ABSTRACT: A mechanism for reducing the size range of solid materials utilizing a motor powered impeller having a plurality of blades rotating within a chamber into which the solid materials are introduced for impact contact with the blades and wear plates disposed thereon. A surface of said chamber is covered with resilient material of substantial thickness with the clearance between said blades and plates and said resilient element being less than the initial size of the largest solid particles introduced. Reduced materials of regulated size as determined by adjustable exit passages are conveyed out of the mechanism by a fan unit. A method for the impact grinding of solids materials utilizing a resilient surface and an impacting element moving at relatively high speed past such surface and disposed at contact angles assuring interaction of impelled particles and the resilient surface.
ORE GRINDING MECHANISM AND METHOD

BACKGROUND OF THE INVENTION

The present invention is concerned with the reduction of particle size for solid materials. Specifically, the invention is directed to the grinding of ores and other mineral or similar products for better usage or for ore beneficiation operations. In such overall field, ball, tube and roll mills have previously been used in which the balls or rolls engage and grind introduced materials to fine particle size as desired. In the same general field some types of attrition mills have been used in which the introduced material is itself the grinding medium.

The present device and method are believed to present a new mechanism or combination of elements that has not previously been used in the described field of endeavor. Some prior usage of some of the components is acknowledged in the related fields of coal pulverizers or in the less pertinent field of feed and grain grinders. U.S. Pat. No. 1,621,571 to Witz is characteristic of the coal pulverizer field, and the U.S. Pat. No. 3,107,867 to Svensson presents a resilient or rubber lining for grinding machines of the ball or tube mill configuration. The previous coal pulverizer developments are not believed to be directly adaptable for use in the size reduction of harder and coarser materials such as the metallic ores. The resilient lining in the Svensson patent seems to be provided to prevent excessive wear. Similar resilient linings in other grinding or attrition apparatus is directed to a similar problem, and it is not believed to present an anticipation of the applicant's device in which a resilient element is provided for cooperative use with a high-speed impact element to obtain particle size reduction through establishment of a beneficial circulation pattern and a cooperative interaction between the impact elements, the material particles and the resilient member.

SUMMARY OF THE INVENTION

Briefly stated, the present invention provides a method and mechanism for obtaining particle size reduction in solids materials of greater hardness than coal. In a specific embodiment of the invention a multiblade impeller is rotated within a substantially closed chamber with the blade ends or wear plates thereof being disposed in proximity to a circumferentially disposed resilient element of substantial thickness. The blades and plate impact members are disposed in a rotative pattern to contact solids materials being introduced and to forcefully impel such materials against other stationary and rotary components inclusive of adjacent blades, wear plates, sidewalls and the mentioned resilient elements. The clearance between the impact elements and the resilient member is less than the expected size of the largest particles introduced, and the resilient member is of substantial thickness to permit localized displacement thereof to avoid stoppage of the impact element. A fan component is provided to draw materials of reduced particle size from the impact chamber, and adjustable elements are provided to regulate the size of the flow escape passage from such chamber to effectively control the output particle size. The fan discharge can be used to convey the reduced materials to subsequent work or treatment stations. Units of relatively compact size and reduced weight may be used to efficiently and economically grind solid materials, ores and construction products.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevation showing a preferred embodiment of the invention.
FIG. 2 is an end elevation of the unit shown in FIG. 1.
FIG. 3 is a partial cross-sectional elevation taken along the line 3-3 of FIG. 2.
FIG. 4 is an end elevation similar to that of FIG. 2 with an end plate removed.
FIG. 5 is a partial schematic illustration of the operating principles of the invention.

FIG. 6 is a side elevation in partial cross section showing a first adjusting mechanism, and
FIG. 7 is a side elevation in partial cross section showing features of an alternate adjusting mechanism.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A first preferred embodiment of the invention is shown in FIGS. 1-6. In these illustrations the ore grinding mechanism is shown to include a pedestal support base 12, a drive motor 13 mounted thereon, and a driven shaft 14 rotatably mounted in the support bearings 16 and 17. The driven shaft 14 is coupled to motor shaft 18 by a coupler 19 that preferably provides compensation for minor misalignment of the shafts 18 and 14 and further incorporates a shear pin or other overload release device so that the motor 13 will be uncoupled from the driven shaft 14 at any time that the mechanism is jammed or whenever an overload condition is encountered. Preferably the overload release should be of a reset type so that the unit can be returned to service as soon as an obstruction or other trouble is removed.

A cantilever end of the shaft 14 extends past the support bearing 17 and into a pair of chambers. A first fan or blower chamber 21 has a fan 22 disposed therein. A second grinding chamber 31 has an impeller 32 rotatably mounted therein on the end of driven shaft 14. A materials introduction chute 33 communicates with the interior of the grinding chamber 31 for the introduction of solids materials through an opening 35. An opening 34 is provided in wall 36 between the blower chamber 21 and grinding chamber 31 so that treated materials from the grinding chamber and air may be introduced into the blower chamber 21 to be accelerated and expelled through the outlet 37 by the fan 22.

