

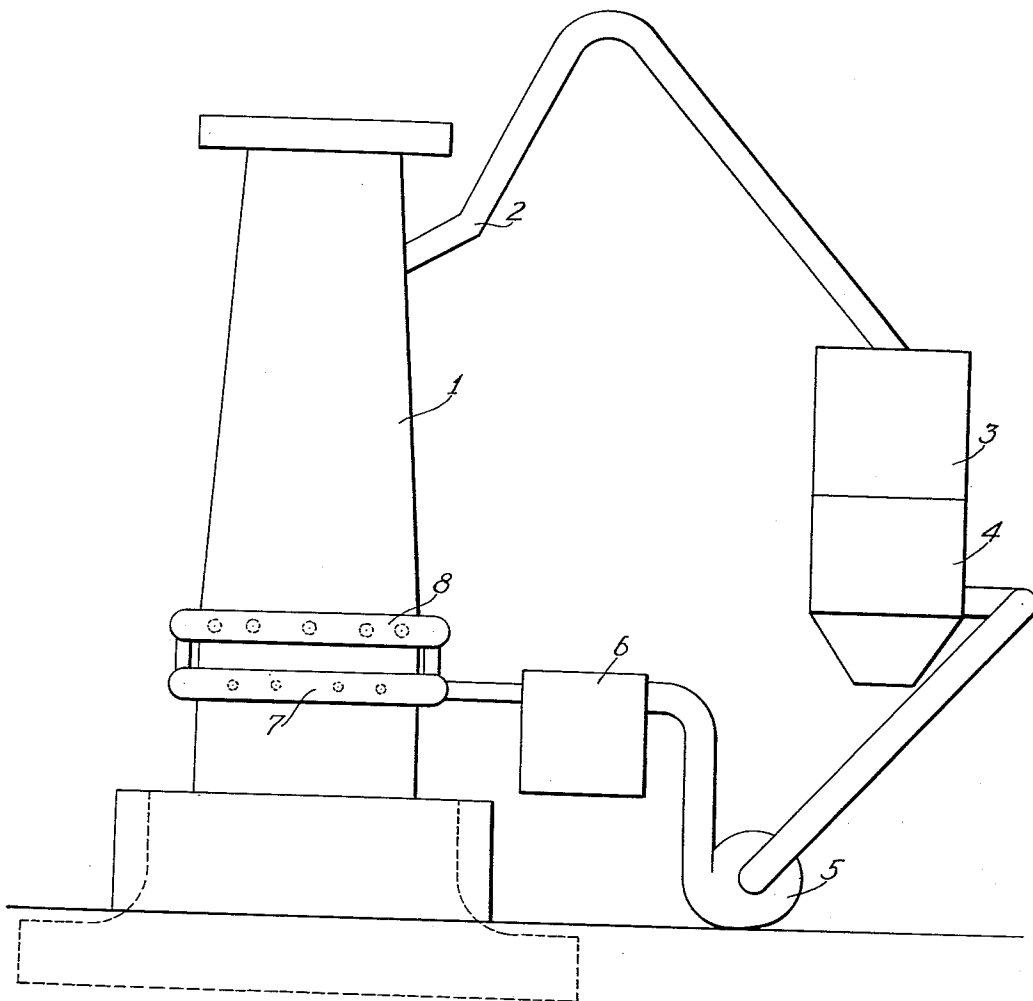
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METHOD OF TREATING IRON ORE BLAST FURNACES

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METHOD OF TREATING IRON ORE BLAST FURNACES

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2 Claims. (Cl. 75—41)

The present invention relates to a method of operating a blast furnace in the manufacture of iron from iron ore.

In the operation of blast furnaces following conventional procedures, iron ore, limestone and coke are charged into the blast furnace. The coke is burned by injecting air through tuyeres into the blast furnace. This produces CO and CO₂ which latter gas reacts with other coke to provide more CO. The CO reduces the iron ore to metallic iron. The materials entering the furnace and the materials leaving the furnace have the following approximate proportions:

Materials entering the furnace

	Tons
Iron ore.....	2
Coke.....	1
Limestone.....	½
Oxygen.....	0.8
Nitrogen.....	3.2
	7.5

Materials leaving the furnace

	Tons
Pig iron.....	1
Slag.....	½
Burned gases.....	2.8
Nitrogen.....	3.2
	7.5

It will be seen from the foregoing that nitrogen makes up almost one-half of the materials entering the furnace. The nitrogen has no function, and, since it represents a large volume of material that must be heated, it retards the operation of the furnace and increases not only the cost of operation but the initial cost of the plant.

The principal object of the present invention is to provide a procedure for operating blast furnaces whereby the disadvantages and waste inherent in conventional procedures are eliminated.

