

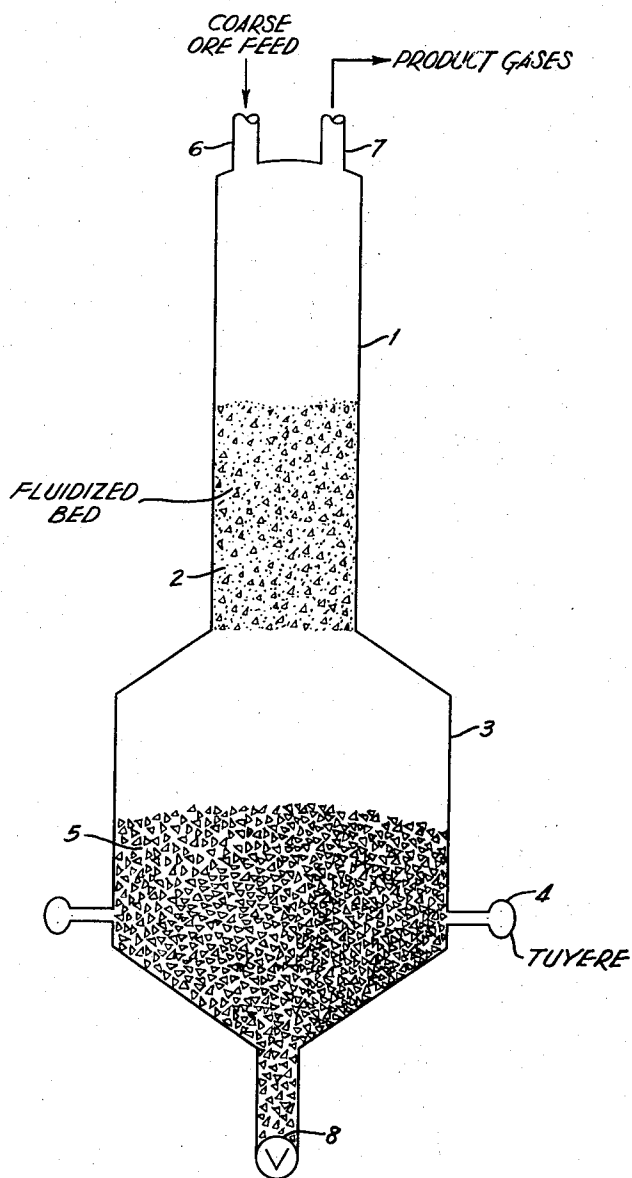
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METHOD OF FLUIDIZATION

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2,870,002

METHOD OF FLUIDIZATION

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5 Claims. (Cl. 75—9)

This invention relates to a fluidization process involving a gas and an ore or other solid in which the gas may react chemically with the ore or other solid or may act physically on the ore or other solid.

In the fluidization technique a minimum gas velocity is required to maintain the bed of solids in the desired fluidized state. This minimum gas velocity is a complex function of the properties of the fluidizing gas and the size and shape of the solid being fluidized. For a given material higher gas velocity is required for a larger particle than for a smaller one. Present practice in industrial units is to supply the solids at a maximum particle size of 14 mesh because the use of particles of much larger size requires such high gas velocities, with attendant increased cost, as to be uneconomical, i. e., the higher the velocity the greater the cost of developing it. A major cost item in a fluidization process is that of grinding the material to a size amenable to fluidization at a gas velocity that is developed economically.

It is among the objects of this invention to provide a method of and apparatus for performing fluidized treatment of a solid material with a gas that makes use of the characteristic of some ores to disintegrate into finer particles when heated, that permits the direct feeding of the solid material in the form of much coarser particles than has heretofore been practicable in the fluidization technique, that avoids the necessity of grinding the solid to readily fluidizable particle size, and that effects the desired result as readily and efficiently as would be the case if the solid were fed in the conventional finely divided form.

A particular object is to provide a method of treating certain sulfur ores that disintegrate due to chemical or physical action under the influence of heat while obtaining the advantages stated in the foregoing object.

Yet another object is to provide a method in accordance with the foregoing objects that provides for utilization of the sensible heat of the spent solids.

A further object is to provide a method in accordance with the foregoing objects in which there is exothermic chemical reaction between the solid and the fluidizing gas.

A further object is to provide simple apparatus for performing the method.

Other objects will appear from the following specification.

The invention will be described with reference to the accompanying drawing which is a schematic representation of one form of apparatus in accordance with and for practicing the method of the invention.

I have discovered, and it is upon this that my invention is in large part predicated, that in the fluidization technique of conducting a process involving a gas and a solid, typified by an ore, an unusually coarse ore feed may be used where the ore is of the type that disintegrates upon being heated. More particularly, in the practice of my invention such an ore in the form of lumps too large to be fluidized practically and economically if not

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heat-disintegrable is fed to a fluidized bed in which the ore reacts chemically with the fluidizing gas with liberation of heat or physically, due to the heat in the gases, giving off gaseous products. Under the influence of heat within the fluidized bed the coarse ore particles disintegrate largely or wholly into particles fine enough for ready fluidization by the conventional gas velocities.

