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Apparatus for Sintering Ores

Filed Jan. 31, 1945

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UNITED STATES PATENT OFFICE

2,506,618

APPARATUS FOR SINTERING ORES

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Application January 31, 1949; Serial No. 675,681

3 Claims. (Cl. 268—52)

This invention relates to methods and apparatus for sintering metallic oxides, particularly ores of iron and other metals and oxides, preparatory to smelting.

Sintering is usually conducted in inclined rotary kilns of considerable length, in fact so long that the well-known "whipping" develops, and as a consequence deterioration of the refractory lining and abnormal pressure on bearings, etc. results. The ores and fuel are generally mixed before being fed into the kiln, thus causing a considerable wastage of fuel, because of inadequate control of the reducing action in the kiln. Heat is applied by burning fuel, such as powdered coal, oil or gas at the discharge end of the kiln without positive control over the direction of the flame nor over its temperature. Consequently the ores are treated in an oxidizing atmosphere at too high a temperature, thus forming fused slags which are the cause of "ringing," i.e., the adherence of the semi-fused material to the refractory lining, which must be removed by one means or another. This "ringing" occurs in the hottest part of the kiln and is principally due to the excess of temperature in the hottest zone of the flame where siliceous gangue or oxides form and fuse into a pasty mass. These pasty slags stick to the refractory lining of the kiln and must be removed continuously by mechanical means which are difficult to apply, since the "ringing" occurs at a distance of thirty to fifty feet from the discharge end of the kiln. It is almost impossible to continually and completely remove them, and if they are not removed the kiln may become completely obstructed. It is difficult, if not impossible, in the rotary kilns now in use to control or correct the temperature and the composition of the mixture during the operation, since accurate flame control is very difficult to attain and more or less segregation of the material takes place in the kiln due to the rolling motion of the charge. This rolling motion throughout the long kiln induces the segregation and prolongs it unnecessarily. Hence the material produced is lacking in homogeneity, size and composition.

After systematic research and experimental tests, I have discovered a method and apparatus by which the conditions governing sintering in rotary retorts for different oxides, and iron ores, in particular, can be properly carried out and controlled. The method is conducted in two steps in two chambers, the first being the feeding and preheating zone, and the other the reaction zone, each zone being located in a separate cylinder having predetermined dimensions and independent rotating speeds. I use no burners whatever but maintain a reducing atmosphere in the reaction zone, where the chemical reaction takes place. By maintaining a reducing atmosphere in this zone and a relatively low temperature, preferably around 1000° C. in the charge, no slagging of siliceous gangue matter with the iron oxides takes place as occurs in the fuel-fired oxidizing kilns, where the hottest zone reaches very high temperatures, on the order of 1300° to 1400° C., so that the slags fuse and the nodules become coated with a glassy iron silicate slag. This glazed coating renders the nodules less permeable to the reducing gases in the blast furnace and in fact largely prevents reduction by CO gas in the upper zones of the blast furnace, thus requiring a longer time for the smelting process and more coke to produce a ton of pig iron.

In accordance with the present invention, a low and controlled temperature method of sintering finely-divided ores and other oxides, including fine dust, mill scale, and the like, is provided whereby highly porous and therefore readily permeable nodules of any desired size are formed without glazing, because the temperature can be controlled and kept below that at which the silicates and other types of slag can form and fuse.

More particularly, the sintering method of this invention comprises first preheating the finely-divided material to be sintered or nodulised, having provided sufficient free carbon, for instance eight to twelve per cent by volume, and supplying a measured and controlled amount of heated oxygen-containing gas, such as air, for oxidation of the carbon. The oxygen is supplied only in such volume in relation to the carbon and under such temperature conditions, that incomplete combustion of the carbon occurs, with the result that nascent carbon monoxide is generated at the interface between the contacting carbon and oxide. This nascent carbon monoxide attacks the oxide particles, and reduces them at their surfaces, so that they soften and become sticky, with the result that as the sticky particles are brought into contact by the revolving action of the kiln, they agglomerate and form nodules. I have found that the most suitable air temperature is about 700—800° C. With air at 700° C. the CO:CO₂ ratio is about 60:40. This mixture is a reducing gas and particularly so if the CO is in nascent state, as in this case. By proper and close control of the carbon and air volume at about 700° C. air temperature, I can raise the CO:CO₂ ratio to about 70:30 or above 2 to 1. Although the exo-
thermic nature of the CO formation raises the temperature of the charge to about 1000° C., the formation and fusion of slag is prevented by controlling the supply of hot air so as to furnish only sufficient oxygen for the generation of a reducing gas. The nodule size may be regulated by lengthening the time of balling until they attain the desired dimensions.

