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PROCESS AND AN APPARATUS FOR MIXING AND
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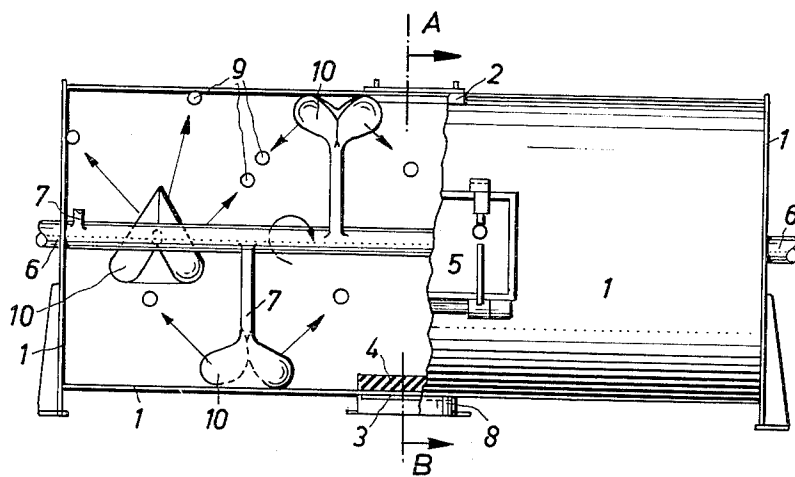


FIG. I.

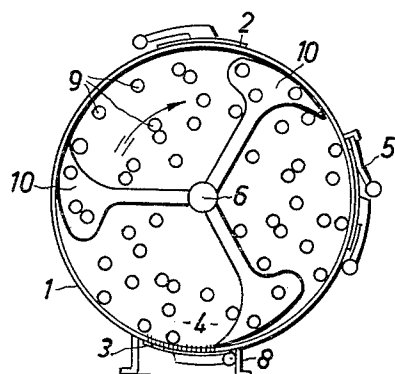


FIG. II.

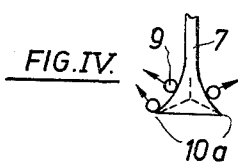


FIG. IV.

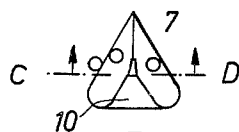


FIG. III.

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PROCESS AND AN APPARATUS FOR MIXING AND COMMUNUTING MATERIALS

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This invention relates to a process and an apparatus for mixing and comminuting materials.

Mixing apparatus which operate with grinding elements, e.g. balls, have been used in the mixing art for many decades. They are chiefly used where the substances which are to be mixed are ground to a very fine state. So-called positive-action mixers in which material is moved about by mechanically driven mixing tools are also known. It is also already known to use mechanically driven mixing tools in conjunction with grinding elements. Thus, mixers are known wherein a drum for material to be ground contains the material to be ground and also grinding balls, portions of the contents of the drum being continuously lifted by mechanical mixing tools, to slide off the tools when the natural angle of slope is reached and fall back on the surface of the material being ground. In these mixers, the grinding elements fall down merely as a result of their own gravity. In other apparatus of this kind, the contents of the drum (both balls and material) are made to revolve so rapidly by rapidly travelling beaters that, as a result of centrifugal force, the contents move along the inner wall of the drum, impinging against baffle surfaces at specific points as they do so and falling back into the interior of the mixing drum; in this apparatus, the balls are therefore circulated at such a speed that rings of the material being mixed form on the wall of the drum as a result of the influence of centrifugal force.

The present invention is concerned with a ball-mill mixer in which the contents of a mixing drum namely substantially spherical comminuting elements, e.g. balls, and material to be mixed are subjected to the action of mechanically driven mixing instrumentalities. The mixer of the invention, like known mixers of this kind, uses a mixing drum which can be closed in a dust-proof fashion, at least one shaft extending coaxially through the mixing drum, and a plurality of mixing and centrifuging instrumentalities which are arranged on the shaft, being carried individually by separate arms and extending with their distal ends as far as the drum wall. The interior of the mixing drum is filled to approximately 10-50%, preferably 20-40%, with balls or similar substantially spherical comminuting elements and is filled with material to be ground until the total contents, including the comminuting elements, take up about 70% of the capacity of the drum. The above given percentage ranges and percentages of 10-50%, 20-40% and 70% correspond respectively to a filling height of 15-50%, 25-42% and 66% of the drum diameter.

