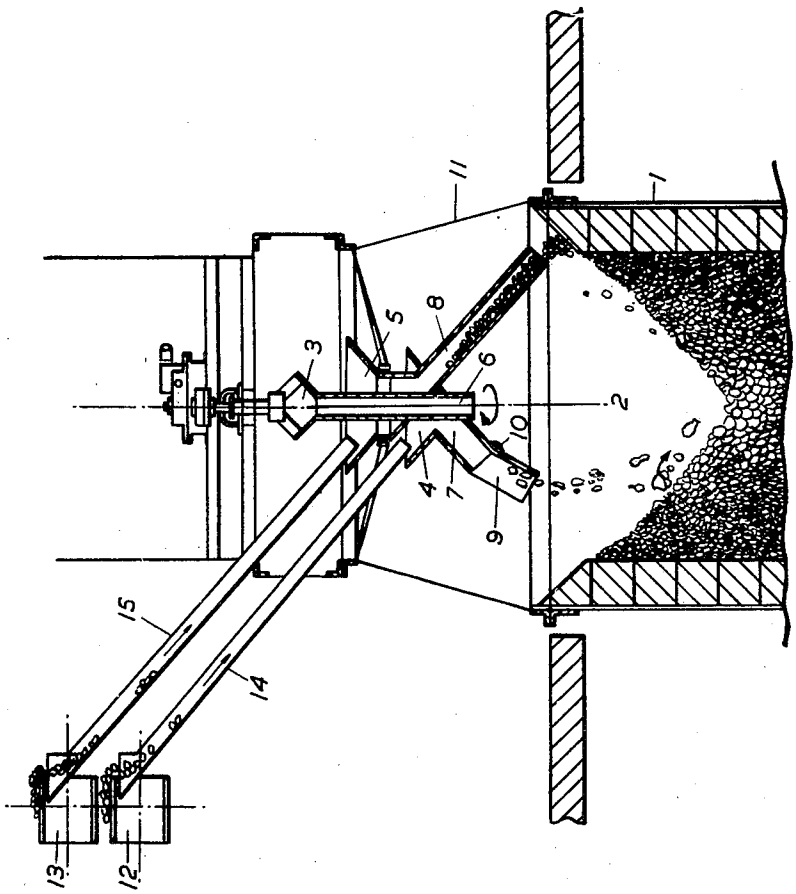
Oct. 6, 1953 F. P. SOMOGYI 2,654,594

OPERATION OF VERTICAL SHAFT FURNACES

Filed Nov. 16, 1949



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Patented Oct. 6, 1953

2,654,594

UNITED STATES PATENT OFFICE

2,654,594

OPERATION OF VERTICAL SHAFT FURNACES

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Application November 16, 1949, Serial No. 127,753
In Great Britain November 17, 1948

4 Claims. (Cl. 263—53)

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This invention relates to improvements in or relating to the construction and operation of vertical shaft furnaces of the kind in which discrete material comprising raw material mixed with solid fuel is charged from the top and passes down in countercurrent to an ascending air-blast through a reaction zone and is finally removed from the bottom of the shaft in a solid condition.

An example of a vertical shaft furnace of the kind specified is furnished by a vertical cement kiln, in which a charge of nodules or briquettes comprising a mixture of coke or anthracite with lime and marle or clay passes downwards through the shaft, is burnt by the ascending air blast and near the middle of the shaft reaches a temperature high enough to sinter the charge to form cement.

It is evident that other examples could be given of shaft furnaces of the kind specified.

The conditions experienced by the material passing down through these furnaces vary with the radial distance of the material from the centre of the shaft. In particular, since heat is lost by radiation in a radial direction, the temperature of the material decreases from the centre to the circumference with the result that the boundary of the reaction zone is considerably deeper in the center of the shaft and sometimes even reaches the bottom of the kiln.

It has now been found, according to the invention, that the adverse thermal and aerodynamic conditions experienced at varying radial distances from the centre may be rendered more nearly uniform by causing the composition and in some instances also the particle size of the charge to vary radially outwards from the centre of the shaft, continuously or in one or more steps.

