This invention relates to improvements in the carbonization and the gasification of bituminous material. Relating particularly to the carbonization or gasification of bituminous combustibles in the form of briquettes, by means of washing gases.

In the drying zone of carbonizing installations or setups on gas producers, the gradual drying process is often interfered with by the steam from the moist washing gases precipitating on the combustibles placed in the shaft. This condensate is absorbed by the combustibles and causes them to swell up. The swelling progresses from the surface of the combustible toward the center and produces swelling tensions which cause a loosening of the combustible texture. Measurements of the temperatures and tests of the combustibles in the carbonization shafts of existing installations have shown that the dangerous condensation zone extends over a large part of the carbonization shaft area so that the combustibles are given a relatively long period of time in which to absorb the moisture which precipitates on them. The drying of these combustibles which have absorbed moisture does not start until the temperature on the combustible surface exceeds the dew point of the washing gas. When the temperature reaches this point the drying begins and proceeds at an increased rate. At first, the outer layer of the combustible shrinks which produces undesirable shrinkage tension and which also causes a loosening of the combustibles' texture. This loosening of the texture of the combustible by the swelling tensions mentioned, as well as by the shrinkage tensions results in the combustibles being affected deleteriously so that they will not stand up under the following mechanical and thermostresses developed during carbonization and if desired during the subsequent gasification. These later mechanical and thermostresses will cause the material that has been affected by the moisture swelling and shrinking to disintegrate. As a result of this, the combustible mass forms such a dense layer in the shaft that the passage of the washing gas used for the carbonization and, if desired, of the gasification medium through the combustible layer becomes difficult. The pressures of the washing gas before entry into the carbonization shaft and of the gasification medium before its entry into the gasification shaft are thereby increased excessively. Due to these built up pressures and the increased resistance of the combustible mass the gases will take the path of least resistance through the combustible layer which causes an uneven carbonization or gasification as the case may be.

A process is known whereby two or more circulation gas currents are introduced in the carbonization shaft at different heights along the shaft. These gases are used to heat the combustibles and are carried out of the carbonization zone separately. In this known process, partly combustion gases and partly gases which are in circulation during the application of the gasification and carbonization process are used. These gases usually contain a considerable amount of steam. Accordingly they show a high dew point so that a correspondingly high amount of steam condenses on the combustible which is introduced in an unheated state.

One object of the invention is the carbonization and gasification of bituminous material in briquette form, without the aforementioned difficulties. This and other objects will become apparent from the following description read in conjunction with the drawings in which:

Fig. 1 shows diagrammatically an illustrative example of the principle of the invention applied to an existing gas producer of a known design for the gasification of bituminous briquettes.

Fig. 2 shows gas producer according to the invention as illustrated in Fig. 1, provided with an added preheating arrangement of the combustible and further provided with several added washing gas arrangements diagrammatically the added preheating arrangements of the combustible of Fig. 2, according to the invention.

According to the invention washing gases are introduced into the carbonization shaft in a dry state or having a relatively small amount of steam. Since the washing gases in the carbonization shaft absorb the moisture and the water formed during combustion, and since the steam is again partly condensed on the combustible material which is brought unheated into the carbonization shaft, the quantity and temperature of the uppermost washing gas currents are so chosen that the surface of the combustible is heated above the dew point of the gas, after a relatively short period of travel of the combustibles through the carbonization zone. If a larger quantity is used it will lower the dew point of the gas in the combustible layer. By heating the surface of the combustible after a relatively short period of travel through the carbonization zone, to a temperature above the dew point of the washing gas, which has absorbed the water vapor out of the moisture present and out of the water formed during combustion, a relatively rapid passage through the dangerous condensation zone is obtained so that, although the washing gases have been introduced in as dry a state as possible, only a relatively short time is available for any possible condensation of the water on the solid combustible material. The deposited water, thus, has no time to penetrate into the interior of the combustible and will immediately be vaporized again, and thus a swelling of the combustible is avoided.

