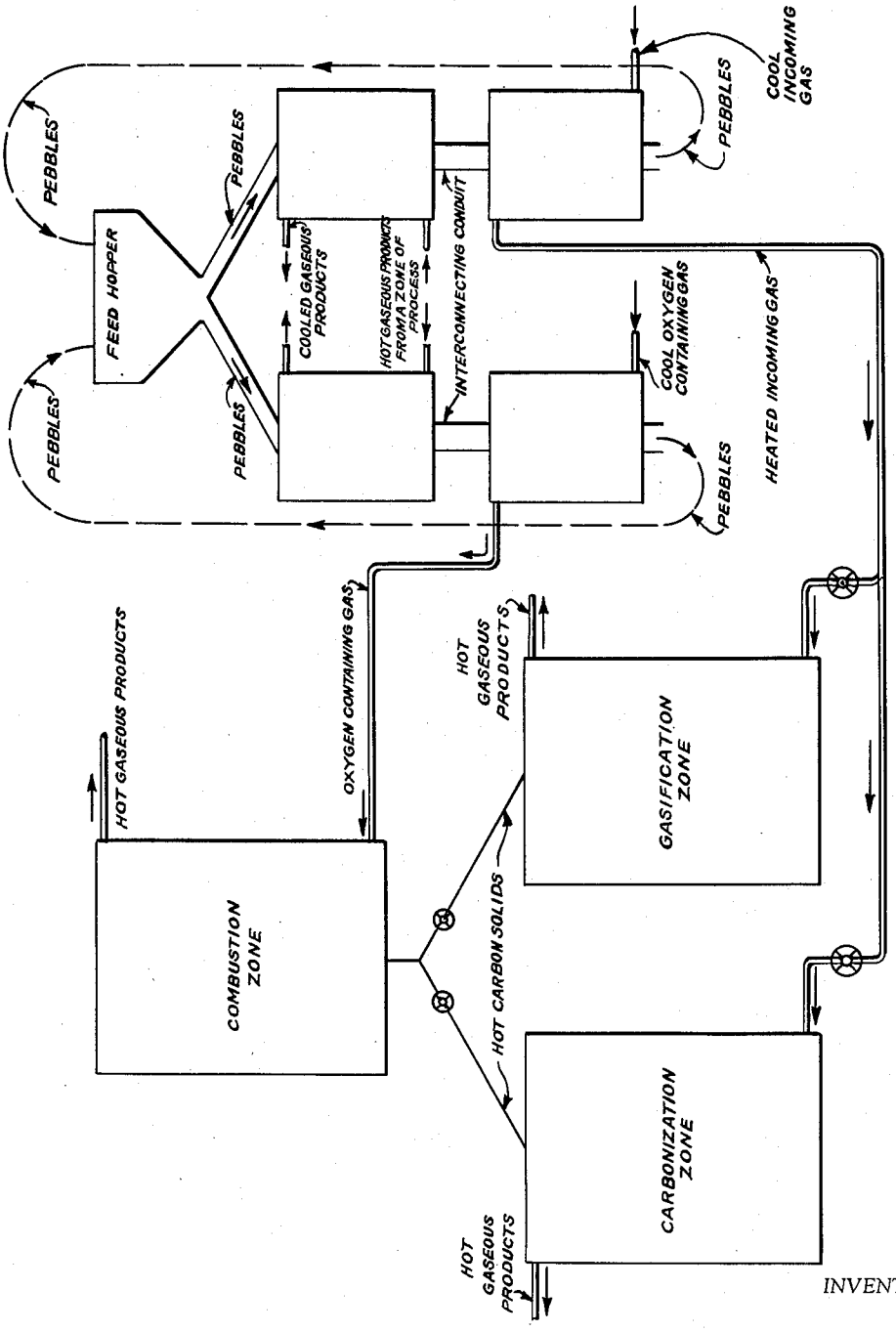
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GASIFICATION OF CARBONACEOUS MATERIALS

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GASIFICATION OF CARBONACEOUS MATERIALS

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This invention relates to processes for the gasification of solid carbonaceous materials and more particularly to such processes in which the solid carbonaceous materials are employed in particulate form.

In these processes for carbonising, for example coal, and/or for the production of gaseous mixtures by the interaction of an oxygen-containing gas and/or steam with hot carbonaceous material, for example coke, the heat required for the carbonising and/or gas producing step or steps is, in general, obtained by the partial combustion of similar carbonaceous material by subjecting it to the action of an oxygen-containing gas at a rate sufficient to maintain the particles in the desired state of fluidisation and to give the desired rate and degree of combustion, then passing hot particulate material from this combustion step to the carbonisation and/or gas-producing step or steps.

The sensible heat contained in the gaseous products of combustion however is not in a form which can be directly utilised in the process. For example, when cold air is used in the combustion of particulate coke in the fluidised state, and the quantity of coke in the fluidised mass is sufficient to limit the temperature of the coke and the products of combustion to about 1000° C., such quantity of coke being dependent upon the proportion and properties of ash present in it, the amount of heat absorbed by the coke will be about 60% of the total heat produced, the remaining 40% being carried out of the combustion step with the gaseous products.