According to one feature of the invention a vertical shaft furnace of the kind specified is provided with means for feeding two or more different charges of discrete material separately into the top of the furnace, each at a different radial distance from the centre of the shaft. By feeding different charges of different composition and, if desired, also of particle size into the furnace in this manner, the composition and, respectively, particle size of the charge is caused to vary radially outwards from the centre of the shaft in the desired manner.

The means for feeding different charges may comprise hoppers, funnels or chutes having outlets adapted to direct the material into the shaft. One outlet may direct material to the centre of the shaft; and another outlet or outlets may direct material to a point or points spaced radially

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from the centre. The other outlet or outlets may be arranged to revolve around the first-mentioned outlet to give an annular feed. A revoluble, angularly-adjustable chute may, for example, be used to effect an annular feed.

In conventional shaft furnaces, since the temperature at the centre is higher than the temperature near the circumference, the ascending air blast is at a higher temperature and is therefore of lower density at the centre than near the circumference. This factor tends to make the mass rate of flow of the air blast lower at the centre than near the circumference. The tendency is reinforced in many cases, as for example in cement-making, by the material of higher temperature at the centre tending to aggregate more, and thus to become less permeable, than the material nearer the circumference. It is an object of the invention, to reduce this tendency.

According to a further feature of the invention, this object is attained by a method of operating vertical shaft furnaces of the kind specified, when additionally the particle size of the charge is caused to decrease rapidly outwards from the centre of the shaft, continuously or in one or more steps.

The desired variation may be obtained by using material of varying particle size and charging the material circumferentially. The surface of the material so charged slopes down to the centre, and in settling to its natural slope the larger particles are automatically segregated to the centre.

Alternatively, two or more charges of different particle size may be fed separately into the top of the furnace at different radial distances from the centre.

For example in a cement kiln, by using different-sized nodules or briquettes of cement-forming material and fuel, the nodules at the center of the shaft will have a larger size as well as a smaller fuel content than those nearer the circumference.

According to a further feature of the invention the temperature gradient from the centre to the circumference of the shaft is reduced by a method of operating shaft furnaces of the kind specified wherein the composition of the charge is caused to vary in such a way that the quantity of heat liberated by a unit elementary volume of the charge passing down the shaft at a given radial distance from the centre increases continuously or in one or more steps as the said radial distance increases.

The charge may contain exothermic, endo-

thermic and inert components. An exothermic component, such as coke, undergoes a chemical reaction in the furnace with liberation of heat. An endothermic component, such as cement-making mixture of lime and marle or clay, undergoes a chemical reaction involving the taking in of heat. An inert component, such as slag, clinker or ash, undergoes no chemical reaction. All the components, of course, absorb heat physically as their temperature is raised.

A given elementary unit volume of the charge may contain one, two or all, of the above components, and the number and proportion of the components will determine the quantity of heat to be liberated.

The desired variation in composition may be obtained by feeding in separate charges of material of different composition as described above.

In the case of cement-making, the nodules charged at or near the centre may contain a higher proportion of cement-forming material and a lower proportion of solid fuel than the nodules charged nearer the circumference. In addition the nodules may contain a proportion of under-burnt cement from a previous operation, which is still capable of exothermic reaction in the furnace, or of inert material, the nodules charged at the centre, containing a higher proportion of under-burnt cement than the nodules charged at the circumference. Alternatively exothermic or inert material may be added separately at the centre.

A preferred embodiment of the invention will now be described by way of example with reference to the accompanying drawing, the single figure of which shows a vertical cross-section of the top of a vertical shaft cement kiln with material feeding hoppers and chutes according to the invention.

Referring to the drawing a vertical cement kiln 1 has a vertical shaft 2 into which a mixture comprising cement-forming material and solid fuel in the form of briquettes is fed from above. Means for feeding the material into the furnace comprise three hoppers, 3, 4 and 5 each having outlet chutes, 6, 7 and 8 respectively. The hopper 3 and the chute 6 are disposed vertically above the top and centrally of the shaft 2, whilst the hoppers 4 and 5 are disposed cencentrically around the chute 6 at different levels, the hopper 5 being on a higher level than the hopper 4 and so arranged that the outlet chute 7 from the hopper 4 discharges material into the shaft 2 at a radial distance intermediate the centre and the circumference of the shaft and the outlet chute 8 of the hopper 5 discharges material in the opposite direction and at a radial distance nearer to the circumference of the shaft.