In one arrangement of the apparatus and procedure according to the invention, the combustible material is preheated as it enters the carbonization zone. This may be done in a known manner by conducting a current of warm washing gas in a separate drying shaft. This drying shaft is separated from the carbonization shaft, and in it the combustible material is preheated by the washing gas. The procedure is successful only if very dry washing gases are used in the separate drying shaft. The quantity of the washing gas used for this purpose must not be too small since in the preheating process by counter current flow the combustible gives off a considerable portion of its moisture to the washing gas. It is thus that the preheating shaft acts as a predryer. Due to the reasons stated above, the dimensions of the preheating shaft become comparatively large, and the structural arrangements may become extensive.

According to the invention, these disadvantages may be avoided by conducting the washing gas used for preheating the combustible in the same flow direction as the combustible. In this way, the separation of the preheat-
ing shaft from the carbonization shaft is avoided since the washing gas current used for preheating can be carried off together with that used for carbonizing and drying. Conducting the gas in the same flow direction as the combustible has the additional advantage in that the warmest gas comes in contact with the coldest combustible. Due to this the surface of the combustible is heated quickly, which aids in avoiding condensation on the combustible in the carbonization shaft since the heating of the surfaces even to small depths are quite effective. Consequently, only a small quantity of washing gas is required, and the heating of the combustible can be accomplished in a considerably smaller area. This will permit in many cases the application of the process according to the invention in existing installations which have no preheating zone, without expensive alterations. This can be accomplished by using the inlet shaft in existing installations as a preheating shaft.

The washing gas used for preheating the combustible may be any warm gas whose steam concentration is not too high and will not effect the properties of the carbonization gas unfavorably. In most cases, no additional gases will be used for preheating, but the same hot gases will be used as are used for washing gas for the carbonization. The entering carbonization gas is subsequently used as a preheating washing gas. In order to control the temperature of the washing gas that is used for preheating, it may be mixed with cold gas, which is passed in the drying process. The temperature of this gas mixture is determined by the properties of the combustible used. The temperature of this gas should normally be as high as possible without adversely affecting the combustible. Usually temperatures not in excess of 300° C. will be used. The quantity and temperature of the washing gas current are so chosen that the surface temperature of the combustible on its way into the carbonization shaft will not substantially exceed the dew point of the washing gas coming up in the carbonization shaft.

Usually a portion of the gasification gas produced in the gasification shaft is used for drying and carbonizing the combustible. This gas still contains the steam which was not exhausted during the generation of the water gas, and on its way through the carbonization shaft, it absorbs the moisture of formation of the combustible. This gas therefore contains a high concentration of steam when it leaves the carbonization shaft. The steam concentration of the washing gases, the dew point and substance of the amount of water which condenses on the combustible can be reduced by decreasing the volume of the gas which enters into the carbonization shaft at the bottom and by introducing one or several streams of washing gas at a low temperature and with a relatively low concentration of water at a higher level.

According to the preferred embodiment of the invention several currents of washing gas are used. This has the additional advantages of making it possible to control the shrinking process advantageously since the carbonization and coking of lumpy combustibles and especially briquettes, produces a greater or lesser amount of shrinkage of these combustibles, depending on their water or tar concentrations. The shrinking process depends particularly on the temperature and is not uniform. The rate of shrinkage is at its maximum at the temperature of intensive drying and, later tar extraction. Controlling the shrinkage is particularly important since during the heat transfer from the washing gases to the combustible, depending on the coefficient of thermal conductivity of the combustible and the temperature and volume of the washing gas, there is always a certain decrease of the temperature of the combustible from the surface toward its core, and thus there will be a corresponding difference in the shrinkage which will cause tensions that loosen the structure of the combustible so that it becomes brittle and will fall apart upon the slightest mechanical impact.

If the heating of the combustible were undertaken in two or three steps, e.g. if first the combustible were dried by a special washing gas cycle and thereafter carbonized by a second independent washing gas cycle, the transfer of the washing gas heat to the combustible would be accomplished, this would be dependent upon the moisture content, and would create inelastic heat transfer conditions in the drying zone as well as in the carbonizing zone. Thus if two independent gas cycles were used, an additional heat transfer in these separate zones to the shrinking process of the combustibles could not be obtained for this depends on the temperatures.

