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OPERATION OF FURNACES

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This invention relates to the operation of furnaces and more particularly to the operation of vertical shaft furnaces of the blast furnace type as used in the manufacture of iron.

In present blast furnace practice the materials consisting of ore, coke and limestone are charged at the top and a hot blast of air is blown in at the bottom into the hearth through a number of tuyères. The hot blast is generally heated from 1000° to 1300° F., average temperatures above 1300° being the exception. Higher temperatures than 1600° F. have never been used, to my knowledge. It is today possible to generate blast temperatures considerably above these points but it is not possible to use these temperatures practically. In fact, even the temperatures about 1300° F. have not been successfully used over extended periods of time. The reason for this is that the furnace, to use the operator's term, refuses to take the heat, which means that the blast pressure unduly increases as the additional heat is applied, the movement of the charges is slowed down, becomes intermittent, and entirely stops as the furnace begins to hang. Such stops are followed by violent slips which are generally forcibly brought about by the momentarily taking off of the wind, which practice is necessitated by the danger of serious damage to the furnace if the stock falls too far at one time.

Various reasons have been advanced for the phenomenon of the furnace in taking the heat. It is my belief that the most important reason is that the expansion of the blast, occasioned by its additional temperature, together with the accelerated combustion due to increased affinity between carbon and oxygen, releases such an increased volume of gases per second that there is no room in the crowded hearth for its prompt release into the upper regions.

It is an object of the present invention to provide a method of furnace operation whereby the fuel consumption is lowered and furnace production increased without change in furnace size.

It is a further object to utilize more fully the heat value of the outgoing gases in the blast furnace process itself by returning the greater portion of such heat value into the hearth of the furnace for obtaining higher blast temperatures.

It is an additional object to operate the furnace in a manner to prevent hanging and sticking of the furnace charge with the consequent disturbances of the furnace operation.

It is also an object to provide a method of operation whereby the air blast may be enriched with oxygen and the reducing power of the furnace gases may be increased with hydrogen.

It is a further object to provide a method whereby water or water vapor may be introduced with the hot blast air.

It is an additional object to provide a method whereby easily adjustable means are given for the operator to regulate hearth temperatures.

Other and further objects will appear as the description proceeds.

My invention comprises the introduction of water, water vapor, or steam with the blast, and I have found that this method of operation serves to counteract the tendency of a furnace to refuse to take the heat when high temperatures are used. Normal movement of the furnace can be quickly reestablished by this means.

On the other hand, the admission of steam through the tuyères cools off the hearths and for this reason cannot be relied upon in operating usual furnaces with usual hot blast stove construction. Through improvements in hot blast stove construction, for which I and others have recently been granted Letters Patent, very high blast temperatures can be maintained. Included among these patents are the following: Brassert et al., 1,771,286, July 22, 1930; Andrews et al., 1,771,282, July 22, 1930; Andrews, C. W., 1,771,242, July 22, 1930; Grilli, et al., 1,815,905, July 28, 1931; Hulse, A. J., 1,771,298, July 22, 1930.

There is no difficulty with these constructions in increasing the blast temperatures up to 2000° F. and considerably higher as the gas and combustion air are both preheated. By the use of these high blast temperatures it is possible to introduce a certain amount of steam or water at the tuyères and still maintain the necessary temperature in the hearth. Whether steam or water is used depends on the amount of blast heat available. The effect of the injection of water or steam is to produce water gas and oxygen in the hearth of the furnace. The effect of the introduction of water or steam in the hearth is the immediate disassociation of the H_2O, which makes available oxygen for increased combustion and hydrogen for increased reduction. It has been found that hydrogen is a very efficient reagent in the reduction of oxides which are not easily reduced by CO in the time and space given in the upper portion of the furnace.

The use of hydrogen has one other advantage when used as a reducing agent. The carbon in the upper part of the stack is not attacked by hydrogen gas. In the usual furnace practice

where carbon monoxide is used as a reducing agent a certain amount of solution loss, or carbon absorption, takes place in the upper portion of the furnace column. If hydrogen displaces a portion of the carbon monoxide as a reducing agent, the solution loss will be prevented in proportion to the quantity of hydrogen employed. The substitution of hydrogen for a portion of the carbon monoxide will therefore provide a greater quantity of carbon for combustion before the tuyères of the furnace than would otherwise be obtained if hydrogen were not employed.

