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(72) Inventor: **Murray, Alastair Scott**
Huntly, Aberdeenshire AB54 4PT (GB)

(74) Representative: **Pattullo, Norman et al**
Murgitroyd and Company
373 Scotland Street
Glasgow G5 8QA (GB)

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(71) Applicant: **QED International Limited**
Huntly, Aberdeenshire AB54 8JZ (GB)

(54) Method of and apparatus for grinding material

(57) A method of and an apparatus for grinding material is described, a vessel (1) for containing a grinding medium such as a ball charge (4). A means (13) for imparting a vibration force upon the vessel (1) is also pro-

vided. The vessel (1) has an inlet (5;6;18) to permit the material to be ground to be input into the vessel (1), and an outlet (5;6;18) to permit the ground material to exit the vessel (1). The inlet (5;6;18) and the outlet (5;16;18) are vertically spaced apart.

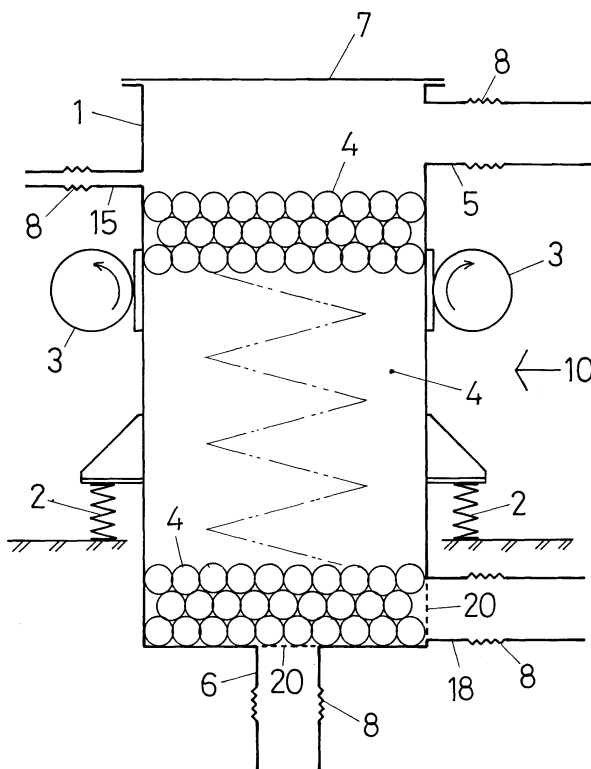


FIG. 1

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Description

[0001] The present invention relates to a method of, and apparatus for, grinding materials, and particularly but not exclusively, relates to a method of, and apparatus for, grinding drill cuttings produced while drilling oil, gas or water wells.

[0002] Conventionally, whilst drilling oil, gas or water wells, drill cuttings are produced from the formation being drilled. With particular reference to oil wells, the drill cuttings produced will often be coated in oil. There are several methods of disposing of oil-based drill cuttings, whether this be transporting the oil cuttings from an off-shore drilling rig to a disposal unit onshore or treating the oil-based cuttings offshore and disposing the drill cuttings over the side of the drilling rig. However, economic and environmental concerns mean that neither of these conventional methods are particularly acceptable.

[0003] It is proposed by the inventors that it would be desirable to grind the drill cuttings to fineness whereby the ground material may be safely dumped overboard from a drilling rig or platform and dispersed by ocean currents, if this proves environmentally acceptable. Alternatively, it may be possible to use the fine, ground drill cuttings for inclusion in a slurry for reinjection into a borehole for disposal. It may be possible to use this method of disposal for water based or oil based cuttings, and/or for Low Specific Activity (L.S.A.) which is naturally occurring radioactive material often present in drill cuttings or separation vessels, etc.