Accordingly, in a preferred arrangement of the procedure according to the invention, two or more washing gas currents are mixed together at different levels of the carbonization or coking shaft. Their volumes, temperature, points of entry into the carbonization shaft are so adapted as to control the shrinking behavior of the combustible as it is being heated. Usually, the lowest temperature of the washing gas current which is led into the carbonization shaft will be the hottest and will correspond to the highest temperature of the combustible. The washing gas or gases carried to the combustible further up in the carbonization shaft will be of a lower temperature. The higher the gas carried to the combustible along the carbonization zone, the higher its temperature. Thus the temperature and the quantities of the washing gases are so controlled that the temperature changes of the combustible during its passage through the shaft will cause as uniform as possible shrinkage conditions in the combustible during this period, and will not cause excessive shrinkage. By use of this method and so controlling the temperature that a uniform shrinkage is obtained, a hard coke is obtained in the shortest carbonizing and coking time. In this manner, any temperature conditions desired in the shaft can be obtained, and thus high yields are obtained while the combustible is heated very carefully.

The temperature of the washing gas currents can be regulated by mixing hot washing gas with cold gases. The cold gases may be taken from the washing gas cycle of the process or extra available gases may be used.

According to the invention, such washing gases are obtained by mixing the hot gasification gas with cold production gas (i.e. cold gasification gas or carbonization gas or both), whose steam contents has been removed or substantially removed. Other gases which may be available, may be used precisely its temperature. In this gasification gas leaving the gasification shaft contains dust from the combustibles it is advisable not to draw it off with a rotary blower. In such cases it is advisable to draw the hot dust containing gas out of the gasification shaft by means of a cold production gas, which is under pressure, by means of a jet blower, which mixes both gases thoroughly and carries them to the carbonization shaft.

Instead of the production gas, any extra gas with a low steam content may be used, as for example water gas. Instead of the jet blowers mentioned, other installations may be used provided that they can mix and carry the gas.

Existing gas producers of known construction used for the gasification of bituminous briquettes may be used, as shown diagrammatically in Fig. 1. There is shown the longitudinal section through the upper part of the gasification and carbonization combustible of a gas producer for the gasification of bituminous briquettes, which was rebuilt for the process of this invention. The gas produced in the gasification shaft 1 is partly sucked through the connection 2 and partly drawn off as washing gas into the carbonization shaft 3, where it transfers a part of its heat to the combustible which is carried into the carbonization stage by the cellur wheel at the top of the shaft. In the upper third of the carbonization shaft a second washing gas stream, which consists of a mixture of the hot gas out of the gasification shaft which has drawn
off at 5 and passes through 5, and cold production gas, is fed in. The direction of the washing gas is indicated by the arrows in the drawing. The pipe line 5 is connected with the outlet 2 of the jet blower 6. The nozzle of the jet blower is connected through a feed line 7 with the production gas line, e.g. to the line 2 behind suitable coolers, which is under higher gas pressure than the gas coming from the outlet 2. If the pressure of the production gas is not sufficient for the mixing and conveying of both the gases, a jet blower which is not shown in the drawing is built into the line 7. The jet blower is connected through the feed line 8 with the circular line 9 from which the gas mixture via the channels 10 which are readily arranged in the carbonization shaft, and via the cone shaped hood 11, into which the channels discharge, is diffused over the cross section of the carbonization shaft. The washing gases together with the carbonization gases and the steam set free out of the combustible are carried off through the outlet 12. They are further treated in a known manner.

The bituminous briquettes are heated over a short path of travel to a surface temperature of about 200° C. by the second washing gas stream. This heating takes place rapidly. The temperature of the washing gas at its entry is 250° C. and can be regulated through the mixture of cold production gas with hot gasification gas by means of a gas regulation meter 13 and 15. The temperature of the washing gas at the outlet is about 100° C. The quantity of the washing gas, which enters the carbonization shaft from the gasification shaft is so chosen that the temperature of the combustible below the entry of the second washing gas rises from 200° C. to about 650° C. to 700° C. at first gradually and then more rapidly. The gas produced in the gasification shaft has a temperature of more than 700° C.