The mixer according to the invention differs from known apparatus of this kind in that the centrifuging and mixing instrumentalities are in the form of ploughshare-like elements having a unilateral and/or bilateral action, the front cutting edges of the elements as they rotate lifting the drum contents, i.e. the balls and the material to be ground, away from the cylindrical wall of the drum and from the end walls thereof, whilst the side surfaces of the centrifuging and mixing elements as they come out of the drum contents continually carry upwards with them some of the drum contents and throw all or some of the contents thus entrained into the upper empty space of the mixing drum towards the interior of

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the drum, and also laterally, and the centrifuging and mixing elements as they perform this work rotate at a specific speed which, based on a drum diameter of 1 meter, corresponds to a peripheral speed of between about 2.5 and about 14 metres per second, preferably between about 4 and about 6 metres per second. These peripheral speeds correspond respectively to between about 50-270 and 75-115 revolutions per minute calculated on a distance of one-half meter between the distal ends of the mixing tools and the drum axis.

The invention is based on the discovery that improved mixing effects can surprisingly be obtained by using ploughshare-like centrifuging and mixing elements of the kind specified and driving them at the aforesaid peripheral speed. The ploughshare-like elements continually lift portions of the drum contents out of the main mass of the contents and project these portions into the upper empty space in the mixing drum. As they do so, the ploughshare-like shape of these elements has the result that the contents of the drum are lifted away from the inner wall thereof so that despite the relatively high peripheral speed the material being mixed is not subjected to impact pressure, undesirable compression of the material is avoided, and seizing-up of the machine is made impossible. The combined use of the elements with the said peripheral speed has the result that the balls are thrown about within the empty space of the drum together with the material and continuously impinge against the material and against other balls, so that as a result a surprisingly improved mixing effect is achieved.

The method according to the invention is characterised in that the material for mixing is put into a mixing container, which is filled to approximately 10-50%, preferably about 20-40%, of its capacity, with loose balls and is provided with constrainedly driven centrifuging or mixing tools, until the empty space in the mixing container amounts to only about 30% of the capacity thereof, and the material to be mixed is, with the loose balls, then subjected to the action of the centrifuging or mixing tools, the tools being driven at a peripheral speed which, calculated on a shaft-tool spacing of 0.50 metre corresponds to a peripheral speed of between about 2.5 and about 14 metres per second, preferably between about 4 and about 6 metres per second.

The following details should be noted in connection with the invention:

The mixing container, which is always the rotating part in known ball mills, can be immovable in the case of the apparatus according to the present invention. Generally movement of the mixing container by itself does not result in any increase in the mixing and grinding effects proportional to the outlay required. A substantial advantage achieved in comparison with known ball mills is that the mixed material can be emptied with the mixing container stationary, which is not only much simpler technically speaking but also makes it possible to work without causing the production of too much dust. Preferably, the mixing containers according to the invention are in the form of fixed horizontal cylinders or drums.

The mixing containers and tools have to be so adapted to one another that during the operation of the mixer the balls cannot be jammed between the mixing tools and the wall of the mixing container. Also, the mixing tools should expediently be so constructed that they can be driven at the highest possible speed whilst using as little energy as possible and causing little wear on the loose balls. With ploughshare-like mixing elements, the peripheral speed can be so increased that the drum contents are partly (particularly in the empty space above the shaft) subjected to an intensive throwing and whirl-

ing process. At the head ends of the mixing drum it is advantageous to arrange unilaterally acting ploughshares positioned so that they throw towards the interior of the drum. The ploughshare-like centrifuging tools lift the material and balls off the drum wall, and even with relatively high peripheral speeds do not form any compacted rings of material, pass through the material with the use of very little force, and accordingly, despite their high peripheral speed, consume very little energy. The centrifuging tools are expediently arranged on a shaft which extends through the mixing container parallel to the cylindrical wall thereof. The centrifuging tools can be arranged in a manner known per se by means of supporting arms on the shaft, for example at right angles to the shaft, and can be distributed in a helical pattern along the shaft. If necessary, two tools adapted to project material in different directions can be provided on each supporting arm.