[0004] Conventional apparatus for grinding materials are known to include substantially horizontal grinding cylinders into which the material to be ground is placed, and the cylinders are vibrated. The cylinders are filled to about 60-70% with a grinding medium, which are conventionally steel or ceramic balls. The material being ground is introduced into the cylinder at one end, and passes longitudinally through the cylinder, in a complex manner, thus allowing the grinding medium to reduce it.

[0005] However, with these conventional substantially horizontal vibratory mills, there is a limit to their size due to the complex engineering required to control the vibratory forces. A major reason for this is that the mills are often filled with steel balls of varied diameter, whereby the gap created between the four balls surrounding it defines the size of particle which can be ground within that gap. This gap is known in the art as the "nip angle". Since the steel balls have different diameters, they will naturally rearrange themselves into distinct layers with the larger diameter balls being on top. Thus, when the material to be ground is introduced into the vibratory mill, the material tends to flow in a parallel direction to the layers of the grinding medium. An example of a conventional substantially horizontal vibratory mill is product number VBM 3034 offered by SVEDALA Industri AB.

[0006] According to a first aspect of the present invention, there is provided an apparatus for grinding material, the apparatus comprising a vessel for containing a

grinding medium, a means for imparting a vibration force upon the vessel, an inlet to permit the material to be ground to be input into the vessel, and an outlet to permit the ground material to exit the vessel, where the inlet and the outlet are vertically spaced apart.

[0007] According to a second aspect of the present invention, there is provided a method of grinding material, the method comprising inserting the material to be ground into a vessel containing a grinding medium, applying a vibrating force to the vessel, and permitting the ground material to exit the vessel from an outlet, where the inlet and the outlet are vertically spaced apart.

[0008] The material to be ground may be input into the vessel after being subject to a primary separation process. Preferably, the material to be ground is drill cuttings.

[0009] According to a third aspect of the present invention, there is provided a method of disposing of drill cuttings, the method comprising inserting the drill cuttings into the inlet as defined in the first or second aspect of the present invention, and disposing of the ground drill cuttings which exit the outlet, as defined in the first or second aspect of the present invention.

[0010] The drill cuttings may be disposed of in the sea, or alternatively, may be disposed of by including the ground material in a slurry, and preferably, reinjecting the slurry into a borehole.

[0011] Preferably, the material to be ground travels in a substantially vertical direction through the grinding medium.

[0012] Preferably, the vessel is a substantially cylindrical vessel, and in use, the vessel is preferably substantially vertical.

[0013] Preferably, the grinding medium is a ball charge which may be comprised of balls having a similar diameter, or alternatively, may be comprised of balls having a differing diameter.

[0014] Preferably, the means for imparting a vibrating force on the vessel is at least a pair of vibratory motors, and more preferably, the vibratory motors are coupled to the vessel at either side of the vessel, and most preferably, the vibratory motors are arranged diametrically opposite each other, and preferably, counter rotate with respect to one another.

[0015] This provides the invention with the advantage that the vibrating force generated acts in a vertical direction with respect to the centre line of the cylinder.

[0016] The vibratory motors are counter rotating, out of balance motors, and may be electric vibratory motors. Alternatively, the vibrating motors may be pneumatic vibratory motors, or alternatively may be hydraulic vibratory motors.

[0017] Preferably, the vessel is supported by a vibration damping means.

[0018] Typically, the inlet and the outlet are conduits which may comprise conduit vibration damping means.

[0019] An embodiment of the present invention will now be described by way of example only with reference

to the accompanying drawing, in which:-

Fig. 1 is a schematic view of an apparatus for grinding material in accordance with the present invention.

[0020] Fig. 1 shows a vibrating grinding mill 10 in accordance with the present invention. The mill 10 comprises a cylindrical body 1 which is configured in a substantially upright position. The cylindrical body 1 is supported from the ground by a resilient mounting 2, such as a set of springs or rubber blocks.

Alternatively, the cylindrical body 1 could be supported from above by steel wire, and in this configuration the steel wire would be similarly provided with a resilient mounting 2.

