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AGGLOMERATING FINELY DIVIDED ALUMINUM SMELTING MIXTURES

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This invention relates to a process for agglomerating finely divided, aluminum-containing minerals preliminary to smelting, transporting, or storing them. The process is particularly applicable to the agglomeration of finely divided mixtures comprising low grade aluminum ores, lime and a reducing agent preliminary to smelting them by electrothermic processes.

Prior to smelting various aluminum ores, it frequently is necessary to reduce them to the form of small particles to render them reactive under the contemplated smelting conditions. However, such a reduction in particle size is attended by the complication that when the pulverulent smelting mixture is introduced into the furnace, the gases which are evolved as a result of the reaction occurring in the furnace, entrain the mixture and remove a substantial proportion of it from the furnace. This problem is particularly acute during the operation of arc type electric furnaces.

For example, when smelting a mixture of aluminum ore, lime, and a reducing agent, gaseous products are generated adjacent the electrodes in amount sufficient to produce gaseous currents of substantial velocity. These currents are strong enough to sweep away an appreciable amount of the mixture as they leave the furnace.

To overcome this difficulty it has been the usual practice in the past to briquette the ore together with the other materials to be charged to the furnace. During this operation these materials are mixed in the stipulated proportions with a binder such as tar or sugar-mill residues. The resulting smelting mixture then is consolidated under substantial pressure into briquettes of the desired size.

The briquetting operation obviously has the primary disadvantage of adding materially to the cost of smelting the mineral because of the inherent cost of the added binder, the cost of the extra labor required, and especially, the cost attendant upon the use of high pressure briquetting machinery. Also, the briquetting technique does not overcome entirely the problem of losing a portion of the pulverulent mineral in the gaseous effluent from the furnace. Upon being introduced into the furnace, the briquettes generally disintegrate before reaching the reaction zone in spite of the fact that they are formed under high pressure. As a consequence, as much as 10% of the powdered mixture is lost in the form of fine dust escaping from the furnace with the evolved gases.

Still further, the disintegrated briquettes clog the furnace, thereby closing the channels required for the escape of the reaction gases. This results in building up a gas pressure within the furnace which prevents it from functioning properly.

It therefore is the general object of this invention to provide a process of agglomerating finely divided aluminum ores preliminary to their introduction into a smelting furnace.

It is another object of this invention to provide a process for the agglomeration of finely divided aluminum-smelting mixtures which binds the component particles

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of the mixtures securely together so that the resulting aggregates will not disintegrate before reaching the reaction zone of a smelting furnace.

It is another object of this invention to provide a process for the agglomeration of finely divided aluminum-smelting mixtures which leads to the production of stable aggregates having sizes and physical properties of such a character as to promote the efficient functioning of the smelting furnace.

It is still another object of this invention to provide a process for the agglomeration of finely divided aluminum-smelting mixture which is low in cost and easily effectuated.

The foregoing and other objects of this invention are accomplished by a procedure, which, broadly stated, comprises providing an aluminum-bearing mineral, pulverizing the mineral, and insuring that the mineral is intimately admixed with a quantity of finely divided lime. At least 10% by weight of lime is thus employed, but not substantially more than is required to smelt the mineral mixture.

A reducing agent such as coke in finely divided form, or other materials necessary to the smelting operation, may be incorporated in the mixture which thereafter is thoroughly intermixed with a plasticizing quantity of water. The resulting plastic mixture then is formed into aggregates of predetermined size and shape.

These may be dried, whereupon they become integrated into pellets or agglomerates having a strength which is of the order of one-half the strength of normal concrete. As a result, they may be transported, stored, or introduced into the smelting furnace for further processing without danger of disintegration.

This effect appears unique for aluminum-bearing minerals, since it is not observed in the case of other minerals such as certain manganese ores. For some reason not known to me, the addition of water to a mixture containing an aluminum bearing mineral and lime produces hard, strong, agglomerates, whereas such an effect is not observed in the case of other minerals which I have investigated.

The herein described process is applicable broadly to any aluminum-bearing mineral in the smelting of which lime is employed. Thus it is applicable to aluminum bearing minerals which contain calcium carbonate and which may be subjected to a preliminary calcining operation during which the calcium carbonate is converted to lime, thus forming the lime in situ.

It also is applicable to aluminum bearing minerals to which lime is added from an extraneous source preliminary to smelting. Accordingly, by way of example, the process is applicable to such aluminum bearing minerals as bauxite, laterite, labradorite, andalusite, and various classes of clays.

The foregoing and other minerals first are reduced to a particle size suitable for smelting. In the usual case, they are reduced to a particle size of from —40 to —200 mesh, U. S. Sieve Series.

