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METHOD OF PREHEATING THE CHARGE IN SHAFT FURNACES

Filed April 25, 1924

Fig. 1.

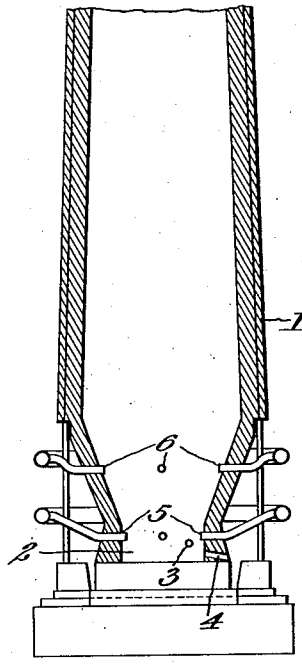
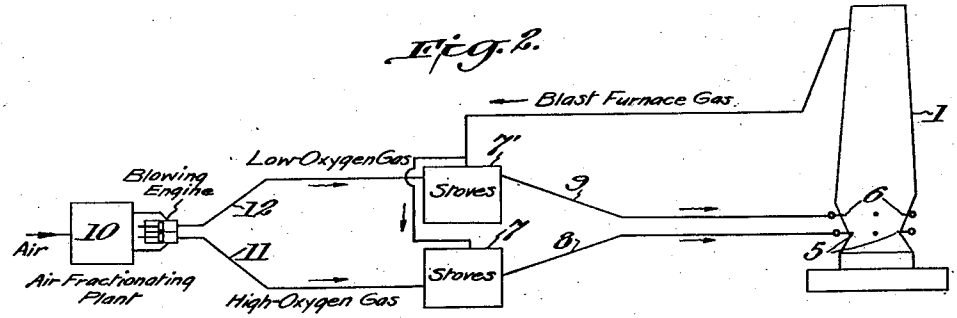


Fig. 2.



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METHOD OF PREHEATING THE CHARGE IN SHAFT FURNACES.

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This invention relates to metallurgical operations conducted in shaft furnaces, or the like, and comprises an improved method of preheating the charge in the furnace. The invention is particularly applicable in the blast smelting of iron ores. In the following description reference will therefore be made primarily to this use, but it is to be understood that the improved method is advantageous in other metallurgical processes.

In standard blast furnace practice the charge fed downwardly through the stack receives heat from two principal sources. These are the heat of combustion in the tuyère zone of the furnace and the heat of the air passing to the furnace from the preheating stoves. The latter source of heat is a very important factor in the proper working of the furnace. When air is supplied from the stoves at 600° C. or above, according to usual practice, its heat content may amount to 20% or more of the heat produced by combustion in the furnace. About 75% of the heat of the air blast is carried by the nitrogen which it contains. The weight of nitrogen passing through the furnace is approximately three times the weight of the iron produced. Nevertheless, the importance of the heating effect of this gas does not appear to have been accurately evaluated heretofore.

I have discovered that any material decrease in the nitrogen content of the air will result in a serious depletion of the thermal units available for preheating the charge. A failure to recognize this fact has been responsible for the difficulties encountered in the use of oxygen or oxygenated air in blast furnace practice.

Such proposals have been made at various times during the last twenty years. So far as I am aware, however, no continuous industrial use has been made of them. It is true that an oxygenated blast produces a higher reaction temperature in the smelting zone than is obtainable with an ordinary air blast, but the advantages of this higher temperature are largely discounted by the fact that the charge is fed into the smelting zone without sufficient preheating.

This defect is a necessary result of operating with an inadequate volume of hot gases ascending through the charge, which requires a very large amount of heat to bring it to the proper temperature. Heat supplied from combustion of coke or other source should raise the temperature of the burden (iron ore and flux) to about 1500° C., or above, before it enters the smelting region, if the furnace is to operate to the best advantage. The burden undergoes no strongly exothermic chemical reaction. The ore must ordinarily be dried, and the limestone flux calcined, in the shaft. The cooling effect of the descending charge is augmented by the water-cooling of the furnace in the tuyère zone.