Preferably the chute 7 has a lower portion 9 pivotally attached to the upper portion thereof by hinges 10 whereby the flow of material from the hopper 4 can be directed radially into the shaft 2 at varying radial distances from the centre thereof.

The hoppers 3, 4 and 5 are arranged to be revolved together about the axis of the chute 6 by any known means and in this way the kiln 1 is provided with a central feed and an annular feed from each of the chutes 7 and 8. The hoppers and the chutes are enclosed in a housing 11 mounted concentrically on top of the kiln.

The material is fed into the hoppers 4 and 5 from overhead conveyors 12 and 13 through chutes 14 and 15 erspectively, the hopper 3 being similarly fed by means not shown.

The following example shows how the process of the invention may be carried into effect, in the case of a cement kiln as described in the foregoing embodiment, the kiln having a height of some 30 feet and an internal shaft diameter of some seven feet.

Example

Cement-forming material and solid fuel are charged into a kiln of the above dimensions and at a rate of approximately 10 tons per hour the material in this case being in the form of nodules or briquettes of substantially uniform size but of different compositions, namely:

(1) At the centre, through the hopper 3,
16.4 percent silica
7.8 percent alumina and iron oxide
50.9 percent lime, and
22.3 percent solid fuel.

(2) Intermediate the centre and the periphery through the hopper 4:
14.7 percent silica
6.9 percent alumina and iron oxide
44.8 percent lime, and
31.9 percent solid fuel.

(3) At the periphery, through hopper 5,
11.7 percent silica
5.6 percent alumina and iron oxide
36.3 percent lime, and
45.3 percent solid fuel.

When briquettes of different size are used, cubes of 6'', 3'', and 1'' may be employed, and discharged by the hoppers, respectively, at the center and at radial distances of 2'6'' and 3'6'' therefrom.

Whilst specific figures of dimensions, compositions rate of charging and particle sizes have been given, solely by way of illustration in the foregoing examples, it should be understood that sizes and compositions may of course vary to some considerable extent depending on the available raw material and on the particular requirements in each individual case.

What I claim is:

1. The method of operating vertical shaft furnaces comprising the steps of introducing at the top of the shaft near the center axis thereof a prepared mixture of cement-forming solid material to be treated and of solid fuel, introducing concurrently at the top of the shaft at least near the wall thereof another prepared mixture of similar material to be treated and solid fuel, the relative fuel content of the latter mixture being greater than the relative fuel content of said first mixture, passing said mixtures downwardly through the reaction zone of the shaft in substantially parallel streams in counter-current to an ascending air-blast wherein the material is heat-treated, and removing the solid reaction products from the bottom of the shaft.

2. The process set forth in claim 1 wherein the cement-forming solid material and fuel is in the form of nodules or briquettes.

3. The method of operating vertical shaft furnaces comprising the steps of introducing at the top of the shaft near the center axis thereof nodules or briquettes of substantially uniform size and individually comprising cement-forming material to be treated and solid fuel, introducing concurrently at the top of the shaft near the wall thereof nodules or briquettes of a relatively smaller size and individually comprising cement-forming material to be treated and solid fuel, the

relative fuel content of the nodules or briquettes of the relatively smaller size being greater than the relative fuel content of said first nodules or briquettes, passing said two types of nodules or briquettes downwardly through the reaction zone of the shaft in substantially parallel streams in counter-current to an ascending air-blast wherein the material is heat-treated, and removing the solid reaction products from the bottom of the shaft.

4. The method of operating vertical shaft furnaces comprising the steps of introducing at the top of the shaft near the center axis thereof nodules or briquettes individually comprising cement-forming material to be treated, solid fuel and inert material, introducing concurrently at the top of the shaft near the wall thereof nodules or briquettes individually comprising cement-forming material to be treated, a relatively higher fuel content and a relatively lower content of inert material than said nodules or briquettes introduced near the center axis, passing said two types of nodules or briquettes downwardly

through the reaction zone of the shaft in substantially parallel streams in counter-current to an ascending air-blast wherein the material is heat-treated, and removing the solid reaction products from the bottom of the shaft.

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