The introduction of water vapor at the hearth of the furnace provides a means for the introduction of hydrogen and oxygen at the tuyères without the accompaniment of the usual quantity of nitrogen. The use of oxygen admitted in the form of steam precludes the introduction of nitrogen with this oxygen. This condition will increase the intensity of the zone of combustion due to the fact that a portion of the inert nitrogen is eliminated from the hearth area.

The result is an increased rate of carbon consumption in the tuyère area. Since the rate of production of a blast furnace is a function of the hourly rate of coke consumption at the tuyères and of the coke consumption per ton of iron, it is evident that by this means an increase of production can be attained, which is limited only by the amount of H_2O, the amount of aqueous addition permissible with the blast temperatures that are available.

A very great advantage of this method of operating blast furnaces is that the operator has immediate control of the hearth temperature without jeopardizing the economy of the process. At the present time this temperature is controlled by a variation in blast temperature for immediate results and by changing the ore burden for ultimate results. If an increase in the hearth temperature is desired, the blast temperature is increased and the ore burden is decreased. Both of these changes result in increased fuel consumption due to direct and indirect causes. If given quantities of steam and water are added through the tuyères under normal conditions and the furnace goes cold, the amount of water introduced into the tuyères is temporarily decreased. This does not affect the blast furnace burden in the slightest, nor does it affect the blast practice. It therefore causes much less of a disturbance than changes which now have to be practiced.

Another advantage of my method is that a much greater use is made of the blast furnace gases in the process itself. Economical conditions have shaped themselves in such a manner that this is of considerable importance. The general adoption of by-product coke ovens in connection with steel plants has been available large quantities of coke oven gas. Natural gas is coming into many centers which will replace surplus coke oven gas sold to communities by the steel industry. Furthermore, means have been devised by the much more economical use of these gases for heating and melting and other purposes resulting in an increased surplus of furnace gases which cannot be economically disposed of. By using these gases to impart additional heat to the hot blast and bring the same back into the furnace process, the furnace process becomes more nearly self-contained with the result that it requires less coke and smaller size apparatus for the same results. It is rendered more independent of collateral industries to use up its valuable gases.

It will be understood that the aqueous fluid will be introduced with the heated blast air continuously in the normal furnace operation according to the present method. The quantity of such aqueous fluid may be varied as the conditions of operation may require. The aqueous vapor may be introduced at high temperatures and may be passed through hot blast stoves or similar heat exchange apparatus in order to raise it to the heat desired for operation. The vapor may join the air in the stoves or may be admitted at the tuyères and there mixed with the hot blast air.

While certain preferred methods of carrying out my invention have been specifically described, these are to be understood as illustrative only as my invention is capable of change and modification to meet varying conditions and requirements, and I contemplate such changes and modifications as come within the spirit and scope of the appended claims.

I claim:

1. The method of shaft furnace operation in the reduction and smelting of iron ores which comprises the preheating of air for combustion to a temperature in excess of 1300° F., and the introduction of said air into the hearth of the furnace together with a continuous flow of aqueous fluid.

2. The method of operating a blast furnace for reduction and smelting of iron ores and controlling the temperature in such furnace, which comprises introducing air preheated to a temperature in excess of 1300° F. into said furnace through the tuyères and introducing continuously with said air a controlled quantity of preheated aqueous fluid.

3. The method of operating a blast furnace for reduction and smelting of iron ores and introducing additional substantially nitrogen-free oxygen, which comprises introducing blast air heated to a temperature above 1300° F. through the tuyères and continuously introducing aqueous vapor to a portion of the furnace where the temperatures are such as to cause disassociation of water to liberate hydrogen and oxygen.

4. The method of operating a blast furnace for reduction and smelting of iron ores and introducing additional substantially nitrogen-free oxygen, which comprises introducing blast air heated to temperatures in excess of 1300° F. through the tuyères and introducing preheated aqueous vapor to a portion of the furnace where the temperatures are such as to cause dissociation of the water, the liberated hydrogen assisting in the reduction of the ore.

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