To obtain the desired agglomerating effect it is necessary that the mineral mixture contain at least 10% by weight (dry weight basis) of lime. The upper limit of lime use is determined normally by the lime requirement of the smelting mixture. A certain proportion of lime is required for combination with the alumina, silica, and other components of the mineral. If sufficient lime is present in the mixture to combine effectively with these constituents, this amount will also be sufficient for agglomerating the mixture. The preferred proportion of lime for accomplishing both functions is from 10 to 60% by weight based on the dry weight of the mixture.

Accordingly if the mixture does not inherently contain a sufficient proportion of lime, more is added, either as unslaked lime (CaO) or as slaked lime (Ca(OH)₂), the primary distinction being that when the lime is slaked preliminary to its addition to the mineral, a smaller quantity of water need be added subsequently. Like the mineral, the lime should be in finely divided form, for example from -40 to -200 mesh, U. S. Sieve Series.

It has been found further that the presence of silica in the mineral materially facilitates the binding of the smelting mixture when it is present therein together with the lime. The binding effect of the silica becomes apparent when at least 1% by weight is present in the mineral. In general, however, it is not desirable to provide a smelting mixture containing a mineral having a silica content of more than about 45% by weight. A preferred range of silica inclusion is from 5 to 25% by weight.

Other materials may be incorporated in the smelting mixture if desirable or necessary. For example, carbon in the form of finely divided coke is incorporated in order to reduce the iron oxide content of the mixture, and if desired a part of the silica and titania. Similarly, other materials of use in the smelting reaction may be included in the desired proportions. These materials, like the mineral, lime and silica should also be in finely divided form, i. e. from -40 to -200 mesh, U. S. Sieve Series.

The various constituents of the smelting mixture may be ground separately and mixed thereafter by any suitable procedure using appropriate apparatus. However, it is preferred to mix and reduce all of the constituents contemporaneously in a single operation. This may be accomplished by introducing them together in a grinder or mill so that they are intimately mixed with each other as they are reduced to the proper particle size.

In the next step of the herein described procedure, sufficient water is added to the pulverulent mixture to render it plastic. This amount is termed herein "a plasticizing quantity" of water. Accordingly, enough water is added to the mixture to render it plastic and extrudable, but not enough to make it semi-liquid or liquid.

The water may be mixed with the other constituents in any appropriate manner, either before, during or after the grinding operation. The resulting plastic mass then is formed by hand, in an extruding machine, or otherwise, into aggregates of the desired size and shape. In contradistinction to briquetting, this step may be carried out in equipment of relatively low cost, since high pressure is not required.

The aggregates which are produced may be dried in air or in an oven kiln at suitable temperatures and durations for removing substantially all of their content of uncombined water. This forms a hard product, the component particles of which are tightly bound together by means of the hydrated lime formed by the reaction between the lime and the water, any silica which may be present assisting in a substantial but unexplained manner in the formation of agglomerates of great strength.

The agglomerates produced in the foregoing manner are hard and their resistance to shock and disintegration exceeds that of briquettes produced by conventional high pressure procedures. They may be transported, stored, or introduced directly into a smelting furnace. In the latter case, it may not always be necessary to dry them first, since they will be dried efficiently by the hot gases present in the preheating zone of the furnace before they reach the reaction zone.

Accordingly, the agglomerated mixture of raw materials loses its humidity in the upper part of the furnace and its chemically combined water in the lower part before it reaches the reaction zone. By the time it has reached the latter zone, its component particles are baked together to form an integrated aggregate. As a result, only a negligible amount of the smelting mixture escapes

from the furnace with the exhaust gases, and there is no clogging of the furnace by disintegrated fragments of the mixture.

The presently described process of agglomerating finely divided minerals is illustrated by the following examples wherein the relative proportions of the constituents are given in percent by weight.

EXAMPLE 1

This example illustrates typical smelting mixtures which may be processed by the presently described invention.

A sample of raw ore having an aluminum oxide content of 36% was ground together with unslaked lime and coke in the proportions given below:

Table I

Mixture	Aluminum ore	Coke	Lime
	Percent	Percent	Percent
A	64.4	23.0	12.6
B	61.1	11.6	27.3
C	54.4	7.5	28.1

These mixtures were ground individually to a particle size indicated by the following sieve analysis (U. S. Sieve Series):

	Percent
+ 40 mesh	2.3
+ 50 mesh	5.9
+ 80 mesh	9.9
+ 100 mesh	14.6
+ 200 mesh	45.1
- 200 mesh	21.9

Water was mixed into the ground mixtures until they became plastic. The plasticized mixtures then were extruded into aggregates measuring $\frac{3}{4}$ inch in diameter by 1 inch in length. These were air dried and introduced into a conventional arc furnace of the class used for smelting aluminum ores. In each case the aggregates remained hard upon reaching the reaction zone and substantially none of the powdered mixture was lost with the furnace gases.

EXAMPLE 2

This example illustrates the effect of the presence of various amounts of silica in the smelting mixtures used in the herein described process.