No disintegration of the briquettes is caused by these various treatments. The combustible remains firm during its gasification whereby a substantial increase in the capacity of the gas producers is obtained.

In cases of a different kind it may be suitable to make the temperature of the washing gases higher or lower than that in the example above. It depends on the quality of the combustible, the steam concentration of the washing gas and the dimensions of the carbonization space.

The place of the uppermost entry of the washing gas into the carbonization shaft is so chosen that the heat transfer from the washing gas to the combustible above the dew point of the first named is effected in a short manner.

In Fig. 3, a further development of the procedure, diagrammatically shown in Fig. 1 is illustrated by a diagram in which, in order to better explain the principle of the further development, all details are omitted which refer to the main process only. Fig. 3 shows the upper part of a carbonizer or a carbonizer setup on top of a gas producer for bituminous combustibles, in a longitudinal section:

- From the bunker 31, the combustible passes through the cellular wheel 4 into the preheating space 33 whose side walls extend into the carbonization room 3. The heating space is open at the bottom so that the combustible can enter unimpeded into the carbonization room in the same quantity in which it is drawn out at the lower end (not shown in Fig. 3) of the carbonization room. Warm washing gas, which flows downward through the combustible layer in the preheating room and transfers a part of its heat to the combustible and heats its surface, is fed into the preheating room through the connection 35 at the top.

- The washing gas stream A4 used for preheating the combustible leaves chamber 33 at its lower end and combines with the washing gas stream which comes up from the carbonization chamber and is designated in the diagram by the reference number B3 and which does the drying and the carbonization of the combustible. The preheating shaft extends into the carbonization shaft far enough that there is a sufficiently large free space above the cone shaped heap of combustible material in which the washing gases can be condensed and carried out through the connection 12. In Fig. 3, the flow of the washing gases mentioned is indicated by lines and arrows. Both washing gas streams leave the carbonization room together via connection 12. They are freed from tar in the known manner, are cooled and can be reused again as washing gases after they have been heated directly or indirectly.

Fig. 4 shows another development, in the form of a diagram, of the procedure shown diagrammatically in Fig. 1. For a better explanation of the principle of this other development, all details referring to the main procedure only are omitted. The washing gas stream A4 replaces the one of the gasification gas which normally comes up from the gasification shaft. Fig. 4 illustrates the principle of the extended development diagrammatically in an illustrative example with three circulation gas inflow feed:

In the carbonization shaft 3 are roof-shaped channels 42, 43 and 44 out of which the washing gas streams A4, B4 and C4 enter into the combustible column in the shaft, diffuse over the cross section of the shaft and rise in it. After the transfer of their heat to the combustible, they leave the shaft at the upper end through the connection 12 and are conducted in the known manner over a tar condensation and cooling arrangements. The combustible is fed into the carbonization shaft through a cellular wheel which is designated by the reference number 4 in this example. The hot combustible material is conveyed further at the lower end of the carbonization shaft in a manner well known but not shown here. Rewashing gases for the carbonization of the combustible are conducted into the channels 42, 43 and 44 through the feed lines 47, 48 and 49, which are connected with the collecting feed line 53 for hot washing gas through the regulators 50, 51 and 52. The lines 54 and 55 also lead into the lines 46 and 49. Lines 54 and 55 are also provided with the regulators 56 and 57 and are connected with line 58 for cold washing gas. The quantities and temperatures of the washing gas streams A4, B4, and B5 are regulated by the regulators, which are built into the feed lines. In the illustrative example, line 47 has no connection with a cold gas feed line since the temperature of gas 53 is to be the same as that of washing gas stream A4.

To determine the effect of this development of the process diagrammatically illustrated in Fig. 1 more accurately, the improvement diagrammatically shown in Fig. 4 was examined separately. The temperature of the washing gas A4 was set at 650° C. that of the washing gas B4 at 350° C. and that of the washing gas C4 at 250° C. It was found to be best to choose such quantities of the washing gases that the cooling of the stream A4 by the combustible up to the entry level of stream B4 has reached about its entering temperature and that the further heat transfer of streams A4 and B4 together up to the entry level of streams C4 reduces their temperature to about 50° C. below the entry temperature of stream C4. The temperature of the washing gases as they left the carbonization shaft at the outlet 12 was about 100° C.