Grinding chamber 31 is closed by an end plate 38 that is held against the outer edge 39 of a circumferential or cylindrical structure 41. This structure is welded or otherwise joined to wall 36. Through bolts 42 secure the end plate 38 and an outboard support 43 to grinding chamber 31. Preferably the seal between the end plate 38 and ring 41 should be dust and airtight when assembled. With the end plate properly in place, a desirable flow pattern from the materials inlet 33 through the mechanism and out the discharge 37 is established.

For the illustrated embodiment the motor 13 is directly connected by the shaft 14 to the fan 22 and grinder impeller 32. A motor normally operating at 1750 R.P.M. can be directly coupled as illustrated to rotate the fan and impeller at relatively high rotative speeds. This high-speed direct coupling has been found to be effective in units incorporating impellers of approximately 18-inch to 30-inch diameter in connection with the particle size reduction of various types of metallic ores. Where other speeds may be found desirable in connection with the grinding of specific materials, the motor 13 may be provided with a speed control 25, or a motor can be coupled through gear or belt reduction elements (not shown) to obtain selective rotative speeds.

Materials introduced in the inlet 33 will be repeatedly contacted by the impeller 32 and specifically by the impeller arms 43 and by wear plates 44 mounted on the outboard end thereof. As shown in FIG. 5, the wear plates 44 are joined to the arms 43 by bolts 46 extending through elongated slots 45 in the arms 43 to facilitate the removal, replacement and position adjustment of the wear plates. Impeller 32 has a hub 47 that is mounted on the shaft 14 by use of a key 48 or other drive connection. In similar manner fan 22 has a hub 49 that may be similarly mounted and secured to the driven shaft 14.

Rotation of the described elements within their respective chambers will cause materials introduced through opening 53 which communicates with the inlet 33 to be contacted by the arms and wear plates 44 of impeller 32. This impacting contact will normally drive the solid materials against the cylindrical structure 41, the end plate 38 or wall 36. Impacting contact with these elements and repeated contacts with the impeller components can cause an attrition or reduction in size of the particle materials. When the materials are reduced in size they
will be carried by the induced air stream through the opening 34 and out the outlet 37.

Improved results are obtained by the present apparatus through incorporation of additional improvements. A torus or cylindrically shaped resilient ring element 51 is interposed to cover the interior surface of structure 41. This resilient ring element which may be formed of rubber or natural or synthetic materials has a substantial thickness and is preferably of quite pliable structure. Where rubber is used, it should be of durometer ranging from 25 to 60 so that it may be readily deformed when contacted by materials therewith.

As shown in FIG. 5, the clearance between the outer ends 52 of wear plates 44 and the inner surface 53 of the resilient ring element 51 should preferably be less than the size of the largest particles 54 to be introduced into the grinding chamber. This clearance should further be related to the thickness and durometer of the resilient element. Accordingly, when material such as the particle 54 will not be cleared to pass between the plate end 52 and the surface 53, deformation of the resilient element 51 sufficient to accommodate passage of such particle should be possible. This combination will specifically prevent stoppage of the impeller 32.

In regular usage, however, it is expected that any trapped particle, such as particle 54, will be broken up into particles of minor size as the result of such entrapment.

A second feature contributing to the beneficial results obtainable through use of the present mechanism is directed to the angular displacement of the arms 43 and wear plates 44 with respect to a true radial configuration. With the arrangement illustrated the impact contact faces 55 and 56 of the arms 43 and wear plates 44, respectively, are not at the point of contact, perpendicular to lines of instantaneous movement for particles contacted thereby. Accordingly, incoming materials such as the particle 64 will normally not be propelled along tangential paths in the grinding chamber. The non- tangential impacting characteristic is believed to keep the incoming materials in suspension for repeated impeller contacts to obtain more efficient attrition. Further, when the material particles do move outwardly into contact with resilient element 51, they are redirected back into the impeller impact zones of the equipment. Through the combination of the resilient element and the non-tangential movement patterns, the impacting solids materials are subjected to repeated impact or attrition contacts contributing to efficient particle size reduction operations.

When the reduced materials are of sufficiently small size, they will be picked up and carried by the incoming air into the blower chamber. Control of the output particle size can be provided by proper choice of the clearance opening into the blower chamber. In preferred embodiments, baffle component 61 is provided to occlude a portion of the opening 34 in wall 36. A cone baffle 61 is beneficially used for this purpose. Such cone baffle is preferably mounted on the driven shaft 14 for rotation therewith at a position providing a minor clearance passage 62 between the opening 34 and the conically shaped face 63 of the baffle 61.

As shown in FIG. 6, baffle 61 may be adjustably mounted on the shaft 14 through use of threads 64. The baffle may be held in adjusted positions by use of a locknut 66. Adjustments of the positioning of baffle 61 and nut 66 on shaft 14 can be made to change the clearance passage 62 between the cone face 63 and opening 34. The cone shape is utilized not only for the purpose of providing a size adjustment, but it is further been found that particles do not tend to build up on the exposed surfaces of such baffle that are disposed within the grinding chamber. Movement patterns within the grinding chamber and gravitational forces keep such surface adjacent the clearance passage 62 free of obstructions to promote efficient flow of air and entrained particles of reduced size through the passage 62 and into the blower chamber 21 for acceleration and subsequent discharge from outlet 37.