Another object of the invention is to provide a method of operating blast furnaces wherein improved reducing conditions in the blast furnace are encountered.

Other objects will be apparent from a consideration of the following specification and claims.

The novel process of the present invention comprises injecting a blast gas containing at least about 25% of oxygen into the high temperature zone of the blast furnace to burn and heat coke in the blast furnace to incandescence, injecting water vapor into the high temperature zone of the blast furnace, reacting said water vapor with said incandescent coke to form hydrogen (H₂) and carbon monoxide (CO) and reducing iron ore in said blast furnace to metallic iron by means of said hydrogen and carbon monoxide, the proportion of said steam to the oxygen in said blast gas being controlled to maintain the

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temperature in the blast furnace at normal blast furnace operating levels.

In the drawing Figure 1 represents a diagrammatic view of an apparatus which may be employed in carrying out the process of the present invention.

By the process of the present invention, nitrogen as one of the materials entering the blast gas may be substantially reduced or eliminated altogether. With a blast gas containing about 25% oxygen, for example, the increase in oxygen over the use of air alone is about 25% and hence, the reduction in the amount of nitrogen over the use of air alone is correspondingly about 25%. The oxygen content of the blast gas employed may range from the figure set forth above up to 100% as in the case where pure oxygen is employed in which case the nitrogen is eliminated altogether. Preferably, the amount of oxygen in the blast gas is at least about 40%.

The combustion of coke by means of a gas containing at least about 25% of oxygen is highly exothermic and it is this fact which would ordinarily lead to unduly high temperatures in the blast furnace, which has discouraged attempts to use a gas more concentrated in oxygen than ordinary air as the blast gas in the operation of a blast furnace. It has been found, however, that the simultaneous injection of substantial amounts of water vapor into the high temperature zone of the blast furnace has a marked controlling effect over the temperatures produced. The reaction between water vapor and incandescent coke (carbon) to produce hydrogen and carbon monoxide is highly endothermic. Hence, in accordance with the present invention, water vapor is also injected into the blast furnace, at the high temperature zone thereof, in conjunction with the high oxygen-containing blast gas to prevent the temperatures which would ordinarily be provided by the combustion of the coke by means of the high oxygen-containing blast gas from exceeding normal blast furnace operating levels. Thus, the amount of steam employed may vary widely depending upon the concentration of oxygen in the blast gas. In general, when the concentration of oxygen in the blast gas is on the order of about 25%, the concentration of water vapor in the blast gas should be at least about 12 grains per cubic foot of blast gas. The normal water vapor content of any air that may be employed will be taken into consideration in selecting the total amount of water vapor injected.

To the large extent that the amount of nitrogen admitted to the blast furnace in accordance with the present invention is reduced, or even substantially eliminated altogether, marked improvement over prior practice is obtained. The reduction in the amount of nitrogen means less inert material that must be heated in the blast furnace, and also less inert gaseous material to provide a diluent effect retarding reactions taking place in the blast furnace.

A further advantageous feature of the present invention is the production of hydrogen through the reaction of the injected water vapor with the coke. Hydrogen gas is a very active reducing agent. Because of its small molecular size, its high molecular velocity and its low viscosity as a gas, it has the ability to permeate solids, such as iron ore, to a much greater extent and more rapidly than other gases, including carbon monoxide, the reducing agent normally relied upon in the production of iron. Hence, the presence of hydrogen in the reducing gases as provided by the process of the present invention effectively increases the surface of iron ore contacted and results in a more efficient process.

The oxygen concentration of the blast gas may be provided by adding oxygen to air. As the concentration of oxygen in the blast gas increases, the proportion of air therein that may be employed is correspondingly reduced.

The oxygen may also be provided by other oxygen-containing materials. For example, hydrogen peroxide solution may be relied upon to supply both oxygen and water vapor.

In accordance with a further feature of the present invention, the gases issuing from the top of the blast furnace which contain carbon monoxide and hydrogen are recirculated to the blast furnace. Such recirculated gases are introduced into the high temperature zone of the furnace through the tuyeres. Additional water vapor and oxygen are added to the recirculated gases.

Moreover, a portion of the recirculated gases can be burned for preheating the remainder of the gases to a high temperature before injection back into the blast furnace.

The conventional blast furnace gas possesses the following approximate composition by volume:

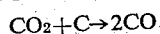
	Per cent
CO ₂ -----	11.5
CO -----	27.5
H ₂ -----	1
H ₂ O -----	2
N ₂ -----	58.0

A typical blast furnace gas obtained according to the process of the present invention has the following composition by volume:

	Per cent
CO ₂ -----	15
CO -----	72
H ₂ -----	2
H ₂ O -----	2
N ₂ -----	2

The conventional blast furnace gas illustrated above has a calorific value of about 790 KCal per m³ while the blast furnace gas obtained in accordance with the present invention as illustrated above has a calorific value of 2500 KCal per m³.

