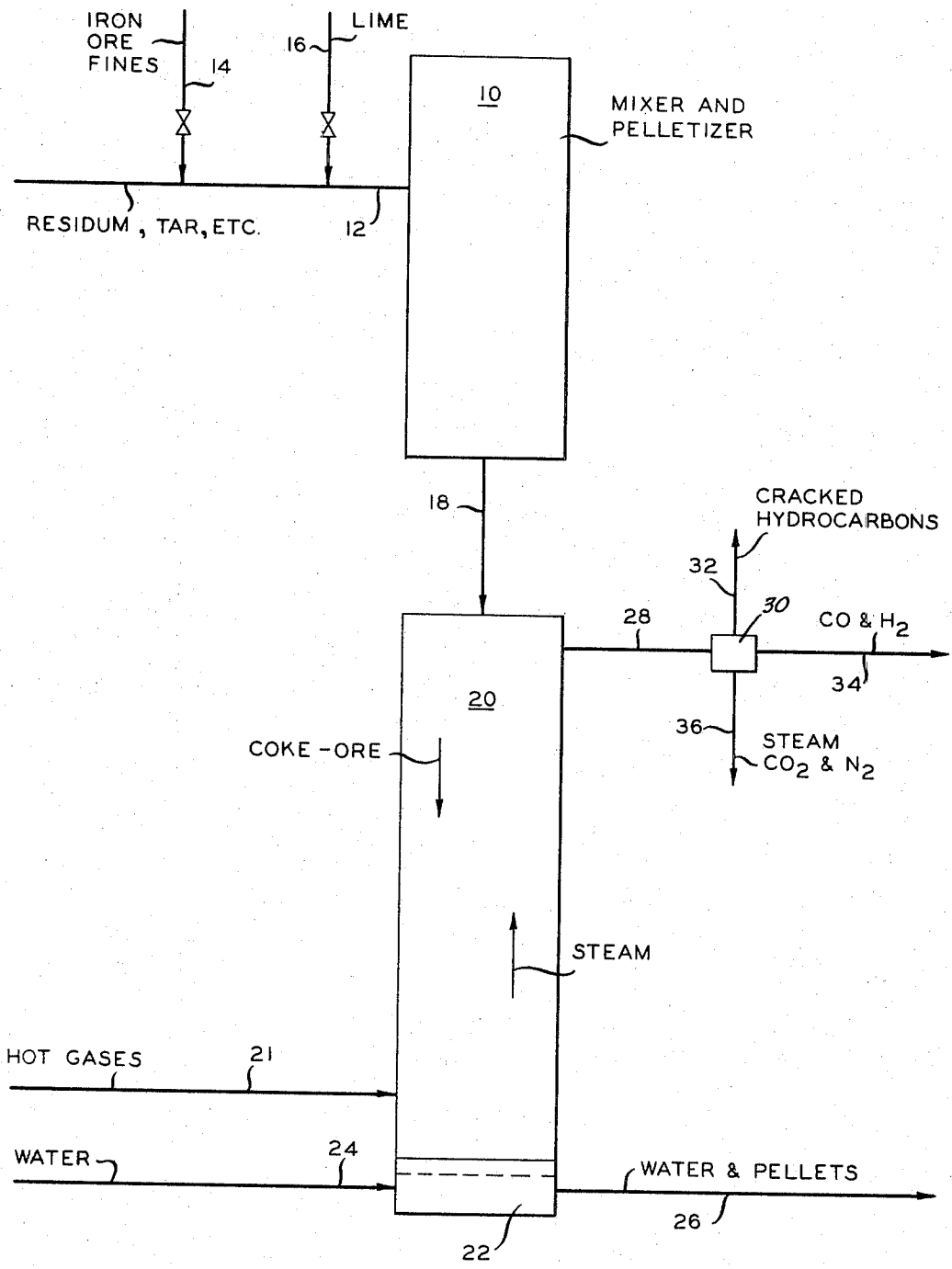
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PELLETING IRON ORE FINES

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PELLETING IRON ORE FINES

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ABSTRACT OF THE DISCLOSURE

Iron ore is admixed with heavy hydrocarbon coke-producing material such as residuum, pitch, or asphaltenes, to which lime may be added, and the resulting mixture in pellet form is coked at a temperature in the range of about 800 to 2000° F. under cracking conditions in a reducing ambient to produce beneficiated iron ore. The hot coked pellets are cooled with water in the bottom of the coking tower and the resulting steam ascends the tower to provide CO and H by reaction with the hydrocarbon material and/or coke in the pellets.