As shown in Fig. 2 as an example, in the production of gas, according to the invention, out of bituminous combustible materials as shown by diagram in Fig. 1, the lowest line in the carbonization shaft for feeding in the washing gas A4 is naturally omitted since a part of the hot gasification gas produced in the gasification shaft immediately under it is drawn as a washing gas directly out used which is not shown in the diagram. In Fig. 2, as also in Fig. 1, the carbonization shaft is designated by the reference.
number 3, the cellular wheel with number 4, and the outlet connection by reference number 12. The jet blowers 59 and 60, drawn here diagrammatically, act like jet blower 6, but can be replaced by other convexer or mixing arrangements.

It is, however, understood that the process according to the invention, diagrammatically shown in Fig. 1 can as illustrated in Fig. 2, not only be executed with both extensions of the invention simultaneously, but that the process, according to the invention, as shown diagrammatically in Fig. 1, can also be carried out with one extension thereof, as illustrated in principle in Figures 3 and 4 according to the invention, and that details may be changed without leaving the scope of the invention.

When referring to a gas with a low moisture content, gases having no moisture content therein, and gases having a relatively small amount of moisture are meant.

As washing gases, first of all the gases shall be used which result in the carrying out of the process itself, e.g. in the carbonization of the carbonization gas itself may be used which is drawn off with the washing gas at the exit of the carbonizer and is then freed of tar and cooled in a known manner. Its heating is effected preferably indirectly since the gas is heated thus dry. When using a direct heating by partial combustion with air, care has to be taken that the combustible is rapidly heated superficially above the dew point of the gas. In case the carbonization is effected only as first step of the gasification of the combustible, part of the gasification gas, for instance producer gas or water gas, the sensible heat of which is directly utilized for the carbonization, is expediently used as washing gas for the carbonization.

All other gases, however, may also be used as washing gas, provided they are practical free of oxygen and do not decompose up to a temperature of 600° C. The reactions between the combustible and constituents of the washing gas, for instance carbon dioxide, occur hardly, since the carbonization takes place up to a temperature of approximately 500–600° C. and, at the relatively low temperatures, only a heat transfer occurs. The washing gases may consequently contain in any concentration carbon dioxide, carbon monoxide, hydrogen, methane, ethylene, and nitrogen, and also small portions of higher hydrocarbons, i.e. they may be industrial gases resulting usually in chemical plants. No unfavourable reactions between the forming washing gases and the above mentioned gases occur.

The moisture of the washing gases is of deleterious influence only in the zone of the shaft in which the combustible has a lower temperature than corresponds to the dew point of these gases. In case the combustible has a high swelling tendency, it will be preheated, as already described, by conducting at first the combustible and the washing gas co-currently. The dew point of this washing gas should not exceed 30° C., if possible. Preheating of the surface of the combustible may be carried out in this zone up to 100° C., so that the washing gases which, below this zone, are conducted counter-currently to the combustible may have any moisture content.

Should, however, preheating not be possible in the afore mentioned way, for instance for structural reasons, or should the swelling tendency of the combustible be moderate, the moisture content of the washing gases may be the higher the more the combustible endures a superficial rapid heating above the dew point of said washing gases without damage to its texture. Depending on the swelling properties of the combustible, the admissible moisture content of the washing gases in this zone of the shaft varies between 80 grams and 350 grams of washing steam per N m.³ (normal cubic meter) of washing gas. Since the washing gases, however, load themselves with the steam from the combustible, they must have, before their introduction, only a moisture content which is correspondingly lower. This moisture content will normally be between 30 grams and 150 grams of steam per N m.³ of washing gas. The consequence thereof is, of course, that the moisture content of the upper washing gases introduced into the shaft must be the lower the higher it is in the washing gases introduced below.