It is clearly advantageous to decrease the proportion of the total heat produced in the combustion step which is lost in the gaseous products from that step. It is likewise an advantage to decrease the heat lost in the gaseous products from the other steps of the process.

To this end it has already been proposed to bring the gaseous products from the combustion or other steps of such processes into indirect heat exchange, for example in conventional tubular or plate type heat exchangers, with the gases and/or vapours being passed to the process.

I have found that the heat in the gaseous products from a combustion or other step of such processes may be more advantageously used to preheat incoming gases and/or vapours, for example the oxygen-containing gas supplied to the combustion step whereby a much higher percentage of the heat produced in this step is made available to the process, if such preheating is carried out as hereinafter described.

Moreover, the method of the present invention

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is particularly advantageous in the carbonisation and/or gasification processes above mentioned as it ensures a much higher utilisation of the heat produced than is possible by the methods of the prior art and permits continuity of operation as the heat exchange apparatus does not become fouled with dust.

According to the present invention there is provided, in a process for the carbonisation and/or gasification of particulate solid carbonaceous material maintained in the fluidised state, the method of preheating incoming gases and/or vapours which comprises passing the hot gaseous products from a step of the process upwardly through a vessel in countercurrent flow to a mass of solid material in the form of pebbles moving downwardly under gravity through the vessel, whereby the pebbles are heated and the gaseous products are cooled, then passing the heated pebbles downwardly under gravity through an interconnecting conduit and into a second vessel down which the pebbles move, under gravity, and countercurrently to an upwardly flowing stream of the incoming gas and/or vapour, whereby the pebbles are cooled and the incoming gas and/or vapour is heated and subsequently passed to any desired step of the process.

It will be understood that the dimensions of the interconnecting conduit between the vessels should be such as to provide, when the conduit is full of downwardly moving pebbles, sufficient pressure drop to prevent substantial flow of gas and/or vapour from the lower into the upper vessel.

The arrangement of two vessels through which solid material is caused to flow countercurrently to gas and/or vapour for the purpose of heat exchange, as above described, will hereinafter be referred to as "a set of pebble-heaters."

The cooled pebbles leave the second vessel at the bottom and are returned to the top of the first vessel either directly or indirectly by any suitable means, for example a bucket elevator, the rate of flow of the pebbles through the vessels being regulated to give the desired cooling of the gaseous products from the process and the desired preheating of the incoming gas and/or vapour.

As a further feature of the present invention the method of preheating incoming gases and/or vapours, as above described, is applied to at least two steps of a process for the carbonisation and/or gasification of particulate solid carbonaceous material maintained in the fluidised state, one of said steps being a combustion step, and at least some of the pebbles used in the sets of

pebble-heaters are exchanged between them in such manner that carbonaceous matter, for example tar, which may have been deposited on the pebbles when recovering heat from the gaseous products from a gasification or carbonisation step, will be removed by combustion as the pebbles are passed through the pebble-heater employed for preheating the air or other oxygen-containing gas being fed to the combustion step.

The exchange of pebbles between the sets of pebble-heaters may be continuous or intermittent as desired. It has been found convenient, for this purpose and for the control of the quantities of pebbles to be exchanged between the two or more sets of pebble-heaters, to raise the cooled pebbles leaving the bottom of the second vessels of the sets of pebble-heaters, for example by means of a bucket elevator, and to discharge them into a separate hopper or bin for each pebble-heater and to redistribute them as desired from these hoppers or bins to the tops of the first vessels of the sets of pebble-heaters.

The pebbles may be of any solid material which is sufficiently refractory to withstand the operating temperatures, for example 1000° C. to 1200° C., and the repeated heating and cooling. Examples of suitable materials are alumina and mullite.

The term "pebble" as used in this specification is to be understood to mean bodies of such a shape as to permit flow by gravity. They may be ovoidal or spheroidal or only roughly ovoidal or spheroidal; preferably they should have substantially smooth surfaces but it is possible to use materials with rough faces and sharp edges. Substantially spherical pellets or balls of uniform size and shape formed of mullite have been found to be particularly suitable for use in the method of the present invention.

Alternatively certain naturally occurring materials and minerals may be used when suitably prepared by such methods as crushing and screening. Although in general such naturally occurring materials will have refractory properties inferior to those of such materials as alumina and mullite, nevertheless the greater loss due to breakage and spalling might be tolerated because of the relative cheapness of the material. The size of such bodies may be varied over a wide range, for example $\frac{1}{16}$'' to $\frac{3}{4}$'' in mean diameter but it is preferred to use balls of about $\frac{3}{8}$'' diameter.

