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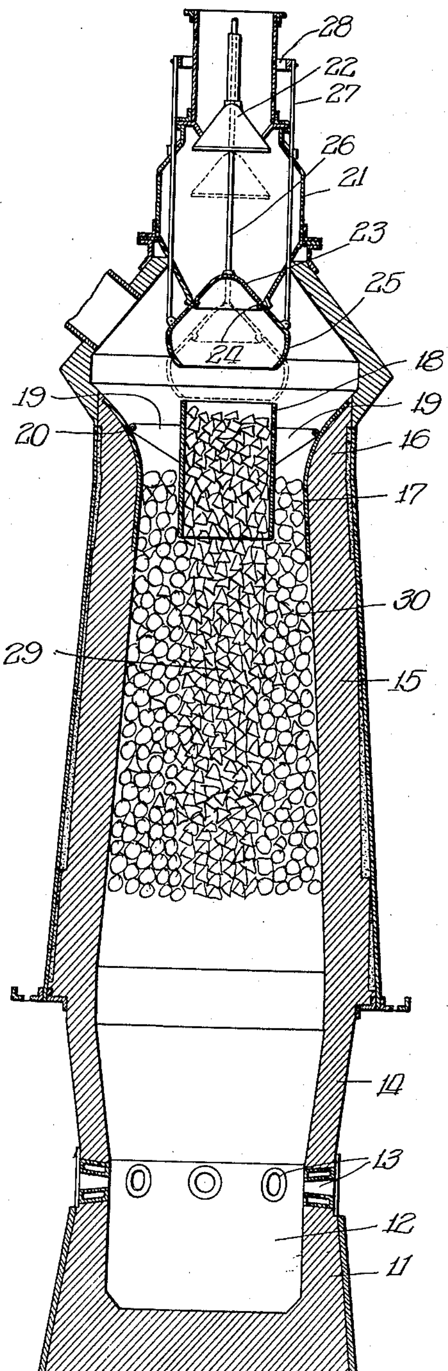

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METHOD OF OPERATING AN IRON BLAST FURNACE

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This invention relates to a new and improved method of operating an iron blast furnace and more particularly to the relative distribution of the components of the furnace charge. By my improved method economy in the use of raw materials is increased and the quality of the product is improved.

My present invention may be carried out by means of the apparatus described in my prior Patents Nos. 1,815,897, 1,905,679 and 2,155,927 or by the use of other apparatus capable of being operated so as to produce similar results in the selective distribution of the charge in the blast furnace.

This invention relates to the correction of certain conditions which occur in the majority of cases with regard to the materials making up a blast furnace charge or to minimize undesirable effects caused by such conditions. The furnace charge normally comprises ore or iron bearing material, fuel, generally coke, and fluxing material, most usually introduced as limestone. All of these materials vary with respect to qualities which affect their fitness for economic use in the blast furnace operation.

The iron ore may be very hard, with great powers of resistance to crushing and abrasion, or it may be a soft, earthy mass, the particles of which naturally separate down to a size which results in the condition known as mud if enough water is present, or as dust in its absence. The chemical composition of the ore may vary with respect to the form in which the iron itself occurs. The iron may be present as ferric oxide or ferroso-ferric oxide, as carbonate, or even as silicate.

If it is present as carbonate, the carbonate of iron is quite likely to be mixed with carbonate of lime, which also occurs in the ore. In some cases iron oxide as hematite is intimately mixed with quartz or other siliceous rock. Various means of concentrating ore are employed, all of which result in a reduction of the particle size of the ore. In many cases this reduction proceeds to a point where subsequent agglomeration is necessary, in order to avoid loss of ore through flue dust carried over by the furnace gases. This agglomeration is usually carried on by sintering, excepting in cases where the silica content is so high that the sintering operation is accompanied by formation of fayalite, in which case agglomeration by briquetting is preferable, since it leaves the silica free.

Coke as fuel varies but little in the general nature of its action within the furnace. Finely divided coke is objectionable, on account of the resistance which it presents to the passage of gases. There has also been much speculation with regard to the combustibility of coke, which is another way of expressing the volume of the space in front of the tuyères, within which the oxygen of the blast unites with the carbon of the coke. Basically, however, the action of coke within the upper portions of the furnace is merely that of providing an open structure through the voids within which the furnace gases may penetrate. The temperature of the coke gradually rises, and in the presence of gas containing a considerable quantity of CO_2 at a high temperature, a reaction CO_2 plus $C=2CO$ is known to occur. This action probably affects but little the size of the individual pieces of coke, which reaches the point where combustion occurs without further change. By means of this combustion the carbon of the coke is gasified, and the earthy materials which form the ash are released, generally in a fine state of division, and are projected inwardly and upwardly through the interstices of the coke, until they become entangled in the slag with which they coalesce, and of which they form a part. The distance from the point where dissolution of the coke occurs, at which silica or alumina may exist independently of the slag, has never been determined. It is possible that silica as a fume may go completely through the furnace without absorption. However, it seems probable that most of the coke ash unites with the slag within a comparatively short distance, for example, within ten feet of the tuyères.