The gas flow rates in each stage of the drying carbonization and gasification is dependent on the period of time in which the combustible may be dried and carbonized without disintegration. This period of time is different for every combustible and furthermore dependent on its water content, its lump size and the required firmness of the carbonization coke. By way of tests, the shrinkage behavior of the combustible in dependence on the temperature is determined and graphically drafted, if necessary. There is generally to be said in this connection, that the combustibles have completely given off their moisture up to a temperature of approximately 200° C. The carbonization until the complete extraction of tar is terminated at approximately 580° to 550° C. Beyond this the further degasification of the combustible may be carried out up to 800° C. and higher, in case this appears to be desirable for the further use of the coke. According to this shrinkage behavior determined, the most favourable course of temperature at the shortest drying, carbonization and gasification period and the desired firmness of the coke may be established where also any limitations on the injection rate of the gases into the respective zones are established. From the most favourable course of temperature and the heat requirements of the combustible for its drying and carbonization, there result number, quantities and temperatures of the washing gas currents to be introduced in different heights of the carbonization shaft. The heat transfer of the washing gas in dependence on the time must accordingly be approached practically to the most favourable heating course determined by the period of time from the washing gas currents introduced below into the combustible shaft and which must have the combustible temperature desired, the upper washing gas currents are only introduced for the adjustment of the most favourable temperature course of the combustible layer up to approximately 550° C. or below, since the influence of the coke desired and the kind of combustible, the period of time, the temperature amounts, under observance of the most favourable heating course, to approximately ½ to 4 hours for drying and to ½ to 6 hours for carbonization. For very moist combustibles, for instance at a moisture content of 25% and more, the drying period required may be still longer.

The process in accordance with the invention is, in normal cases, not carried out under pressure, but may be carried out, in particular cases, also under pressures higher or lower than atmospheric pressure. In case the pressure applied differs substantially from atmospheric pressure, the physical regularities, especially the change of the temperature in the drying process and the changes of the condensation conditions of steam and tar on the combustible, are to be considered. This may be effected by changing the temperature, the quantity and, if necessary, the steam concentration of the upper washing gas currents.

Any limitation in respect of the particular bituminous material, gases, or apparatus used do not exist. Any lumpy bituminous combustible may be processed successfully when considering in the described manner its properties and behavior during the heating.

I claim:

1. In the carbonization and the gasification of bituminous materials with washing gases, the improvement which comprises establishing a treating zone, passing such bituminous materials downward through said treating zone, passing at least two separate streams of washing
gases including one uppermost gas stream and at least one lower gas stream into said zone at least two separate heights in intimate contact with the bituminous material in said zone, the uppermost stream of washing gas being a washing gas of low moisture content and sufficient heat to rapidly heat the surface of the bituminous material to a temperature above the dew point of the lower washing gas stream after contact with the bituminous material, and collectively removing said washing gases and the volatile carbonization and drying products from the upper portion of said zone.

2. Improvement according to claim 1, in which said uppermost stream of washing gas is passed in co-current flow contact with said bituminous material and in which the lower streams of washing gases are passed in counter-current flow contact with said bituminous material.

3. Improvement according to claim 1, in which said uppermost stream of washing gas is at a lower temperature than the lower streams of washing gases.

4. Improvement according to claim 1, in which said uppermost stream of washing gas mixes during contact with said bituminous material with the washing gases from the lower streams and in which the combined temperature is sufficient to rapidly heat the surface of the bituminous material to a temperature above the dew point of the lower gas stream.

5. Improvement according to claim 4, in which said uppermost stream of washing gas is at a lower temperature than the lower stream of washing gases.

6. Improvement according to claim 1, in which said bituminous material is contacted with at least three separate streams of washing gases at different heights in said zone.

7. Improvement according to claim 6, in which the uppermost stream of washing gas is passed in co-current flow contact with said bituminous material, and in which the lower streams of washing gases are passed in counter-flow contact with the bituminous material, each stream of washing gases below said uppermost stream combining with the streams below it in said zone at the height at which it is passed into said zone.

8. Improvement according to claim 1 in which said bituminous material is in the form of briquettes.

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