[0021] Attached at either side of the cylindrical body 1 are two suitably sized electric vibrating motors 3 which are mounted diametrically opposite each other approximately one third of the way up of the vertical height of the cylindrical body 1. The vibrating motors 3 are run in such a manner as to generate a high vibration force which acts in a vertical direction with respect to the centre line of the cylindrical body 1. An example of a suitable vibrating motor 3 is a counter rotating roller unit, product no MVSI 3/900-290 offered by Vibratechniques Limited of the United Kingdom. The electric vibrating motors 3 are arranged such that they counter rotate with respect to each other. It should be noted that additional pairs of vibrating motors 3 could be further attached to the outer surface of the cylindrical body 1 as long as they are diametrically opposite each other.

[0022] An upper conduit 5 is located at the upper end of the cylindrical body 1, and a lower conduit 6 is located at the lower end of the cylindrical body 1. One of the upper 5 and lower 6 conduits are used to input material to be ground into the cylindrical body 1, and the other of the upper 5 or lower 6 conduits provides an outlet for the ground material. An alternative conduit 18 is located at the side of the lower end of the cylindrical body 1. The upper 5, lower 6 and alternative 18 conduits all have vibration isolation pipework 8 sections therein which could typically could be formed from a concertinaed rubber material. This vibration isolation pipework 8 isolates the vibrating mill 10 from pipework outwith the mill 10.

[0023] The uppermost end of the cylindrical body 1 is provided with a removable cover 7 to permit access into the interior of the cylindrical body 1. An optional liquid additive inlet 15 is also provided to allow liquid additives to be input into the interior of the cylindrical body 1 to enhance the grinding of the material (not shown).

[0024] The interior of the cylindrical body 1 is filled to a suitable height with a grinding medium 4, which is typically ball charge 4 in the form of steel or ceramic balls. The ball charge 4 can be chosen to suit the material to be ground. For instance, the ball charge 4 can be all of the same diameter. Alternatively, and preferably, the ball charge is of differing diameters, and is therefore a size graded ball charge 4. In operation, when the cylindrical body 1 is vibrated by the vibrating motors 3, the grading

or sizing of the ball charge 4 is selected to give a reducing "nip angle" as the material travels through the ball charge 4, and thus avoid excessive space between the balls.

[0025] The lower 6 and alternative 18 conduits are provided with perforated plates 20 at their respective entrance to the cylindrical body 1 to ensure that the ball charge 4 is retained within the cylindrical body 1.

[0026] In use, the vibrating mill 10 is operated by counter rotating the pair of vibration motors 3. This consequently induces a vibration on the cylindrical body 1, which in turn provides a vibratory motion to the ball charge 4, in a vertical direction with respect to the centre line of the cylindrical body 1.

[0027] The material to be ground (not shown) can then, for instance, be inserted into the cylindrical body 1 via the upper conduit 5. The material to be ground will then, naturally due to gravity, fall through the ball charge 4 and will be progressively ground as it follows its path therethrough. The ground material will then exit the cylindrical body 1 via the lower conduit 6, or alternatively the alternative side conduit 18.

[0028] Alternatively, the material to be ground can be input into the cylindrical body 1 via the upper 5 or lower conduit 6 or the alternative side conduit 18 by means of a pump (not shown), which pumps the material to be ground up through the ball charge 4 to exit the cylindrical body 1 through the lower conduit 6, or upper conduit 5 or alternative side conduit 18.

[0029] The advantage of providing a vertical flow path for the material to be ground is that there is an additional 1g of force added to the ball charge 4, due to gravity.

[0030] Since it is possible to pass the material to be ground through a number of layers of ball charge 4, the ball charge 4 can be chosen with the biggest balls being able to accept the biggest material to be ground into their nip angle, and the smallest balls being chosen to provide a nip angle defining how fine the ground material is to be.