The method of heat recovery of the present invention is illustrated in the accompanying drawing which diagrammatically shows a plant for the carbonization and gasification of particulate solid carbonaceous material, said plant comprising a carbonization zone, a gasification zone, a combustion zone and a heat recovery system of two sets of pebble-heaters. In operation, a portion of the heat required in the carbonization and/or the gasification zone is supplied by the passage of hot, partially burnt particulate carbonaceous material from the combustion zone to the carbonization and/or gasification zone. Hot gaseous products from at least one of the combustion, carbonization and gasification zones are passed upwardly through the upper vessels of the illustrated sets of pebble-heaters where they are cooled by heat interchange with the pebbles passing downwardly therein. Oxygen-containing gas is passed upwardly through the lower vessel of one of the sets of pebble-heaters where it is preheated by heat interchange with the heated pebbles passing downwardly from the upper vessel, the heated oxygen-containing gas being then passed to the combustion zone. The gas or vapor required for the carbonization and/or gasification zone is passed upwardly through the lower vessel of the other set of pebble-heaters where it is preheated by heat interchange with the heated pebbles passing downwardly therein, the heated gas being then passed to the gasification and/or carbonization zone. Cooled pebbles leave the bottom of the lower vessel in each set of pebble-heaters and are elevated to a feed hopper positioned above the upper vessels of the sets of pebble-heaters. The pebbles are then passed from the feed hopper to the two sets of pebble heaters in the quantities desired.

The method of the present invention is further illustrated in the following example, which describes the preheating of air for use in a combustion step by means of heat recovered from the gaseous products of the same step.

Example

In a plant for the production of water gas in which hot particulate carbonaceous material is transferred from a combustion step to the gas-producing step, the gaseous products of combustion amounting to about 880 cubic metres per hour, measured at room temperature and pressure, at a temperature of 1050° C. were led to the base of a 2'9'' internal diameter by 3'0'' long vessel and into the top of the vessel there were fed mullite balls of $\frac{5}{8}$'' diameter at the rate of 1100 kilograms per hour. In passing countercurrently to the mullite balls the gaseous combustion products were cooled to 240° C. and the mullite balls were heated from about 100° C. to 950° C. The mullite balls leaving the bottom of the vessel were passed by gravity through a 3'' bore pipe, 30'0'' long to a second vessel of 2'0'' diameter by 5'6'' long down which they flowed under gravity. Air at atmospheric temperature was fed, at the rate of 860 cubic metres per hour, measured at room temperature and pressure, into the bottom of the second vessel and was withdrawn from the top of this vessel at a temperature of 900° C. and led to the combustion step of the process. The mullite balls leaving the bottom of the second vessel had been cooled to about 120° C. and were returned to the top of the first vessel by means of a mechanical elevator.

The heat recovered in this way was absorbed in the combustion step by increasing the amount of particulate coke and ash fluidised per unit quantity of the air fed to the combustion step and the heat recovered was thus made available for producing water gas when the hot particulate coke was transferred to the gas-producing step in which the hot solids were brought into contact with steam.

With the heat thus recovered 88% of the total heat liberated in the combustion step was made available to the process.

The method of the present invention is particularly advantageous in the processes hereinbefore described, as the heat exchange apparatus does not become fouled with dust contained in the gaseous combustion and reaction products and as it is perfectly continuous and in consequence avoids disturbances in the flow of the gaseous reactants through the plant, thus ensuring smooth operation of such processes.

The term "gas" as used in this specification and/or in the appended claims is to be understood to mean substances which are gaseous

under normal conditions of temperature and pressure, normally liquid substances in vaporised form, and mixtures of these.

I claim:

1. In processes for the carbonization and gasification of particulate solid carbonaceous material by interacting gas with hot particulate carbonaceous material maintained in the fluidized state, said hot particulate carbonaceous material being partially burnt in a combustion zone by subjecting it to the action of an oxygen-containing gas at a rate sufficient to maintain the particles in the fluidized state and to give the desired rate and degree of combustion, then being passed to at least one of a carbonization zone wherein there is maintained a fluidized mass of particulate carbonaceous material being carbonized, and a gasification zone in which a fluidized mass of particulate carbonaceous material is being gasified by interaction with gas, the method of recovering heat which comprises passing hot gaseous products from a step of the process upwardly through the upper vessel of a first set of pebble-heaters, passing a mass of solid material in the form of pebbles downwardly under gravity through said first set of pebble-heaters, passing a gas upwardly through the lower vessel of said first set of pebble-heaters and then to a gas producing step of the process other than the combustion step, elevating pebbles from the bottom of said first set of pebble-heaters to a hopper above its upper vessel, passing at least some of the pebbles from said hopper into said upper vessel of the first set of pebble-heaters and the remainder into the upper vessel of a second set

of pebble-heaters, passing hot gaseous products from a step of the process upwardly through the upper vessel of said second set of pebble-heaters, passing a mass of solid material in the form of pebbles downwardly under gravity through said second set of pebble-heaters, passing an oxygen-containing gas upwardly through the lower vessel of said second set of pebble-heaters and then to the combustion step of the process, elevating pebbles from the bottom of said second set of pebble-heaters to a hopper above its upper vessel, passing at least some of the pebbles from said hopper into said upper vessel of the second set of pebble-heaters and the remainder into the upper vessel of the first set of pebble-heaters.

2. A process as recited in claim 1 in which the oxygen-containing gas is air.

3. A process as recited in claim 1 in which the exchange of pebbles between the sets of pebble-heaters is continuous.

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