Depending on the kind of mixing or centrifuging tools, the size and weight of the loose balls and the material to be mixed and ground, the peripheral speed of the mixing tools according to the invention must be kept between about 2.5 and about 14 metres per second, i.e. between about 50-270 revolutions per minute, calculated on a spacing of about 0.50 meter between the distal ends of the mixing tools and the axis of the drum. The peripheral speed of the tools can be increased until rings of material form on the cylindrical wall of the mixing container as a result of centrifugal force. Loose rings of material do not disturb the process, whereas on the other hand considerably compacted rings of material are not tolerable. The critical rotational speeds at which rings of material form depend on the form and arrangement of the tools. The highest critical speed is obtained with mixers provided with unilateral-action or bilateral-action ploughshare-like mixing tools which are so shaped and arranged that they lift the material and the balls away from the walls of the mixing container. The leading edges of these mixing tools engage under the curvature of the balls. When rotating quickly, even at relatively high speeds, they prevent the formation of densely compacted rings of mixed material, since they intercept the greater part of the centrifugal force produced in the material being mixed. The amount of force required for the various mixing tools is least in cases where ploughshare-like mixing elements are used. The greater the amount of movement produced by the mixing elements in the ball-material mixture, the greater is the frictional action of the balls and mixing elements on the material, and therefore the quicker the grinding and mixing process.

The mixers according to the invention are filled with balls up to 10-50%, preferably 20-40% of the available capacity in the mixing container, and then are filled with material to be mixed up to a point at which 70% of the available capacity is taken up. The balls are generally to be of a diameter of about 10-50 mm. They are expediently made from a non-splintering and substantially abrasion-resistant material, which is preferably a synthetic plastic material. In order to increase their weight, they can be provided with a core made of a material having a higher specific gravity, e.g. a metal. Instead of balls, it would also be possible to use elements which are in the form of an ellipsoid, or egg-shaped. The form of the impact elements used, and also their weight, size and quantity employed, depend on the actual mixing problems which have to be dealt with in particular cases. Charging and emptying apertures can be arranged at the top and bottom of the mixer. The apertures are advantageously closed by flaps adapted to the curvature of the cylinder since otherwise it would be possible for balls to be jammed therein. By the use of suitable pipes, the material to be mixed can be introduced and discharged without giving off dust. At the upstream side of the emptying flap there is arranged a

screen which is also adapted in shape to the curvature of the drum and which, at the time of emptying, allows the material which has been mixed but not the balls to pass through.

The technical effect which is obtained by the mixer according to the invention consists in that with the use of this mixer it is possible for mixing problems to be solved in a considerably shorter time and the product obtained is mixed to a greater degree than is possible with the use of known ball mills. Also the entire mixing and grinding process including the charging and emptying of the mixing container can be carried out without giving off dust whereas with the use of known ball mills the emptying of the mixing container entailed giving off a considerable amount of very unpleasant dust.

The invention is illustrated by the accompanying drawings.

In the drawings:

FIGURE 1 is a longitudinal view, partly in section, and FIGURE 2 is a section on line A—B of FIGURE 1,

and FIGURE 3 is a view of a ploughshare-like tool, and FIGURE 4 is a section on line C—D of FIGURE 3.

The mixer illustrated comprises a cylindrical mixing container or drum 1 provided at the top with a charging aperture which is during the mixing process closed by a closure means or flap 2 the shape of which is adapted to the curvature of the drum. Provided at the lowest point of the mixing drum 1, are discharge apertures which are closed by a closure means or flap 3. Inside the drum and immediately before the flap 3 is a fixed or detachable screen 4 through which, as the mixing elements rotate, the mixed material but not loose grinding balls 9 can pass after the flap has been opened. The flap 3 is situated inside a pipe 8 and has at its lower end a flange to which further outflow pipes can be connected by means of a flange joint to permit dust-free emptying. For the purpose of cleaning, renewing or changing the loose balls, the cylindrical wall of the drum has an aperture which is closed by a flap 5 adapted in shape to the curvature of the drum. Arranged in the middle of the mixing drum and parallel to the cylindrical wall of the drum is a shaft 6 about the periphery, and distributed along the length, of which are arranged supporting arms 7 for mixing elements. Loose balls 9, must be non-splintering and substantially abrasion-resistant.

