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GRINDING BALL AND PROCESS OF MAKING.

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The comminution of various products frequently requires the use of grinding machinery, commonly known as ball mills, pebble mills or tube mills. These mills are commonly lined with iron, steel, porcelain or a natural silica rock called silex. The grinding media in the mills having a non-metallic lining are usually flint pebbles, although in some cases porcelain balls are used.

Flint pebbles are not very satisfactory for a number of reasons among which are a tendency to chip and a tendency to slip one over the other because of their irregular or non-spherical shape. Porcelain balls overcome the latter objection to some extent if accurately made but they have the disadvantage of possessing a slippery surface not desirable for performing a grinding function, and they are subject as a rule to chipping. The chips will contaminate the ground product and make necessary a screening operation to remove the large pieces or chips.

Another objection to the use of flint pebbles and porcelain balls for the purpose stated is their limited grinding capacity due to a low specific gravity or unit of weight for a given mass.

In my improved grinding balls I have overcome many of the foregoing difficulties by using a special composition of my invention, imparting characteristics which later will be described in detail, together with the process of manufacture.

As a result of many experiments conducted in a specially designed machine to illustrate the action of "ball flow" or as it is technically called, "cascade", I found that the shape of a grinding ball should be as nearly as possible a true sphere. Furthermore, I found that balls with a very smooth or slippery surface showed a tendency to slide one over the other instead of rolling one on the other. Since the grinding action in a mill designed for fine comminution is essentially that of a multiplicity of small roller crushers, it is obvious that each pair of balls in contact should describe a true rolling motion rather than one involving slippage.

The study of this action demonstrated the advantage of a slightly roughened surface on the balls which would permit their adjacent surfaces to interlock, or so to speak, gear together, during the "cascade". The problem was to discover a method of manufacture whereby such an undulating or roughened surface might in some way be continuously maintained if the balls wear away as a result of long continued use.

Since hardness, toughness and extremely high density are essential characteristics in grinding balls, it is obvious that the incorporation of large grains of material in the body composition would not produce the desired effect, as it would be impossible to prevent such grains from breaking out of the bond, or chipping off, under the severe mechanical use to which the ball charge is subjected in milling practice.

My improved method of attaining the desired result consists essentially in the fabrication of a ceramic body composed entirely of very fine flour or powder in which a certain portion of the powder is agglomerated, by means of a percentage of moisture slightly in excess of that required for the moulding of said powder, by what is technically known as the dust process. When such a mixture is moulded and fired in a ceramic kiln the resultant fired body is composed of a mass of uniform hardness but of varying density. In other words, continued abrasion on the surface of such a body accentuates the variation of density by progressively exposing those portions of the body which contained the greatest percentage of moisture (the denser portions) in a series of microscopic lumps on the surface. The slightly undulating or roughened surface thus produced is found to be a constant function or condition of the body as it wears away.

The preferred process for manufacture of my improved grinding ball body may be described as follows:

The raw material may consist of a finely divided powder of a suitable ceramic body of which the following is merely a type to which I do not desire to be limited: pyrophyllite 97%, forsterite 3%, intimately ground together to pass a screen having 150 openings per inch. The powder is admixed with sufficient water to cause approximately 50% of it, by volume, to become agglomerated

into balls while the balance of the powder is merely damp. The water used in this mixture must have had previously dissolved in it, one-half of one percent of gum acacia to provide dry strength in the mass. Approximately 10% water will accomplish this result.

The mixture may be prepared in any standard type of mixing machine such as what is known as a paint mixer in which paddles stir the powder continuously without breaking the agglomerated balls.

The prepared mixture is then passed through a screening device which reduces the agglomerated moist balls to a uniform size of one-tenth inch and less after which the screened mixture is again stirred to insure uniformity.

The damp mixture is then charged into cylindrical moulds in a press of any suitable design, such as an hydraulic press, in order to consolidate the mixture into briquettes having dimensions slightly larger than the desired size of the finished ball. These briquettes are then dried in a drier of conventional design, after which they are turned in a specially designed machine to approximately true spheres. The spheres are then fired in a ceramic kiln to a temperature sufficient to bring about the desired density and hardness after which the ball is ready for use.

The step of reducing the agglomerated moist balls to uniform size, and then remixing the mixture to render the mass containing the balls homogeneous, i. e., with the balls equally distributed throughout, is highly important. Such step insures that the spots of high density through the mass will be uniformly distributed, and this necessarily provides for the required uniform condition of roughness or undulation of the ball surface, as well as continued maintenance of that uniformity. I provide the small percentage of gum acacia in order to toughen the particles of the compound by developing adhesion therebetween that is found helpful in compelling the formation of the undulating surface when the balls are finally caused to assume their spherical shape.