Limestone or other similar fluxing material is generally scattered throughout the mass of the charge in such a way that it comes in contact in as intimate a way as its size permits with the ore and the coke. This intimacy of contact produces certain results which are detrimental to the economical carrying out of the blast furnace process. These results are due to the formation of primary slags known as ferrites, and composed of lime or similar material as a base, and of ferric oxide as the acid radical. These slags form at temperatures as low as 600 to 700° C. (1112 to 1292° F.). Their formation is maximum where lime and iron oxide exist side by side, as in certain calcareous spathic ores in which the contact is sufficiently intimate to permit chemical action as soon as the necessary temperature is attained. The formation of these slags results in a pasty or semi-liquid condition of a part of the charge at comparatively low temperatures.

A second form of primary slag which may be produced within the furnace is fayalite,

$$2FeO.SiO_2.$$

This forms at a temperature of about 1300° C. (2380° F.).

Any slag into which iron oxide enters is likely to be decomposed and the iron oxide removed by reduction as the temperature and the reducing power of the gases increase. In the case of the ferrites, any considerable removal of iron oxide will unquestionably result in an increased basicity, and in the presence of chemically unsatisfied lime, with a resulting increase in viscosity of the charge at the point where this reaction takes place. The only relief for this viscosity is in combination with silica. This silica may in some degree be furnished by the ore, but in the proportions required by the final slag, it can only be furnished by the ash of the coke. It will be apparent from the above statements that if slag in the form of iron ferrite forms at low temperatures, the charge will be partially liquefied by the slagging process which results in ferrite formation. It will further be apparent that dissolution of ferrites by decomposition and iron reduction may very probably occur due to increased temperature and reducing power of the furnace gases at a point above that at which the coke ash provides the materials necessary for restoration and further increase of the fluidity of the slag. Insofar as high blast temperatures are used, the residual heat from their employment increases the rate of dissolution of ferrite, and consequently, the interval of height within the furnace between the point of ferrite dissolution and that of full formation of slag from the ash of the coke. High blast temperatures therefore, under circumstances where lime and iron oxide may mix intimately, produce a local condition of existence of a previously formed slag, which has become locally and temporarily infusible and viscous, and which tends to prevent the free flow of material to the tuyères.

It is also true that decomposition of primary slags of silicate of iron, insofar as these slags exist, will occur as the reduction of iron proceeds. However, if such an action occurs, it will, in general, provide silica, of which a deficiency exists, so that no increase of viscosity or inability to employ high blast temperatures may be expected to result from this cause.

The usual method of filling the iron blast furnace consists in discharging ore, fuel and flux from a so-called bell, which has its vertical axis at the center of the furnace, and which discharges outwardly from the center of the furnace toward the walls. The result of this manner of charging is that the fuel, on account of its relatively great bulk, makes up the greater part of the charge and is present in all parts of the furnace. The ore, which makes up a comparatively small part of the volume of the charge, varies with respect to its radial distribution in accordance with its physical character and the size of the charge which is discharged from the bell at any one time. If the ore is physically fine, it will tend to segregate toward the outer part of the circle of the furnace top, since the bell deposits it there and fine material has relatively little lateral movement through rolling. If the ore is hard and coarse, it tends to follow more nearly the movement of the coke as the latter distributes itself in the furnace top. Limestone also has a movement similar to that of the coke. The consequence is that the coke, ore and flux are fairly well mixed with the ore and stone in close contact with each other.

It is an object of the present invention to provide a new and improved method of operating a shaft furnace and more particularly an iron blast furnace.

It is a further object to provide such a method by the use of which there is economy in the use of raw materials and improvement in the quality of the product.

It is also an object to provide a method of selectively charging and locating the constituents of the furnace charge in such a way as to avoid many difficulties inherent in the operation of furnaces charged in the usual manner.

It is an additional object to provide a method of furnace charging which permits the maximum possible use of blast introduced into the furnace at high temperatures.

Other and further objects will appear as the description proceeds.

I have shown in the accompanying drawing one form of apparatus adapted for carrying out the method of operation of the present invention.

The single figure of the drawing is a vertical transverse section through a blast furnace, comprising a base 11, hearth 12, tuyères 13, bosh 14 and shaft section 15. The upper portion of the shaft is shown as flared outwardly at 16 above the normal stock line, and is protected by stock line plates 17. A large distributing tube 18 is suspended in the upper portion of the stack by the arms 19 connected to the plates 17 at 20. The charging hopper 21 is supported upon the upper portion of the furnace and the upper end of the hopper 21 is closed by the small bell 22. The lower end of the hopper 21 is closed by the large bell 23, which has the peripheral flange 24 underlying the upper edge of the movable distributing hopper 25. The large bell 23 is raised or lowered by means of the rod 26, while the distributing hopper 25 is raised and lowered by means of the rods 27 connected by yoke 28.