The importance of eliminating part of the grinding to fine particles becomes evident upon consideration of Rittinger's Law, the validity of which, at least in the range of small particle sizes, has been confirmed by the work of the U. S. Bureau of Mines reported in its Bulletin 402. That law states that the work required for size reduction in general is proportional to the new surface area formed. Assuming, for simplicity, that the particles being ground are spheres, a plant grinding ore 5 inches in diameter to 1/2 inch diameter will use only about one-half the power required to reduce the same size feed to 14 mesh. Consequently it is clear that in the practice of this invention major savings are attained by the ability to use a coarser feed than has been conventional.

In the practice of this invention the coarse ore is fed, say as 1/2 inch lumps, to a fluidized bed in a shaft the lower end of which opens freely into a chamber of substantially greater cross sectional area to which the fluidizing gas is supplied. The cross sectional area of the shaft and of its associated chamber are so related to each other and to the velocity of the gas supplied to the chamber that the velocity within the chamber is sufficient to keep the bed in the shaft but such that due to the lesser cross sectional area in the shaft the increased velocity in the shaft suffices to fluidize the bed.

The large ore particles fed to the bed disintegrate, or shatter, upon contact with or in moving through the bed due to the chemical or physical reaction between the ore and the fluidizing gas so that all, or a large part, of the ore feed disintegrates into a size that is readily fluidized. Any material that does not so disintegrate eventually reaches and passes from the bottom of the bed into the chamber. One may or may not make use of the heat recovery feature of this invention. In order to make use of that feature, the velocity of gas in the bed is so controlled that most of the finer particles also discharge slowly into the chamber. The accumulation of spent ore is withdrawn from the chamber, continuously or intermittently, in any of a variety of ways. Due to the retarded movement through the bed, the oversize particles will have been largely reacted before they drop from the bed. Likewise, product gases are withdrawn from the bed and treated in accordance with the reaction products and the ultimate products desired.

In the practice of the invention the heat in the bed may be supplied by exothermic reaction between the ore and the fluidizing gas or it may be supplied by burning a combustible gas in the bed or by fluidizing with heated inert gas. For example, in the case of disintegrable sulfur ores fluidizing with hot inert gas will effect the desired disintegration and at the same time cause distillation of sulfur from the ore. Or, various chemical reactions may be accomplished, as by fluidizing with air under conditions to cause combustion of part or all of the sulfur to sulfur dioxide with liberation of the heat necessary to cause physical disintegration of the coarse feed. Again, chlorine will react with elemental sulfur or sulfide sulfur in ores. Likewise, although the invention is typified by and explained with reference to certain sulfur ores, it is applicable likewise to other solids that disintegrate under the influence of heat or by reaction.

The invention may be described in further detail with reference to the accompanying drawing. The apparatus comprises a shaft 1 for receiving a fluidized bed 2. At

its lower end the shaft opens into a chamber 3 of substantially greater cross sectional area than that of shaft 1. Gas for fluidizing is supplied to the lower end of chamber 3 through a conventional tuyere arrangement 4. It is preferred that at its lower end chamber 3 slopes downwardly and inwardly at an angle greater than the angle of repose of the material that collects in the chamber.

In accordance with the invention the gas is supplied at a velocity such that the body 5 of cinder in chamber 3 is quiescent but such relative to the cross section of shaft 1 as to hold and fluidize bed 2 within the shaft, thus eliminating the bed plate that supports the fluidized bed in conventional fluidizing apparatus and which would, if used, permit the build up of oversize solids and eventually halt fluidization. In other words, the shaft is freely open to chamber 3.

For most purposes the cross sectional area of shaft 1 is but a fraction of that of the chamber 3, its exact area being dependent upon the velocity of the gas from chamber 3 and the character and depth of the bed so as to hold the bed within the shaft but at the same time so that the increase in velocity of the gas when it passes into the shaft will fluidize the bed. Of course, the velocity of gas as it enters the shaft must be such as not to prevent the discharge of cinder and oversize material from bed 2 into chamber 3. Preferably the relations are such that, for many purposes, the velocity in the bed is from 0.5 to 2.0 feet per second. For most purposes it is preferred that the velocity within the shaft shall be below the minimum carry-over velocity of the bed and treated ore, or cinder, particles although if desired for any reason it can be such as to cause complete, or substantially complete, carry-over of cinder with the product gases, in which case only spent oversize material passes to chamber 3.

