal particles are withdrawn from the mixing, drying and preheating vessel 11 through a conduit 19 for suspension in the fluidizing gases in conduit 18 and transportation therethrough into the first stage carbonization vessel 12.

Within the first stage carbonization vessel 12, the dried, preheated coal particles are maintained under fluidized conditions in the plastic temperature range from about 725 to about 825° F. The superficial linear velocity of the fluidizing gases is preferably in the range of 0.1 to 5.0 feet per second. The ratio of char to coal within the first stage carbonization vessel 12 is sufficient to prevent agglomeration of the feed coal during the treatment. I have found that about three parts by weight of recycle char is sufficient for preventing caking of even the most strongly agglomerative coals. Heat is supplied to the first stage carbonization vessel 12 by recycle of hot char particles through the conduit 20 from the second stage carbonization vessel 13. The necessary char for preventing agglomeration within the first stage carbonization vessel 12 is provided from the recycle char through the conduit 20 and also from the particles which have previously been recycled through the conduit 17 to form

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the blended feed material which enters the first stage carbonization vessel 12 through the conduits 19 and 18.

Feed coal is maintained within the first stage carbonization vessel 12 at a temperature within the plastic range under non-agglomerating fluidized solids contacting conditions for at least five minutes to assure that subsequent second stage carbonization at a temperature above the plastic range in the vessel 13 will not result in agglomeration. Preferably the duration of first stage carbonization in the vessel 12 is from about five to about twenty minutes. For this purpose, residence time of the coal particles within the first stage carbonization zone is calculated on a superficial basis by dividing the coal feed rate (e.g. pounds per minute) into the solids inventory of the first carbonization zone (e.g. pounds). First stage carbonization for less than five minutes is generally ineffective in reducing the agglomeration tendency of the feed coal for the second stage carbonization operation. First stage carbonization for a period in excess of about twenty minutes, while advantageous from the agglomeration standpoint, nevertheless results in a decreased overall tar yield from the process.

First stage carbonization of the coal in the vessel 12 results in evolution of up to about 50 percent of the available volatile materials in the coal. This volatile material appears as tar and gas which is picked up by the rising fluidizing gases and recovered overhead through a conduit 21 and introduced into the second stage carbonization vessel 13 as fluidizing gas, preferably at a superficial linear velocity of about 0.1 to 5.0 feet per second. A blend of recycle char and partially carbonized coal particles is withdrawn from the first stage carbonization vessel 12 through a conduit 22 for suspension in the gases circulating through the conduit 21 and transportation therethrough into the second stage carbonization vessel 13. Carbonization of the coal particles is completed in the second stage carbonization vessel 13 which is maintained at a temperature above the plastic range, i.e., 850-1200° F., preferably about 950° F. Having been subjected to a first stage carbonization treatment within the plastic range and being mixed with sufficient recycle, non-agglomerating char particles, the coal entering the second stage carbonization vessel 13 can be effectively treated therein without agglomeration. Heat is supplied to the second stage carbonization vessel 13 by recycle of heated particles of char through a conduit 23 from the char combustion vessel 14. The volatile material evolved from the coal in the second stage carbonization vessel 13 along with that previously evolved in the first stage carbonization vessel 12 is recovered with the recycle fluidizing gas from the second stage carbonization vessel 13 through an overhead conduit 24. Non-condensable gases are recovered from the overhead stream in conduit 24 and a portion thereof employed as the recycle gas in conduit 16.

The residence time of coal in the second carbonization zone should be sufficient to assure substantially complete evolution of valuable volatile matter therefrom. For this purpose, residence time may be calculated by dividing the coal feed rate into the overall system (e.g., pounds per hour) into the solids inventory of the second stage carbonization vessel 13 (e.g., pounds). On this basis, the residence time of coal in the second stage carbonization vessel 13 preferably is from about five to about forty minutes.