I do not wish to be restricted to the precise ingredients of my mixture as stated for it is to be borne in mind that ceramic substances other than those mentioned herein may be employed in the practice of my process. The fundamental phase of my invention is to use the principle of rendering the ball surface rough or undulating, by establishing in the body of the ball elements of greater density than the remainder of said body. Thus under conditions of constant wearing down of the surfaces these high density elements constantly maintain the undulatory character of the surface.

Having thus described my invention what I claim as new and desire to secure by Letters Patent is:

1. A grinding ball comprising pyrophyllite baked at high temperature.

2. A composition for making grinding balls consisting of pyrophyllite (97%) forsterite (3%) intimately ground together, and water sufficient to agglomerate a certain portion of the mixture into elements of greater density than the balance thereof.

3. A grinding ball composed principally of reduced pyrophyllite in a body made up of elements of relatively high and low densities, with the high density elements uniformly distributed throughout the mass of the body.

4. A composition for making grinding balls consisting of pyrophyllite (97%) forsterite (3%) intimately ground together, and water sufficient to agglomerate a certain portion of the mixture into elements of greater density than the balance thereof, the elements of greater density being uniformly distributed throughout the body of the mixture.

5. A composition for making grinding balls, consisting of pyrophyllite (97%), forsterite (3%), gum acacia (½%), and water.

6. A composition for making grinding balls consisting of pyrophyllite (97%) forsterite (3%) intimately ground together, and water sufficient to agglomerate a certain portion of the mixture into elements of greater density than the balance thereof, together with an agglutinant.

7. A grinding ball consisting of a ceramic compound comminuted to provide a fine powdery body, with water sufficient to agglomerate into balls a certain proportion of the body, said balls forming elements or zones of higher density than the rest of the body and thereby creating constant surface roughness for the ball, when baked.

8. The method of making a ceramic article having a constantly renewing rough or undulating surface, consisting of forming a powder of ceramic substance, agglomerating a certain portion of the powdered mass into elements of higher density than the balance of the mass with moisture, distributing said elements of higher density uniformly throughout the mass, and then shaping the mass and baking it.

9. The method of making a ceramic article having a constantly renewing rough or undulating surface, consisting of forming a powder of ceramic substance, causing a certain proportion of the powder to be collected into ball-like elements of higher density than the balance of the powder, distributing the said elements uniformly through the powdered mass, and shaping and baking said mass to take the form desired.

10. The process of making ceramic arti-

cles, consisting of mixing with a ceramic powder, elements of the same powder agglomerated to assume higher density than the powder, distributing said high density elements uniformly through the powdered mass, and shaping and baking the final mixture.

11. The process of making ceramic articles, consisting of mixing with a ceramic powder, elements of the same powder agglomerated to assume higher density than the powder, and of a certain maximum size, distributing said high density elements uniformly through the powdered mass, and shaping and baking the final mixture.

12. The composition which consists of a fine powdery body having portions thereof agglomerated into elements of higher density than the balance of the body, distributed through the latter, and baked to provide hardness.

13. The method of making a ceramic article, consisting of mixing a fine ceramic powder with water sufficient to agglomerate a portion of the powder into balls of higher density than the rest of the powder, distributing said high density balls uniformly through the rest of the powder, and then shaping and baking the final product thus obtained.

14. The process of making a ceramic product which consists of mixing suitable ceramic substances in powdered condition with moisture sufficient to agglomerate a portion of said substance into balls or pellets of higher density than the body of the substances, distributing said balls or pellets uniformly throughout said body, molding said substances into required shapes, and baking the shapes.

15. The process of making a ceramic product which consists of mixing suitable eramic substances in powdered condition with moisture sufficient to agglomerate a portion of said substance into balls or pellets of higher density than the body of the substances, distributing said balls or pellets throughout said body, molding said substances into required shapes, drying the molded shapes, grinding said shapes to provide thereon the effective working surface of high and low density characteristics, and then firing or baking the shapes to bring them to the required hardness for use.

16. The process of making a ceramic product, which consists in mixing suitable ceramic substances in powdered form, with sufficient moisture to agglomerate a certain proportion of said substances into balls adapted to provide high density zones or spots, mixing these substances with their agglomerated portions, to substantially uniformly distribute the latter among the unagglomerated particles, molding the substance to required shapes, and firing the molded shapes at high temperature to provide necessary hardness for use.

17. The process of making a ceramic product, which consists in mixing suitable ceramic substances in powdered form, with sufficient moisture to agglomerate a certain proportion of said substances into balls adapted to provide high density zones or spots, mixing these substances with their agglomerated portions, to substantially uniformly distribute the latter among the unagglomerated particles, molding the substances to required shapes, subjecting the molded shapes to the action of an abrading device to grind one of the surfaces of the shapes to bring out the high and low density characteristics of the same to provide what may be termed the working surface, then firing the shapes in a high temperature furnace to produce required hardness for use.

In testimony whereof I affix my signature.

THOMAS S. CURTIS.