This invention relates to a process for producing pellets of iron ore fines and coke in which the iron ore is partially reduced or beneficiated.

The conventional method for the production of iron comprises mixing iron ore, limestone, and metallurgical coke and feeding the mixture to the top of a blast furnace. Molten iron and slag are separately recovered from the bottom of the furnace. The metallurgical coke employed is of high strength so as to support the charge without crushing and thus give sufficient porosity to the reaction bed for blasting.

Iron ore deposits exist in proximity to petroleum fields but remote from coal deposits which might provide coke for the manufacture of iron.

This invention is concerned with a method or process for utilizing petroleum residues and heavy coke-forming hydrocarbons in preparing beneficiated iron ore for smelting.

Accordingly, it is an object of the invention to provide a process for forming beneficiated iron ore pellets or briquets containing adequate coke produced from heavy hydrocarbon materials in sufficient quantity for smelting, with or without the incorporation of lime therein. Another object is to provide a process for making such pellets or briquets which utilizes relatively cheap hydrocarbon materials as the coke-forming agent. A further object is to provide a process for beneficiating an iron ore and simultaneously forming coked pellets or briquets thereof while preventing formation of fines from the pellets or briquets. Other objects of the invention will become apparent to one skilled in the art upon consideration of the accompanying disclosure.

A broad aspect of the invention comprises forming a mixture of heavy hydrocarbon material having coke forming properties and iron ore fines, gravitating the resulting pellets or briquets thru an ascending stream of hot combustion gas including CO and H_2 so as to crack the heavy hydrocarbon to coke and lighter hydrocarbons, gravitating the coked hardened pellets into a mass of liquid so as to cool the pellets without forming fines thereof, and recovering the cooled, hardened, and coked pellets from the liquid. The preferred liquid is water since gravitating the hot coked pellets into water produces steam which ascends the coking tower and reacts with the hydrocarbon material to form CO and H_2, this in turn reducing a portion of the iron ore in the pellets. The temperature in the coking zone is maintained at cracking and coking temperatures in the range of 800 to 2000° F. and preferably above 1200° F. Pressures in the range of 0 to 50 p.s.i.g. are maintained in the coking zone. Hot combustion gases produced from any suitable source are fed

into the lower section of the coking zone at sufficiently high temperatures in said range to maintain cracking and coking conditions.

A moving stream of liquid, such as water, is passed thru the bottom section of the coking tower so as to cool the pellets or briquets and carry same to suitable recovery means for separating the liquid from the coked pellets. Light hydrocarbon oils may also be used as the liquid in the bottom of the coking tower. In this event, sufficient steam and/or CO and H_2 must be introduced with the combustion gas to provide substantial reduction of the iron ore to beneficiate the same. Lime in flux providing proportions is preferably introduced to the iron ore and heavy hydrocarbon mixture prior to or during the pelleting or briqueting step.

A more complete understanding of the invention may be had by reference to the accompanying drawing which is a flow sheet illustrating a preferred embodiment of the process. A mixer and pelletizer **10** is supplied with heavy hydrocarbon coke-producing material such as residuum, tar, pitch, or asphaltenes, iron ore fines, and lime (when desired) thru line **12**, the iron ore fines being introduced to line **12** thru line **14** and the lime being added thru line **16**. Vessel **10** may be any type of mixer and pelletizer, this piece of equipment being commercially available. The proportions of the various ingredients of the pellets required for the process are well known in the art and are set forth in U.S. Patents 3,072,474 and 3,097,156. It is preferred to form the pellets at least ¼" and up to 2" in size.

The pellets or briquets formed in apparatus **10** are passed via line **18** into a coking tower **20** and there gravitated thru the tower in contact with an ascending stream of hot combustion gases introduced thru line **21** at a temperature sufficient to maintain cracking and coking conditions such as in the range of 800 to 2000° F. and at a pressure in the range of 0 to 50 p.s.i.g. Sufficient CO and H_2 are present in the coking zone to effect substantial reduction of the iron ore and sinter same to form hard coked pellets.

The coked and sintered pellets are gravitated into the bottom section **22** of tower **20** thru which a stream of liquid is passed from line **24** to line **26**, maintaining a mass of water in section **22** for receiving the gravitating pellets or briquets from the coking zone. Any conventional method of maintaining a liquid level in section **22** near the top of this section may be utilized, such as a liquid level controller (not shown). It is also feasible to operate a submerged conveyor in the form of a perforate belt in the bottom of section **22** for removing sintered and partially reduced iron ore pellets.