Non-agglomerating char is withdrawn from the second stage carbonization vessel 13 through a conduit 25 as product. A portion of the product char may be bypassed through a conduit 26, entrained in a stream of air flowing through a conduit 27, and introduced into the char combustion vessel 14 for exothermic partial combustion at a temperature above that of the second stage carbonization vessel 13. Hot char particles from the char combustion vessel 14 are recycled through the conduit 23 to supply heat and char dilution for the second

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stage carbonization vessel 13. Gaseous products of the partial char combustion are withdrawn overhead from the vessel 14 through a conduit 28.

The mixing, drying and preheating vessel 11 and the char combustion vessel 14 are not absolutely required to conduct the present invention. If, for example, a supply of fluidizable dry preheated coal is available in the coal supply vessel 10, such material may be introduced directly into the first stage carbonization vessel 12 which has a sufficient inventory of char to render ineffective the agglomerating tendency of the coal under the conditions maintained therein. I have found, however, that it is advantageous to introduce a blended stream containing both fresh coal and recycle char to improve operability at the critical injection point from which coal dispersion must be effected. Similarly the char combustion vessel 14 may be eliminated since its only function is to supply heat to the second stage carbonization vessel 13. Supply of heat in this manner requires that at least a portion of the product char be exposed to the elevated temperature maintained within the char combustion vessel 14. In some applications the additional devolatilization of a portion of the char under these elevated temperature conditions may be undesirable. Where such is the case, other means for supplying heat to the second stage carbonization vessel 13 may be employed, for example, recirculation of heated inert particles which may be readily removed from the product char.

By the process of the present invention, the throughput of a carbonization system may be substantially increased without adversely affecting the tar yield potentially realizable from an agglomerative coal. By permitting operability without agglomeration at char recycle ratios as low as 3 to 1, coal throughput rates hitherto unobtainable may be realized.

To illustrate the improved results from the present invention, two examples will be described for fluidized carbonization of agglomerative coals from the Pittsburgh Seam.

Example A

Pittsburgh Seam coal was crushed to pass through a 14 mesh Tyler standard screen. This coal was mixed with eight parts of finely divided char obtained as a product from a previous carbonization process. The mixture was introduced into a vessel containing a fluidized bed of char at 950° F. at a rate of 9.0 pounds of the mixture per hour for more than 21 hours. No agglomeration difficulties were encountered. This example demonstrated operability of untreated coal in a fluidized carbonization process. Any attempt to decrease the ratio of char-to-coal or to increase the feed rate results in severe agglomeration difficulties.

Example B

Coal from the Pittsburgh Seam was crushed to pass through a 14 mesh Tyler screen and was mixed with 3 parts by weight of finely divided char obtained as product from a previous carbonization process. The mixture was introduced into a first carbonization vessel containing a bed of char under fluidized conditions at a temperature of 781° F. at a rate of 15.2 pounds per hour. The coal residence time in the first carbonization vessel was more than five minutes. No agglomerative difficulties were encountered in this first carbonization vessel. The volatile content of the 3:1 char and coal feed mixture was 10.63 percent by weight. The volatile content of the solids produced in the first carbonization vessel was 5.80 percent by weight.

The solids from the first carbonization vessel were thereafter introduced at a rate of 13.6 pounds per hour into a second carbonization vessel containing a fluidized bed of char at 947° F. No agglomeration difficulties were encountered in the second carbonization vessel. Carbonization was substantially completed since the solid

product from the second carbonization vessel had a volatile content of only 3.35 percent by weight.

The improved throughput of the carbonization system according to the present invention is at once apparent. Single stage treatment can be successfully carried out by using a feed mixture containing 8 parts char to 1 part coal at 9.0 pounds per hour, i.e., 1 pound of coal per hour. My present invention permits feeding a mixture of 3 parts char to 1 part coal at 15.2 pounds per hour, i.e., 3.8 pounds of coal per hour.