The FIGURE 1 construction includes ploughshare-like mixing elements 10 carried by the arms 7 and extending with their distal ends close up to the cylindrical wall and the ends of the drum as appropriate. They can be unilateral-action or bilateral-action ploughshares. It is advantageous to arrange at the ends of the drum unilateral-action elements positioned so as to throw towards the interior of the drum. The shape of the bilateral-action mixing elements 10 can be seen more accurately from FIGURES 3 and 4.

During rotation, the leading edges 10a (FIGURE 4) of the elements 10 slide close along the cylindrical wall of the drum like a wedge below the material to be mixed or the loose balls 9 and therefore lift the contents of the drum 1 away from the cylindrical wall thereof. Since the material is lifted off towards the interior of the drum, it is subjected to substantially no compression, so that the elements 10 can be driven with the minimum expenditure of force. The low expenditure of force in turn makes it possible to drive the ploughshare-like elements at a fairly high rotational speed until an intensive centrifuging and whirling effect is achieved. The peripheral speed can be increased sufficiently for the centrifugal force produced within the material to form a ring of material on the cylindrical wall of the drum, but must fall back at least partly into the interior of the drum again. As long as the rings of mixed material are still loose in structure, they do not disturb the mixing operation. The lifting-off effect of the mixing elements 10 has the result that as they

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rotate they take up the greater part of the centrifugal force produced in the material, and despite the high peripheral speeds keep the ring of material in a loosened-up state.

When the FIGURE 1 apparatus is driven at a high speed by a motor, but bearing in mind the maximum permissible limit, the entire contents of the mixing container particularly those above the shaft are subjected to a throwing and whirling process. The loose balls 9 are continually thrown by the side surfaces of the mixing elements 10 in the directions indicated by the arrows, i.e. in the direction towards the axis of the drum, through the whirling material which is to be mixed.

When the loose balls impinge against surfaces of the mixing elements, mixing container walls and other balls, the coarse grains of material or agglomerations of material situated thereon are disintegrated.

With mixers constructed as shown in the drawings, the mixing time can, as compared with known ball-mills, be reduced to about e.g. 5-20% of the hitherto conventional time, depending on the kind of mixing problem in each particular case.

A particular advantage of the apparatus according to the invention resides in the fact that it is also possible to subject therein materials to the mixing procedure which during the mixing process tend to stick to the walls of the mixing container, as is often the case with colour pigments e.g. lithopones. It has been found that although in apparatus according to the invention the materials still have a tendency to stick, the loose balls continually knock off or disintegrate after a short time any material which has adhered to the walls, and thus the inner surfaces of the container are kept free of accretions.

What we claim is:

1. A method of mixing and comminuting a material in a stationary cylindrical drum in which a plurality of mixing instrumentalities are arranged for rotation about the drum axis and in which the distal ends of said instrumentalities are adjacent to the drum and, when rotated, direct loose substances contained in the drum toward said axis, said method comprising the steps of introducing into said drum loose substantially spherical comminuting elements until the elements fill between about 10 and 50 percent of the interior of said drum, introducing into said drum the material to be mixed and comminuted in such quantities that the elements and the material together fill about 70 percent of the interior of said drum, and then subjecting the elements and the material to the action of said mixing instrumentalities by rotating said instrumentalities at a constant supercritical peripheral speed in the range of about 2.5-14 meters per second, based on a drum diameter of 1 meter, whereby the material and the comminuting elements are continuously deflected from the wall and thrown toward the axis of said drum and a comminuting action takes place upon impact of the material against said comminuting elements, against said deflecting instrumentalities and against the interior of said drum.

2. A method of mixing and comminuting a material in a stationary cylindrical drum in which a plurality of mixing instrumentalities are arranged for rotation about the drum axis and in which the distal ends of said instrumentalities are adjacent to the drum and, when rotated, direct loose substances contained in the drum toward said axis, said method comprising the steps of introducing into said drum loose substantially spherical comminuting elements until the elements fill between about 10 and 50 percent of the interior of said drum, introducing into said drum the material to be mixed and comminuted in such quantities that the elements and the material together fill about 70 percent of the interior of said drum, and then subjecting the elements and the material to the action of said mixing instrumentalities by rotating said instrumentalities at a constant supercritical peripheral speed in the range of about 4-6 meters

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per second, based on a drum diameter of 1 meter, whereby the material and the comminuting elements are continuously deflected from the wall and thrown toward the axis of said drum and a comminuting action takes place upon impact of the material against said comminuting elements, against said deflecting instrumentalities and against the interior of said drum.