The carbon dioxide (CO₂) contained in the blast furnace gases and recirculated in accordance with one embodiment of the present invention reacts with the coke to supply further carbon monoxide as follows:



This reaction is also endothermic and will have a cooling effect in the blast furnace, so that this cooling effect may be taken into consideration in determining the amount of water vapor added to the recirculated gases.

While the decomposition of the H₂O (and CO₂ in the recirculated blast furnace gases) requires an additional amount of heat at the tuyeres, this is partially compensated for by the fact that a smaller weight of total gases must be heated due to the substantial reduction in the amount of nitrogen.

Referring to the drawing, Figure 1 is a diagrammatic illustration of an apparatus including a blast furnace which may be employed in carrying out the process of the present invention. 1 represents a conventional blast furnace. 8 represents tuyeres through which the oxygen-containing blast gas necessary to support combustion of the coke in the blast furnace is admitted to the blast furnace. 7 represents tuyeres through which vaporized water or hydrogen peroxide solution is admitted to the blast furnace for reaction with the coke therein to produce hydrogen and carbon monoxide. 2 represents a conduit through which the blast furnace gases are conducted to a dust separator 3 and a humidifier 4. 5 is a fan by which the humidified blast furnace gases are forced through preheater 6 and tuyeres 7 back into the blast furnace.

In carrying out the process of the present invention, the blast furnace 1 is charged with the usual charge ingredi-

ents including iron ore, coke and limestone. The coke is burned and heated to incandescence, being blasted by the oxygen-containing blast gas admitted through tuyeres 8. Water vapor is simultaneously admitted through tuyeres 7 into the charge where it reacts with the incandescent coke producing highly reducing hydrogen and carbon monoxide gas. The endothermicity of the reaction between the water vapor and the coke maintains the temperatures provided through the use of the oxygen-containing blast gas at conventional operating levels which are normally at about 2900-3100° F. at the high temperature zone slightly above the top of the tuyeres. The blast furnace gas issuing from the top of the charge is conveyed through the conduit 2 to a dust separator 3 where the dust is removed. The cleaned gas is then conducted to humidifier 4 wherein the required amount of water vapor is added. As stated, hydrogen peroxide solutions may be relied upon to supply both water vapor and oxygen and this material may be injected into humidifier 4. The thus humidified gas is then forced by means of fan 5 through heater 6 in which a portion of the gas is burned for preheating the remainder of the gas. The preheated gas is then injected through tuyeres 7 back into the blast furnace, where the water vapor and carbon dioxide reacts with the incandescent coke.

In operating in accordance with the preferred embodiment of the present invention wherein the gases are recirculated and preheated by combustion of a portion thereof, the hot stoves of the Cowper or other types are unnecessary since the gases charged to the furnace will be hot, and contain water vapor which in conjunction with the oxygen admitted controls the temperature at the desired level.

Since the weight and volume of gas travelling upwardly through the blast furnace are reduced by the reduction in the amount of nitrogen, it is possible to employ finer charges. By this arrangement, the ore may be pulverized to smaller particles thus exposing greater surface area for the reactions.

Considerable modification is possible in the selection of the materials added to the blast furnace in conjunction with the water vapor and oxygen, as well as in the amount of water vapor and oxygen, and also in the particular procedure employed without departing from the scope of the present invention.

I claim:

1. The method of operating a blast furnace in the manufacture of iron from iron ore which comprises injecting a blast gas comprising at least about 25% of oxygen into the high temperature zone of a blast furnace to burn and heat coke therein to incandescence; injecting water vapor into the high temperature zone of the blast furnace, reacting the water vapor with incandescent coke therein to produce carbon monoxide and hydrogen, reducing iron ore in said blast furnace by means of said carbon monoxide and hydrogen, the proportion of water vapor to oxygen injected into the blast furnace maintaining the temperatures in the blast furnace at blast furnace operating levels, removing the resulting blast furnace gas from the top of said blast furnace, adding water vapor to said gases and recirculating said gases to the blast furnace for further injection thereof into the blast furnace.

2. The method of claim 1 wherein a portion of said recirculated gases is burned to preheat the remaining gas before introduction to the blast furnace.

References Cited in the file of this patent

UNITED STATES PATENTS

1,742,750	Bradley -----	Jan. 7, 1930
2,290,192	Karwat -----	July 21, 1942
2,560,471	Platon -----	July 10, 1951
2,593,257	Bradley et al. -----	Apr. 15, 1952