This increased throughput is effected by confining the coal under fluidized conditions at a plastic temperature from about 725° to about 825° F. for at least five minutes. The method employed to prevent agglomeration of the coal during this first treatment preferably is through dilution of the coal with finely divided non-agglomerating solids, preferably a recycle stream of the char produced in the process. The present invention differs from that described in my prior U.S. Patent 2,677,650 in that the agglomerating coal according to the present invention is actually partially carbonized in the plastic range between 725 and 825° F. for at least five minutes to effect removal of up to 50 percent of the volatile material prior to carbonization. The resulting coal throughput is substantially increased over that realizable according to my aforementioned prior patent.

According to the provisions of the patent statutes, I have explained the principle, preferred construction, and mode of operation of my invention and have illustrated and described what I now consider to represent its best embodiment. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. The method of carbonizing a finely divided agglomerative coal having plastic properties in the temperature range from about 725° to about 825° F., which comprises maintaining said coal in a fluidized state in admixture with finely divided non-agglomerative solids at a distillation temperature in the plastic range of said coal between about 725 and about 825° F. for at least five minutes, the quantity of said non-agglomerative solids being sufficient to prevent agglomeration of said coal, the ratio of said solids to said coal being less than would be required to render ineffective the agglomerating tendency of the coal under similar fluidized conditions at a carbonizing temperature above the plastic range of the coal and above about 825° F., thereafter raising the temperature of the thus treated partially devolatilized coal in admixture with said solids while in a fluidized state to a carbonization temperature above 825° F. until substantially complete carbonization has been effected, and separately recovering finely divided devolatilized coal and evolved coal vapors.

2. The method of carbonizing a finely divided agglomerative coal having plastic properties in the temperature range from about 725° to about 825° F., which comprises maintaining said coal in a fluidized state in admixture with finely divided non-agglomerative solids comprising char at a distillation temperature in the plastic range of said coal between about 725 and about 825° F. for at least five minutes, the quantity of said non-agglomerative solids being sufficient to prevent agglomeration of said coal, the ratio of said solids to said coal being less than would be required to render ineffective the agglomerating tendency of the coal under similar fluidized conditions at a carbonizing temperature above the plastic range of the coal and above about 825° F., thereafter raising the temperature of the thus treated partially devolatilized coal in admixture with said solids while in a fluidized state to a carbonization temperature above 825° F. until substantially complete carbonization has been effected, and separately recovering finely divided devolatilized coal and evolved coal vapors.

3. The method of carbonizing a finely divided agglomerative coal having plastic properties in the temperature range from about 725° to about 825° F., which comprises establishing a fluidized bed comprising said coal and finely divided solid particles of char at a distillation temperature in the plastic range of said coal between about 725 and about 825° F., the quantity of said char being sufficient to prevent agglomeration of said coal therein, continuously introducing coal and char into said fluidized bed in a ratio which is less than that which would be required to render ineffective the agglomerating tendency of the coal under similar conditions in a fluidized bed maintained at a carbonizing temperature above the plastic range of the coal and above 825° F., moreover introducing said coal and said char into said fluidized bed at such a rate that the coal remains therein for at least five minutes, continuously withdrawing a mixture of partially devolatilized coal and said char from said fluidized bed, thereafter maintaining the said mixture under fluidized conditions at a carbonization temperature above the plastic range of the coal and above about 825° F. until substantially complete carbonization has been effected and separately recovering finely divided devolatilized coal and evolved coal vapors.