A higher combustion temperature does not itself compensate for these heat losses, or insure proper preheating. By lowering the burden ratio (pounds of ore and flux to pounds of coke) the action may be improved somewhat, but such procedure is uneconomical. No substantial advantage is derived from an increased rapidity of descent of the charge, caused by quicker smelting. Any tendency in this direction is largely impeded by the greater heat absorbing capacity of the charge when fed at a more rapid rate.

In accordance with the present invention, difficulties arising from insufficient preheating are avoided by passing into the furnace, at a point or points above the smelting zone, a hot gas incapable of producing any substantial smelting of the charge.

Nitrogen, or nitrogen in admixture with some oxygen, is preferred, but other suitable gases or gaseous mixtures may be used. Considerable heat may be safely derived by the combustion of fuel in the charge by oxygen of the preheating gas. The carbon monoxid so generated is advantageous, as it assists in the reduction of the ore. In all cases, however, the oxygen content of that gas should be materially less than that of atmospheric air. An air blast at a point above the ordinary tuyère level is to be avoided, as coke would be needlessly consumed in large quantities and the resulting fusion of the charge above the lower tuyères would have serious disadvantages. By using a gas low in oxygen I am able to avoid these difficulties.

The preheating gas as it enters the furnace may contain some carbon monoxid or other reducing gases. However, I do not use top gases from the stack, nor other gases containing a high proportion of the oxids of carbon, for preheating the charge. Such gases are sometimes recirculated for the pur-

pose of assisting in the reduction of the ore, but their use is unnecessary in working the furnace by the present process. The preheating gas entering the furnace has low reducing power and high temperature, as compared with top gases.

The temperature of the preheating gas may vary considerably, but it is preferably, at least 600° C. Temperatures of 1000° C. or more are desirable in some circumstances.

In the accompanying drawings, illustrative of the invention,

Fig. 1 is a diagrammatic partial vertical section through a blast furnace provided with preheating means and

Fig. 2 is a diagram of a blast furnace plant using oxygenated air and a preheating gas rich in nitrogen.

Referring to Fig. 1, numeral 1 denotes the shaft of a furnace of usual type, having a hearth 2, cinder notch 3 and metal tap hole 4. Tuyères 5 are installed in the customary manner.

To carry out the purposes of this invention, one or more tuyères or sets of tuyères are provided, preferably above those already referred to. As illustrative, four tuyères 6 (of which three only are shown) are placed symmetrically somewhat above the tuyères 5. This location is deemed especially advantageous, as substantially the maximum preheating effect of the gases is obtained. However, the tuyères 6 may be otherwise arranged, if desired, both with respect to their level and to their circumferential position.

The preheating gas (nitrogen, nitrogen-oxygen mixture, or the like) is heated to the proper temperature in stoves and forced into the shaft under suitable pressure, say 12 to 15 lbs. per sq. in. The volume of preheated gas required may be readily determined theoretically for given conditions by means of published data familiar to those skilled in the art.

The smelting is preferably effected by heated air blown in through tuyères 5. However, the present invention is equally applicable to cold blast smelting. It has special advantages in connection with the use of an oxygenated blast, as hereinafter described in connection with Fig. 2.

In that figure, reference numerals 5 and 6 denote as before the tuyères respectively serving to introduce the smelting and preheating gases into the furnaces. Stoves 7, 7′ are respectively connected by pipe line 8 with tuyères 5 and by pipe line 9 with tuyères 6. While the stoves are indicated as units, it will be understood that subdivisions are provided, as well understood in the art, to permit the heating of one section while another is receiving the air passing to the furnace. A plant for preparing from air a fraction enriched in oxygen is indicated by numeral 10. This fraction is passed through pipe 11 to stoves 7 and thence to tuyères 5. The residual fraction of the air, containing a high proportion of nitrogen, is passed through pipe 12 to stoves 7′ and thence to tuyères 6. A blowing engine forces the air fractions to the stoves. A preheating gas is led to the stoves from the blast furnace stack as indicated or from some other suitable source.