The ore is fed continuously to shaft 1, as by appropriate feeding means, not shown, to a conduit 6 so that the ore falls to the upper surface of bed 2. In accordance with the invention the ore feed contains particles so coarse, e. g., one-half inch lumps, as to be not fluidizable under the gas velocities normally used in fluidizing, e. g., 0.5 to 2.0 feet per second. As the ore enters the bed it disintegrates, either wholly or in part into sizes amenable to fluidization, say 14 mesh or finer, due to the action of heat present in the bed or generated by reaction between the ore and the fluidizing gas. Product gases are withdrawn from the top of the shaft through a conduit 7 and treated according to the operation being conducted.

Any coarse ore particles that are not disintegrated to fluidizable size will eventually work to the bottom of the bed under the fluidizing action and will fall into chamber 3 from which they may be removed periodically or continuously by the use of any suitable valving means 8 that does not interfere with the fluidizing.

The invention is particularly applicable to the treatment of certain sulfur ores that are found in surface deposits in Peru and Chile and which, when dropped into a bed supplied with air, will under the resultant combustion fall apart into particles readily fluidizable, leaving only about 10 percent, and not more than about 20 percent, of the feed in lumps too large for fluidization. Such ores carry sulfur mechanically rather than chemically bound, and usually they are of siliceous nature. In other words, in such ores the sulfur is free as contrasted with that in pyrites. Alternatively, these same ores will disintegrate when dropped into a bed supplied with a burning gas or with hot, inert gases.

In the bed, assuming air as the fluidizing gas, at least some of the sulfur of the ore will be burned to sulfur dioxide, and the product gases, composed largely of sulfur vapor, sulfur dioxide and nitrogen, are withdrawn and treated to recover the sulfur and possibly the sulfur dioxide, which may be recovered as such or used for the production of elemental sulfur. Depending upon the ore and upon the conditions within the bed, such as volume of air feed, the product gases may contain no sulfur vapor

but only sulfur dioxide, nitrogen, and any excess oxygen, from which the sulfur dioxide may be recovered.

Under the conditions described a slow general downward movement of cinder through the fluidized bed occurs so that the cinder progressively discharges from the lower end of shaft 1 into chamber 3. At the same time the motion of the small particles comprising the preponderant portion of the bed retards the downward motion of oversize, undisintegrated lumps thus providing sufficient time for disintegration without using an excessively deep bed. And due to the same factor, any lumps that are not disintegrated contain little unreacted material when they fall from the bed.

A particular feature resides in the preheating of the inlet gas in the body 5 of quiescent, hot cinder in chamber 3. Thereby a higher degree of thermal efficiency is attained than is the case where the hot solids are transferred to a separate unit, with loss of sensible heat in transit. This is particularly important in the case of sulfur ores because the reaction occurs at temperatures above about 500° C.

In starting up a bed, ore of minus 14 mesh may first be supplied to form an original bed that is fluidized by air, or other gas, while supplying heat to initiate the reaction. When the bed has reached the proper temperature the feed of fine material is discontinued and thereafter the ore is fed in the coarse form characteristic of this invention. Alternatively, if desired for any purpose, the bed may be formed initially from an inert material that is brought to temperature in any desired way, as by means of gas burners, after which the coarse ore feed is initiated and continued. Various inert materials may be used for this purpose, an example being firebrick of 20 x 60 mesh size.

Although in the embodiment shown the ore is fed above the surface of the fluidized bed, it will be understood that it can likewise be fed directly into the bed, e. g., laterally or sub-surface.

In view of what has been said the term "reacting" as used in the claims is to be taken to include both true chemical reaction accompanied by disintegration to smaller particle size as well as the physical reaction of disintegration unaccompanied by chemical action. Likewise, the term "ore" is used to refer to solids that are disintegrable by heat or by reaction.

According to the provisions of the patent statutes, I have explained the principle of my invention and have illustrated and described what I now consider to represent its best embodiment. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

I claim:

1. In a fluidized bed method of reacting a gas and an ore, the steps comprising establishing said bed in a shaft the lower end of which opens freely into a chamber of substantially larger cross sectional area, continuously feeding to said bed ore disintegrable by reaction in the form of lumps too large to be fluidized and by reaction disintegrating such lumps into particles of fluidizable size, continuously passing said gas into said chamber at a velocity such relative to the cross sectional area of said shaft that the increased gas velocity in the shaft fluidizes disintegrated ore in said bed while permitting slow discharge of oversize material and of cinder into said chamber, discharging material from said chamber at a rate such as to maintain therein a substantially quiescent body thereof the upper surface of which is spaced from the lower, freely open end of said shaft, supplying heat in said bed, and withdrawing gases from said shaft above said bed.

2. A method according to claim 1, the velocity of the gas in said shaft being below the minimum carry-over value.

3. A method according to claim 2 in which said gas is

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introduced into said body in said chamber at a velocity below that which will fluidize said body.

4. A method according to claim 1 in which said heat is supplied by reaction between the ore and the gas.

5. A method according to claim 1 in which said ore is a sulfur ore and said gas is air.

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