Where a single product is being handled by the apparatus, the clearances may be fixed or a specific passage 62 may be provided. Units that are to be used in laboratories or in custom milling operations can be provided with an adjusting mechanism so that the output particle size range can be changed.

A separate type of adjusting mechanism is shown in FIG. 7, where cone baffle 161 is mounted for reciprocal movement along the shaft 14. A key 67 is engaged to screw threads 68 on an adjusting bolt 69 extending through shaft 14, so that rotation of the bolt will cause the key 67 to be moved reciprocally in a slide opening 71 in the shaft 14. Movement of the key 67 will cause a corresponding movement of the baffle 161 and its cone surface 163. With the embodiment shown in FIG. 7 the bolt 69 can be extended to the exterior of the plate 38 or past any outboard support bearings for shaft 14 to be easily accessible for manipulation to adjust clearance passage 62.

For all embodiments of the invention certain parts and components may be beneficially made of abrasion resistant steel, or such parts may alternately be protected by hard surface facings. In actual operation the arms 43 have given satisfactory service when made of mild steel. Similarly the wall 36 and end plate 38 are not subjected to much wear. The wall 49 should preferably be of abrasion resistant steel. Replacement plates or even new plates can be hard surface welded with Stellite or Stoudite types of material to provide high impact and abrasion resistance.

Units incorporating the described components and characteristics have been used to prepare various solids materials for ore processing, ore treatment and other uses. The product obtained can be regulated in particle size, and in general the output product is advantageous comparable to that derived from the use of ball and tube mills. Actually the output product can be regulated quite coarsely so that the initial discharge will be satisfactory for direct usage. Accordingly, downstream grading and recirculation techniques and equipment may be eliminated.

The output from a grinding unit 31 of approximately 2-foot diameter that is driven by a 3 horsepower motor provides enough product for many beneficial uses. On a horsepower expended per weight of produce derived basis, the unit has economic advantages when compared to present day ball mill ore grinding practices. In addition to such production cost advantages, other benefits may be realized from use of the described apparatus. The cost of installation is relatively low, and the substantially reduced size and weight of the equipment makes it possible for this apparatus to be used at remote sites in connection with ore concentration operations. These units are actually of a size facilitating portability. Accordingly, such units together with other ore treatment and handling apparatus can be combined into a portable installation that can be moved to operating sites. The provision of a fan or blower as a component of the apparatus has a direct benefit, inasmuch as the discharged product can be fed directly to various ore separating apparatus. Various known types of gravity separators may be coupled directly to the outlet 37 to obtain a selective output product.

The foregoing and additional beneficial results are obtainable through use of apparatus incorporating the described features or combinations thereof as set forth in the appended claims.

We claim:

1. A method for grinding solids materials such as ores which comprises the establishment of a confined zone having a resilient boundary layer, moving an impacting member in a non-contacting relationship through said zone at high velocity with an established clearance between said impact member and the resilient boundary of said zone, gravitationally introducing solids materials that may be of particle size greater than the established clearance between said impact member and the resilient boundary of said zone directly into said zone for random contact with said impact member whereby said materials are: reduced in size by the force of impact; entrapped between
suggested impact member and the resilient boundary to be reduced in size by grinding attrition; and/or accelerated for impingement against said resilient boundary or for recontact with said impact member, and discharging said ground materials when of a desired size through a discharge opening of regulated size.

2. The method of claim 1 wherein said resilient boundary is deformable to an extent providing clearance past said impact member for solids materials entrapped at said boundary.

3. Ore grinding apparatus for reducing the size of solids materials introduced therein comprising walls defining a chamber, a rotary impeller for movement at high velocities through said chamber, a plurality of wear plates on said rotary impeller for movement about said chamber, a resilient element in said chamber and in position away from contact by said rotary impeller or the wear plates disposed thereon, means for reciprocally adjusting the position of said wear plates for adjusting and maintaining the clearance between said wear plates and resilient element without changing the respective angular dispositions thereof, and means for introducing solids materials into said chamber that may be of particle size greater than the established clearance between said wear plates and the resilient element disposed therein whereby said materials are reduced in size by the force of impact; entrapped between said wear plates and the resilient element to be reduced in size by grinding attrition; and/or accelerated for impingement against said resilient element or for recontact with said rotary impeller and wear plates as impact members to obtain further size reduction for the solids materials.

4. Structure as set forth in claim 3 wherein said wear plates are disposed at a nonnormal angle with respect to the adjacent surface of said resilient element.

5. Structure as set forth in claim 3 wherein said resilient element is deformable and of sufficient thickness to provide clearance past said wear plates for solids materials that may be entrapped by said resilient element.