A convenient and simple apparatus for conducting the described two-stage process comprises two inclined and aligned rotary cylinders, the upper cylinder containing the preheating zone and the lower cylinder the reaction zone. The material to be sintered is preheated in the preheating cylinder by the hot gases from the reaction cylinder and is discharged into the latter, which is preferably shorter though larger in diameter.

The carbon in finely-divided form is preferably supplied through a central tube extending the length of the preheating cylinder and revolving with it so as to discharge the carbon into the reaction zone in the stated percentage for admixture with the preheated oxide discharged simultaneously from the preheating cylinder. In case blast furnace flue dust is to be sintered, which always contains carbon, it is only necessary to add sufficient carbon content to bring the carbon content to the desired percentage. A preheated air blast of such volume and temperature to supply the necessary oxygen to induce the formation with the carbon of nascent carbon monoxide is directed upon the oxide and carbon mixture by one or more jet pipes introduced into the reaction zone. Volume and temperature of the air blast are so controlled as to prevent the temperature of the materials from rising to the point of slagging, yet sufficiently high to cause the oxide particles to partly reduce at the surface and thus soften, so when they roll over in contact with each other, they stick together and agglomerate into nodules, the size of which can be predetermined as described.

It will be seen that by the sintering method and apparatus of this invention, a highly desirable and inexpensive sinter is obtained which is not glazed and hence is readily permissible by the reducing gases in the subsequent blast furnace operation, and which contains an excess of free carbon facilitating final reduction and melting and sintering during handling prior to and while charging into the blast furnace or the like.

For a more complete understanding of the invention, reference may be had to the accompanying drawings in which:

Fig. 1 illustrates diagrammatically a preferred form of apparatus in which the sintering process may be conducted effectively and efficiently;

Fig. 2 is a transverse section through the reaction and sintering cylinder as seen along the line 4-4 of Fig. 1.

Assuming by way of example that the oxide material to be sintered is blast furnace flue dust, containing about 5% free carbon, as is common, the dust is charged into the preheating tube 10 by hopper 11, and is preheated by the hot gaseous products flowing through preheating cylinder 10 from sintering cylinder 12 into which the former projects and with which it communicates, as shown. Sintering cylinder 12 is preferably of larger diameter but shorter in length than the preheating cylinder 10. As shown in Fig. 1, the two cylinders 10 and 12 are gear driven from a common shaft 13, but the gear reduction is such that the sintering cylinder is driven more slowly, so that the material remains therein at least as long as it does in the preheating cylinder, although the latter is longer. The free ends of both cylinders 10 and 12 are sealed by stationary walls 14 and 15, respectively, and the adjacent space between the cylinders at their juncture is sealed by stationary partition 16, so that the system is sealed for retention of heat and minimization of dust loss. Preheating cylinder 10 is provided with the usual longitudinal rabble flanges or bars 17, so that the material is raised and tumbled through the gases, thus facilitating preheating. The spent gases flow out of preheater 10 through opening 14 and stack 18.

In order to provide a carbon content in the charge of between about 8 and about 12% carbon in the form of finely-divided coke, coal, pitch, carbon black, or the like, is added thereto in the sintering cylinder 12 by means of a tube 20 which extends longitudinally through the entire length of the upper or preheating cylinder 10 and is being fed into the upper end of the tube 20 by means of hopper 19. The tube 20 revolves with the upper cylinder and by this motion the carbon is moved therethrough at a uniform rate and discharged at a measured rate into the lower or sintering cylinder 12. If the oxide to be sintered is flue dust having a carbon content of about 5%, about 3 to 9% carbon is added thereto by supplying the proper amount at 19. If the charge is fine or granular ore, mill scale, or other finely-divided oxide, virtually all the carbon charge, i.e., about 8 to about 12% is added at 18. This carbon is in excess of that theoretically required to effect the sintering at the given temperatures, but is so provided to assure substantially uniform carbonization of all the oxide particles. The excess carbon is dispersed evenly throughout the sinter and facilitates subsequent reduction and melting, as well as precluding reoxidation. Although addition of all of the carbon in the sintering cylinder 12 is preferred, the presence of carbon in the preheating cylinder, such as that which is present in flue dust, is immaterial for the reason that insufficient oxygen remains for the reaction and sufficient temperatures are not reached in preheating cylinder 10. The carbon is preheated as it travels through tube 20 and discharges into sintering cylinder 12 at substantially the same point as does the oxide, as shown in Fig. 1. The agitation provided by rotation of the cylinder 12 insures intimate admixture of the oxide and carbon, so that each oxide particle is substantially coated with carbon.