Effluent gases and vapors are removed from the upper section of tower **20** via line **28** and are passed thru conventional separation means **30** so as to recover cracked hydrocarbons thru line **32**, CO and H_2 thru line **34**, and other gases such as steam, N_2 and CO_2 thru line **36**.

When utilizing water as the cooling medium in the bottom of tower **20**, a substantial amount of steam is formed as the hot coked pellets enter the cooling water and this steam ascends the tower where it reacts with a portion of the coke to form CO and H_2 in accordance with the well known watergas reaction. These gases (CO and H_2) have a reducing effect on the ore in the pellets, causing reduction and sintering thereof to further harden the pellets and beneficiate the iron ore. When utilizing a liquid other than water, such as oil, in section **22** to receive the gravitating pellets, it is advantageous to recycle CO and H_2 from line **34** to line **21**. This may also be done even though water is used as the cooling liquid in section **22** of the tower.

To illustrate the invention, 160 pounds of residuum having a 300° F. ring and ball softening point is admixed

with 200 pounds of iron ore fines (Fe_3O_4) and pelleted in mixer **10** at 325° F. The pellets are cooled in line **18** to about 100° F. and gravitated thru tower **20** under retarded flow conditions caused by ascending combustion gases introduced thru line **21** at a temperature of about 2000° F. so as to heat the pellets to about 1800° F. About 1800 pounds of sintered partially reduced iron ore (Fe_3O_2) fall into the mass of water in the bottom of the tower and are recovered in line **26** with subsequent separation from the water therein. The steam produced by the cooling of the pellets in the quench water rises thru the tower to react with the coke in the pellets, producing CO reducing gas.

Certain modifications of the invention will become apparent to those skilled in the art and the illustrative details disclosed are not to be construed as imposing unnecessary limitations on the invention.

I claim:

1. A process for producing partially reduced iron ore and coke pellets which comprises the steps of:

(1) mixing iron ore fines and heavy coke-forming hydrocarbon in proportions to form pellets;

(2) forming pellets of the mixture of step (1);

(3) gravitating the pellets of step (2) thru a coking zone in an ascending stream of hot combustion gas so as to maintain a temperature in said zone in the range of 800 to 2000° F., thereby cracking said hydrocarbon to form coke and lighter hydrocarbons;

(4) producing hard pellets of coke and iron ore in the coking zone of step (3);

(5) gravitating the pellets of step (4) directly from the coking zone into water to cool said pellets and form steam;

(6) passing the steam formed in step (5) upwardly thru said coking zone so as to react with a portion of the coke in said pellets to form CO and H_2, said CO and H_2 effecting partial reduction and sintering of iron ore in said pellets; and

(7) recovering the cooled pellets from step (6).

2. The process of claim **1** wherein the heavy hydrocarbon is selected from the group consisting of residuum, tar, pitch, asphaltenes, and mixtures thereof.

3. The process of claim **1** including the step of incorporating lime in the pellets in steps (1) and (2) in fluxing proportions.

4. The process of claim **1** including the steps of:

(8) recovering a gaseous stream from the upper section of the coking zone;

(9) separating hydrocarbons from the stream of step (8) as a product of the process; and

(10) recycling at least a portion of the remaining gases from step (9), including CO and H_2, to the coking zone.

5. A process for producing partially reduced iron ore and coke pellets which comprises the steps of:

(1) mixing iron ore fines and heavy coke-forming hydrocarbon in proportions to form pellets;

(2) forming pellets of the mixture of step (1);

(3) gravitating the pellets of step (2) thru a coking zone in an ascending stream of hot combustion gas, including CO, H_2, and steam, at a cracking and coking temperature in the range of 800 to 2000° F. so as to produce lighter hydrocarbons and hard pellets containing coke and partially reduced iron ore;

(4) gravitating the pellets from the coking zone of step (3) into a mass of water to cool said pellets and form steam while avoiding formation of fines;

(5) passing the steam formed in step (4) upwardly thru said coking zone to react a portion thereof with said coke to provide CO, H_2, and steam for step (3); and

(6) recovering cooled pellets from step (4).

6. The process of claim **5** including the steps of:

(7) recovering the lighter hydrocarbons of step (3);

(8) recovering CO and H_2 formed in step (3); and

(9) recycling the CO and H_2 from step (7) to step (3).

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