In the drawing, both bells are shown in closed position in full lines and in open position in broken lines. The operation of the apparatus will be readily apparent. The material to be charged is placed in the hopper 21 by lowering the upper bell 22. This bell is then raised to form a closure to the furnace during the operation of the large bell. If it is desired then to charge the material to the center of the furnace, the large bell 23 is lowered, while the distributing hopper 25 is held in its full line position. This hopper 25 causes material flowing over the bell 23 to be deflected inwardly and deposited in the distributing tube 18. If it is desired to charge the material from hopper 21 in an annulus adjacent the periphery of the furnace, the bell 23 and distributing hopper 25 are jointly lowered to the broken line position of the drawing. The bell and hopper together close the distributing tube 18 so that all material from the hopper 21 is deposited around this tube adjacent the periphery of the furnace. In the drawing the central column 29 is shown as composed of different material from the peripheral annulus 30. It will be understood that the invention is not dependent upon the particular means for carrying it out and that any suitable apparatus may be used for that purpose.

By means of the apparatus shown in the drawing or in my prior patents above identified, it is possible to so charge the furnace that coke will be present throughout the charge, that ore will exist in an annulus whose outer periphery is the wall of the furnace, leaving the center nearly free, while flux may be concentrated in the center of the furnace or may be distributed so that a portion is in the center of the furnace and the remainder is in contact with the ore.

My invention comprises the operation of the furnace in conjunction with charging equipment which is capable of maintaining a separation, partial or total, between the ore and the flux down to a point immediately above the tuyères. This separation is effected by charging any desired proportion of the flux in the center of the furnace and away from the ore.

By this method, it is possible to supply any desired amount of flux in contact with the ore, while at the same time maintaining a separation between the excess of lime necessary to a desired final composition of the slag and the part of the charge which descends directly to the tuyères and which comes in contact with the furnace walls. Limestone placed in the center of the furnace will ultimately pass in front of the tuyères, but the change from a central position to one near the circumference will take place low in the furnace, and below the point at which trouble is usually experienced from the infusibility of the slag. The rate of descent of material in the center of the furnace is slower than that nearer the periphery, since a cone of inert material exists in the center of the furnace, at the bottom, and limestone charged into the center must reach the tuyères by passing over this cone. However, the regulation of limestone charged in this manner can readily be effected.

It is well known that furnaces operating on acid slags work better and more regularly and are capable of realizing the economies due to high blast temperatures better than furnaces with more lime in the charge. On the other hand, the removal of sulphur from the pig iron requires an amount of lime in the charge too great for free and uninterrupted descent. By my invention both objectives, namely, a free and uninterrupted descent of the charge even in the presence of high blast temperature may be secured, together with an iron of low sulphur content.

By my method of charging, the present tendency of the furnace gases to escape from the top at the center of the furnace with a high carbon monoxide content and at a high temperature is overcome. The centrally charged limestone is thoroughly preheated, but on account of its isolation reaches a point a little above the tuyères with little or no fluxing and still in the solid state, in which condition it is readily pervious to gases, and interposes no obstacle to the descent of the charge.

It is to be understood that one of the advantages of my invention is the ability of the operator to vary the proportion of stone charged into the center. It is not to be supposed that all the limestone will be charged into the center, excepting in cases where the ore contains lime. It will be possible for the operator to vary the basicity of the slag which forms near the furnace walls, and so to avoid the troubles due to the decomposition of an incipient basic slag, as heretofore described.

I claim:

1. The method of operating a shaft furnace charged with iron ore, fuel and flux which comprises charging a portion of the flux mixed with the ore in a vertically extending column in the furnace and charging another portion of the flux by itself to form a separate adjacent vertically extending column.

2. The method of operating a shaft furnace charged with iron ore, fuel and flux which comprises charging a portion of the flux mixed with the ore in an annulus outwardly bounded by the furnace walls and charging flux by itself in the center of the furnace.

3. The method of operating a shaft furnace charged with iron ore, fuel and flux which comprises charging ore and fuel in an annulus outwardly bounded by the furnace walls and charging flux by itself in the center of the furnace.

4. The method of operating a shaft furnace charged with iron ore, fuel and flux which comprises maintaining an annular, vertically extending column bounded by the furnace walls, which column comprises fuel and ore without substantial admixture of flux and a central column of material consisting mainly of flux.

5. The method of operating an iron blast furnace charged with iron ore, coke and limestone which comprises charging ore and coke in an annulus outwardly bounded by the furnace walls, charging limestone by itself in the center of the furnace and using a highly heated blast.

ARTHUR J. BOYNTON.