Important improvements in the operation of the furnace are produced by this distributed introduction of the air. The temperature in the hearth and bosh regions is very high, owing to the augmented oxygen concentration of the smelting gas. Hence the rate of smelting, and consequently the rate of feed of the charge, is much increased. The charge is properly preheated by the non-smelting gas, so that the smelting takes place without the handicap of a cooling charge. The output of the furnace per unit weight of fuel consumed is materially raised by the new process.

There are also numerous incidental advantages inherent in the process. For example, it is practicable to use low grade ores or flux which can not be satisfactorily worked at the temperature of the ordinary hot air blast furnace. Further, the chemical and physical reactions in the furnace may be largely controlled by a judicious regulation of the entering gases.

It will be unnecessary to describe here a plant for producing oxygen-enriched air. Various means for obtaining this result are known. I generally prefer to have at least 30% of oxygen by weight in the smelting gas, but more or less may be used under particular conditions. If this gas is prepared from air, the residual gas will contain about 18% of oxygen, and is excellently suited for the preheating gas. The advantages of the invention, as described above, are in no way dependent upon the fractionation of air to which reference has been particularly made. Oxygenated and nitrogenated gas or the like may be obtained from any suitable source. The preheating gas, as well as the smelting gas, may be dried, if desired. While I regard the sensible heat of the gas blown in at the upper tuyère level as the primary source of heat, more or less heat may be generated by combustion at that level, as noted above.

As stated above, the invention is not limited to use in the smelting of iron. The general process described may be adopted in various other connections, with or without modification, and is therefore defined broadly in the appended claims.

I claim:

1. Process of preheating the charge in shaft furnaces, comprising passing a hot, non-smelting gas comprising an oxygen-nitrogen mixture in which the ratio of oxygen to nitrogen is less than that in atmos-

pheric air into the furnace above the smelting zone.

2. Process of preheating the ore-flux-carbon charge in a blast furnace, comprising passing a heated gas substantially non-reactive with the constituents of the charge into the furnace above the smelting zone.

3. Process of operating shaft furnaces, comprising passing into the charged furnace a gas adapted to produce the desired reduction reaction in the charge, and separately passing into the furnace another gas, comprising an oxygen-nitrogen mixture containing less oxygen than atmospheric air, but carrying sufficient heat to preheat the charge at least in part.

4. Process of operating shaft furnaces, comprising passing into the charged furnace a gas adapted to produce the desired reduction reaction in the charge, preheating another gas, comprising an oxygen-nitrogen mixture containing less oxygen than atmospheric air, and passing it in heat-interchanging relation to the charge.

5. Process of operating shaft furnaces, comprising passing the furnace charge downwardly in contact with an ascending current of a hot gas introduced into the furnace at a point above the site of the main reaction therein, said gas being substantially incapable of producing the desired reaction in the charge and comprising an oxygen-nitrogen mixture containing less oxygen than atmospheric air, and separately introducing adjacent to the base of the furnace a gas adapted to effect such reaction.

6. Process of operating blast furnaces for the smelting of ores, comprising passing into the charged furnace heated air divided into a plurality of fractions with different contents of oxygen, the portion high in oxygen passing to the smelting zone, and the portion low in oxygen ascending through the charge to preheat the same.

7. Process of operating blast furnaces for the smelting of iron ores, comprising passing into the charged smelting zone a gas containing a proportion of oxygen higher than that in atmospheric air, and passing through the bulk of the charge a hot gas containing a proportion of oxygen lower than that in atmospheric air and having low reducing power.

8. Process of operating blast furnaces for the smelting of iron ores, comprising preparing from air a gas containing a materially increased proportion of oxygen, passing said gas into the charged smelting zone of the furnace, preheating the residue of the air treated, and passing it through the charge, whereby the charge is heated to the proper temperature before entering the smelting zone.

In testimony whereof, I affix my signature.

ALEXANDER L. FEILD.