A sample of low silica laterite ore containing 30% alumina and 6% silica was ground with lime and coke to form mixtures, the major proportion of which passed a 40 mesh sieve. Sufficient water was added to the mixtures to make them plastic. They then were formed into cylindrical specimens measuring two inches in diameter by 4 inches in length. These were dried at a temperature of 120° C. and their compressive strength measured under increased load applied at a rate of 1000 pounds per minute. The compositions of the various mixtures tested and their ultimate compressive strengths are given in Table II below.

Table II

Dry mixture			Water added, percent of dry mixture	Ultimate compressive strength, p. s. i.
Percent laterite	Percent coke	Percent lime		
87.15	12.85	None	30.5	187
86.52	12.80	.68	30.0	200
81.20	12.41	6.39	32.7	115
72.30	10.74	16.96	40.6	487

Other aggregated specimens were prepared from a high silica laterite ore containing 36% alumina and 19% silica. These specimens were prepared and tested in the same manner as indicated above for the low silica specimens. The results are given in Table III below.

Table III

Dry mixture			Water added, percent of dry mixture	Ultimate compressive strength, p. s. i.
Percent laterite	Percent coke	Percent lime		
87.15	12.85	None	45.2	379
86.52	12.80	.68	45.3	427
81.20	12.41	6.39	32.7	195
72.80	10.74	16.96	40.6	526

Thus it is apparent that by the present invention I have provided a procedure for the efficient agglomeration of finely divided, aluminum-containing minerals preliminary to storage, transportation or smelting. The method is easily carried out using as the integrating component a material, i. e. lime, which is one of the constituents of the smelting mixture.

As a consequence the cost of adding an extraneous binder such as tar or sugarmill waste is avoided. In addition, the aggregation may be effectuated in equipment of relatively low cost and the aggregates when produced promote the efficient operation of the furnace into which they subsequently are introduced for smelting.

It is to be understood that the forms of my invention herewith shown and described are to be taken as preferred examples of the same and that various changes in the shape, size and arrangement of apparatus and order of process steps may be resorted to without departing from the spirit of my invention or the scope of the subjoined claims.

Having thus described my invention, I claim:

1. The process of agglomerating finely divided, aluminum-containing minerals preliminary to smelting which comprises providing the aluminum-containing mineral in admixture with from 10 to 60% lime, mixing with the mineral and lime a plasticizing quantity of water, and forming the resulting plastic mixture comprising mineral, lime and water into aggregates of predetermined size and shape, whereby the resulting aggregates will not disintegrate before subsequent smelting thereof, percent being expressed as percent by weight of the dry mixture.

2. The process of agglomerating finely divided, aluminum-containing mineral smelting mixtures preliminary to smelting which comprises providing an aluminum-containing mineral in admixture with from 10 to 60% lime, adding a plasticizing quantity of water, forming the resulting plastic mixture comprising mineral, lime and water into aggregates of predetermined size and shape, and drying the resulting aggregates, whereby the dried aggregates will not disintegrate before subsequent smelting thereof, percent being expressed as percent by weight of the dry mixture.

3. The process of agglomerating finely divided, aluminum-containing minerals preliminary to smelting which comprises providing an aluminum-containing mineral in admixture with from 1 to 45% silica by weight, mixing

the mineral with sufficient lime to form a mixture containing from 10 to 60% by weight lime, mixing with the resulting mixture a plasticizing quantity of water, and forming the resulting plastic mixture comprising mineral, silica, lime and water into aggregates of predetermined size and shape, whereby the resulting aggregates will not disintegrate before subsequent smelting.

4. The process of agglomerating finely divided, aluminum-containing mineral smelting mixtures preliminary to smelting which comprises providing the aluminum-containing mineral in admixture with from 10 to 60% lime and from 5 to 25% silica, mixing with the resulting mixture a plasticizing quantity of water, and forming the resulting plastic mixture comprising mineral, lime, silica and water into aggregates of predetermined size and shape, whereby the resulting aggregates will not disintegrate before subsequent smelting, percent being expressed as percent by weight of the dry mixture.

5. The process of agglomerating aluminum-containing minerals in particle form preliminary to subsequent smelting, comprising mixing with the aluminum-containing mineral a composition providing lime in quantity ranging between 10% by weight and an amount sufficient for said subsequent smelting, mixing with the mineral and lime a plasticizing quantity of water, and forming the resulting plastic mixture comprising mineral, lime and water into aggregates of predetermined size and shape, whereby the resulting aggregates will not disintegrate before subsequent smelting thereof.

6. The process of agglomerating aluminum-containing minerals in particle form preliminary to subsequent smelting, comprising mixing with the aluminum-containing mineral a composition providing from 10 to 60% lime, mixing with the mineral and lime a plasticizing quantity of water, and forming the resulting plastic mixture comprising mineral, lime and water into aggregates of predetermined size and shape, whereby the resulting aggregates will not disintegrate before subsequent smelting thereof, percent being expressed as percent by weight of the dry mixture.

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