The heat necessary to induce the formation of nascent carbon monoxide, which causes softening and consequent agglomeration of the oxide particles, is preferably supplied by the exothermic nature of the incomplete combustion of the carbon in a measured and closely controlled amount of oxygen supplied by preheated air at 700-800° C. The preheated air is supplied by jet pipes 21 projecting through end walls 15 and 16 of sintering cylinder 12, with their jet apertures directed downwardly onto the mixture of oxide and carbon. Upon being heated by the air to 700-800°, the desired exothermic incomplete combustion of the carbon is induced in the mixture so that its internal temperature is raised to about 900-1000° C.

As the mixture rolls over and over by reason of the rotation of the cylinder 12, the surfaces of the oxide particles and the carbon in contact...
therewith are heated by the incomplete combustion of carbon, and nascent carbon monoxide is formed at the interface between the contacting carbon and oxide particles. Inasmuch as nascent carbon monoxide is extremely reactive, it reduces and renders the surfaces of the particles adhesive to each other, so that the contacting particles agglomerate and grit together. As they are rolled over in the cylinder 12, these small agglomerates of softened and sticky particles adhere to others, thus balling and forming nodules of any size desired for the subsequent treatment, preferably from about ¼ to ¾ inch in size, depending upon the time they are kept in contact during sintering. When the nodules attain the desired size they are discharged by spout gate 13.

Because they are composed of surface-softened particles, which stick together by virtually point contact without fusion of the whole particle, the nodules are porous but not so readily friable that they crush or disintegrate during normal handling and charging into the blast furnace, for example. As stated, the carbon is supplied in greater quantity than is theoretically necessary to effect the sinter, not only to assure adequate carbon for each particle by maintaining the carbon monoxide-carbon dioxide ratio above equilibrium, but also to include some excess of carbon in the finished nodules, which are thereby rendered more readily reducible in the blast furnace as well as being precluded from oxidation prior to charging.

Although the invention is particularly applicable to sintering iron ores for blast furnace use, it may be applied with equal facility to sintering the oxides of other metals at temperatures below those at which their slags fuse, the temperature being only that which is necessary to induce the formation of carbon monoxide in the nascent state, when it is most active as a surface-softening agent for the oxide to be sintered. Also, although the apparatus disclosed herein is simple and effective, the process may be conducted in other forms of apparatus that will secure the desired result, and it is to be understood that neither the process nor the apparatus are limited to those described or illustrated herein, except within the scope of the appended claims.

I claim:

1. In sintering apparatus, the combination of a rotary sintering cylinder, a rotary preheating cylinder discharging into said sintering cylinder and in gaseous communication therewith, means for rotating said cylinders at different speeds, a feeding spout for supplying the material to be sintered to said preheating cylinder, a spout rotatable with and extending through said preheating cylinder and into said sintering cylinder for supplying carbon to the point of discharge of said sinter material into said sintering cylinder, and a jet pipe introduced into said sintering cylinder and directed upon the charge therein for providing a blast of preheated air, whereby the sintering action takes place in the sintering cylinder and the hot gaseous products flow therefrom through said preheating cylinder.

2. In sintering apparatus, the combination of a rotary sintering cylinder, a rotary preheating cylinder discharging into said sintering cylinder and in gaseous communication therewith, means for rotating said cylinders at different speeds, a feeding spout for supplying the material to be sintered to said preheating cylinder, a tube extending axially through said preheating cylinder and rotating therewith and projecting into said sintering cylinder for supplying carbon to the point of discharge of said sinter material into said sintering cylinder, and a jet pipe introduced into said sintering cylinder and directed upon the charge therein for providing a blast of preheated air, whereby the sintering action takes place in the sintering cylinder and the hot gaseous products flow therefrom through said preheating cylinder.

3. In sintering apparatus, the combination of a rotary sintering cylinder, a rotary preheating cylinder discharging into said sintering cylinder and in gaseous communication therewith, means for rotating said cylinders at different speeds, a feeding spout for supplying the material to be sintered to said preheating cylinder, a tube mounted concentrically in said preheating cylinder for rotating therewith and discharging into said sintering cylinder, a spout for supplying carbon to said tube for progressive feed thereof as said tube rotated to discharge into said sintering cylinder, means sealing said cylinders against ingress of air, and air jet means in said sintering cylinder for directing preheated air upon the charge therein, whereby the sintering action takes place in the sintering cylinder and the hot gaseous products flow therefrom through said preheating cylinder.

NICOLAS A. SAINDERICHIN.

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