3. A method of mixing and comminuting a material in a stationary cylindrical drum in which a plurality of mixing instrumentalities are arranged for rotation about the drum axis and in which the distal ends of said instrumentalities are adjacent to the drum and, when rotated, direct loose substances contained in the drum toward said axis, said method comprising the steps of introducing into said drum loose substantially spherical comminuting elements until the elements fill between about 20 and 40 percent of the interior of said drum, introducing into said drum the material to be mixed and comminuted in such quantities that the elements and the material together fill about 70 percent of the interior of said drum, and then subjecting the elements and the material to the action of said mixing instrumentalities by rotating said instrumentalities at a constant supercritical peripheral speed in the range of about 2.5-14 meters per second, based on a drum diameter of 1 meter, whereby the material and the comminuting elements are continuously deflected from the wall and thrown toward the axis of said drum and a comminuting action takes place upon impact of the material against said comminuting elements, against said deflecting instrumentalities and against the interior of said drum.

4. A mixing and comminuting apparatus comprising in combination a cylindrical, stationary and horizontally disposed mixing drum, a rotatable shaft extending through said drum coaxially with the said drum, a plurality of arms extending radially from the said shaft, the said arms being axially spaced apart from each other and helically arranged on the said shaft, a plurality of ploughshare-like mixing means each of which is secured to the end of one of said arms in such a way that the tapered front end of the said ploughshare-like mixing means shows in the working direction, the leading edges of the said ploughshare-like mixing means are adjacent to the cylindrical wall of the drum and the side surfaces of the said ploughshare-like mixing means are directed towards the axis of the said drum, loose comminuting elements filling about 10-50 percent of the interior of the said drum and driving means imparting, when turned on, to the said ploughshare-like mixing means a supercritical peripheral speed of about 2.5-14 meters per second, based on a drum diameter of 1 meter.

5. A mixing and comminuting apparatus comprising in combination a cylindrical, stationary and horizontally disposed mixing drum, a rotatable shaft extending through said drum coaxially with the said drum, a plurality of arms extending radially from the said shaft, the said arms being axially spaced apart from each other and helically arranged on the said shaft, a plurality of ploughshare-like mixing means each of which is secured to the end of one of said arms in such a way that the tapered front end of the said ploughshare-like mixing means shows in the working direction, the leading edges of the said ploughshare-like mixing means are adjacent to the cylindrical wall of the drum and the side surfaces of the said ploughshare-like mixing means are directed towards the axis of the said drum, the said ploughshare-like means having the form of unilaterally acting ploughshares when arranged at the head ends of the said drum and otherwise the form of bilaterally acting ploughshares, loose comminuting elements filling about 10-50 percent of the interior of the said drum and driving means imparting, when turned on, to the said ploughshare-like mixing means a supercritical peripheral speed of about 2.5-14 meters per second, based on a drum diameter of 1 meter.

6. A mixing and comminuting apparatus comprising in combination a cylindrical, stationary and horizontally disposed mixing drum, a rotatable shaft extending through said drum coaxially with the said drum, a plurality of arms extending radially from the said shaft, the said arms being axially spaced apart from each other and helically arranged on the said shaft, a plurality of ploughshare-like mixing means each of which is secured to the end of one of said arms in such a way that the tapered front end of the said ploughshare-like mixing means shows in the working direction, the leading edges of the said ploughshare-like mixing means are adjacent to the cylindrical wall of the drum and the side surfaces of the said ploughshare-like mixing means are directed towards the axis of the said drum, the said ploughshare-like means having the form of unilaterally acting ploughshares when arranged at the head ends of the said drum and otherwise the form of bilaterally acting ploughshares, loose comminuting elements filling about 20-40 percent of the interior of the said drum and driving means imparting, when turned on, to the said ploughshare-like mixing means a supercritical peripheral speed of about 4-6 meters per second, based on a drum diameter of 1 meter.

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