4. The method for carbonizing finely divided agglomerative coal having plastic properties in the temperature range from about 725° to about 825° F. to produce therefrom liquid and gaseous distillate and solid char which comprises introducing said coal at a temperature above about 250° F. and below its plastic range into a first carbonization zone maintained under fluidized conditions at a distillation temperature within the plastic range of said coal from about 725 to about 825° F. in the presence of sufficient inert finely divided solid diluent comprising char to render ineffective the agglomerating tendency of said coal therein, the ratio of said diluent to said coal being less than would be required to render ineffective the agglomerating tendency of the coal under similar conditions at a carbonizing temperature above the plastic range of the coal and above about 825° F., maintaining the coal therein for at least 5 minutes to render ineffective the agglomerating tendency of the coal at temperatures above its plastic range, withdrawing thus treated partially devolatilized coal and char in admixture from said first carbonization zone and introducing said admixture into a second carbonization zone maintained under fluidized conditions at a carbonization temperature above the plastic range of said coal, maintaining said admixture in said second carbonization zone until substantially complete carbonization has been effected, withdrawing a first portion of solids from said second carbonization zone as product char, withdrawing a second portion of solids from said second carbonization zone, introducing said second portion of solids into said first carbonization zone as said inert finely divided solid diluent, and recovering the distilled vapors and gases from said first and second carbonization zones as product.

5. The method for carbonizing finely divided agglomerative coal having plastic properties in the temperature range from about 725° to about 825° F. to produce therefrom liquid and gaseous distillate and solid char which comprises introducing said coal at a temperature above about 250° F. and below its plastic range into a first carbonization zone maintained under fluidized conditions at a distillation temperature within the plastic range of said coal from about 725 to about 825° F. in the presence of sufficient inert finely divided solid diluent comprising char to render ineffective the agglomerating tendency of said coal therein, the ratio of said diluent to said coal being less than would be required to render ineffective the agglomerating tendency of the coal under similar conditions at a carbonizing temperature above the plastic range of the coal and above about 825° F., maintaining the coal therein for 5 to 20 minutes to render ineffective the agglomerating tendency of the coal at temperatures

above its plastic range, withdrawing thus treated partially devolatilized coal and char in admixture from said first carbonization zone, introducing said admixture into a second carbonization zone maintained under fluidized conditions at a carbonization temperature above the plastic range of said coal, maintaining said admixture in said second carbonization zone until substantially complete carbonization has been effected, withdrawing a first portion of solids from said second carbonization zone as product char, withdrawing a second portion of solids from said second carbonization zone, introducing said second portion of solids into said first carbonization zone as said inert finely divided solid diluent, recovering a gaseous stream comprising distilled coal vapors and gases from said first carbonization zone and passing said gaseous stream into said second carbonization zone as the fluidizing gas therefor, and recovering liquid and gaseous distillate as product from said second carbonization zone.

6. The method for carbonizing finely divided agglomerative coal having plastic properties in the temperature range from about 725° to about 825° F. to produce therefrom liquid and gaseous distillate and solid char which comprises introducing said coal at a temperature above about 250° F. and below its plastic range into a first carbonization zone maintained under fluidized conditions at a distillation temperature within the plastic range of said coal from about 725 to about 825° F. in the presence of sufficient inert finely divided solid diluent comprising char to render ineffective the agglomerating tendency of said coal therein, the ratio of said diluent to said coal being less than would be required to render ineffective the agglomerating tendency of the coal under similar conditions at a carbonizing temperature above the plastic range of the coal and above about 825° F., maintaining the coal therein for at least 5 minutes to render ineffective the agglomerating tendency of the coal

at temperatures above its plastic range, withdrawing thus treated partially devolatilized coal and char in admixture from said first carbonization zone, introducing said admixture into a second carbonization zone maintained under fluidized conditions at a carbonization temperature above the plastic range of said coal, maintaining said admixture in said second carbonization zone until substantially complete carbonization has been effected, withdrawing a first portion of solids from said second carbonization zone as product char, withdrawing a second portion of solids from said second carbonization zone, introducing said second portion of solids into said first carbonization zone as said inert finely divided solid diluent, withdrawing a third portion of solids from said second carbonization zone, reacting said third portion of solids with air to raise the temperature of the solids in said third portion above that of said second carbonization zone, returning thus heated solids to said second carbonization zone to supply heat therefor, and recovering the distilled vapors and gases from said first and second carbonization zones as product.

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