[0031] It is possible that the vibrating mills 10 could be arranged in series with the material to be ground exiting the outlet of one vibrating mill 10 and entering the inlet of the next vibrating mill 10. Additionally, each mill 10 within the series is likely to have a progressively smaller ball charge 4, and additionally may have progressively smaller charge 4 layered within.

[0032] The, or each, vibrating mill 10, is preferably installed in a close proximity to where the material to be ground is produced and disposed of. In the case of drill cuttings produced by an offshore drilling rig, this location is the drilling rig itself. The ground drill cuttings from the vibrating mill(s) 10 expected to be sufficiently fine for disposal, either overboard into the sea if environmentally acceptable or included in a slurry for reinjection into a borehole, to be a practical solution to the problem of disposing of the drill cuttings.

[0033] Control of the ground material particle size would be affected simply by controlling either the feed input rate into the cylindrical body 1, or alternatively the

discharge rate. Also shale shakers, hydrocyclones, and other conventional external material grading apparatus could also be used as separation or grading equipment before and after the vibrating mill 10.

[0034] Thus, the grinding effect of the vibrating mill 10 of the present invention is governed by the potential kinetic energy of the ball charge 4 as a whole, rather than of each ground material particle as in conventional vibration mills. Further, the vibrating mill 10 can be run at far higher frequencies than conventional vibration mills. In addition, the vibrating mill 10 of the present invention is far more efficient since the material to be ground may only have to make one pass through the ball charge 4.

[0035] Modifications and improvements may be made without departing from the scope of the invention.

Claims

1. An apparatus (10) for grinding material, the apparatus (10) comprising a vessel (1) for containing a grinding medium (4), a means (3) for imparting a vibration force upon the vessel (1), an inlet (5;6;18) to permit the material to be ground to be input into the vessel (1), and an outlet (5;6;18) to permit the ground material to exit the vessel (1), where the inlet (5;6;18) and the outlet (5;6;18) are vertically spaced apart.
2. An apparatus according to claim 1, wherein the material to be ground travels in a substantially vertical direction through the grinding medium (4).
3. An apparatus according to either of claims 1 or 2, wherein the vessel (1) is a substantially cylindrical vessel (1), and in use, is substantially vertical.
4. An apparatus according to any of the preceding claims, wherein the grinding medium (4) is a ball charge (4).
5. An apparatus according to any of the preceding claims, wherein the means (3) for imparting a vibrating force on the vessel is at least a pair of vibratory motors (3).
6. An apparatus according to claim 5, wherein the vibratory motors (3) are coupled to the vessel (1) at either side of the vessel (1).
7. An apparatus according to either of claims 5 or 6, wherein the vibratory motors (3) are arranged diametrically opposite each other.
8. An apparatus according to any of claims 5 to 7, wherein the vibratory motors (3) counter rotate with respect to one another.
9. An apparatus according to any preceding claim, wherein the means (3) for imparting a vibration force on the vessel (1) acts in a vertical direction with respect to the centre line of the vessel (1).
10. An apparatus according to any preceding claim, wherein the vessel (1) is supported by a vibration damping means (2).
11. An apparatus according to any preceding claim, wherein the inlet (5;6;18) and the outlet (5;6;18) are conduits (5;6;18) which comprise conduit vibration damping means (8).
12. A method of grinding material, the method comprising inserting (5;6;18) the material to be ground into a vessel (1) via an inlet (5;6;18) where the vessel (1) contains a grinding medium (4), applying a vibrating force (3) to the vessel (1), and permitting the ground material to exit the vessel (1) from an outlet (5;6;18), where the inlet (5;6;18) and the outlet (5;6;18) are vertically spaced apart.
13. A method according to claim 12, wherein the material to be ground is input (5;6;18) into the vessel (1) after being subject to a primary separation process.
14. A method according to either of claims 12 or 13, wherein the material to be ground is drill cuttings and/or Low Specific Activity.
15. A method of disposing of drill cuttings, the method comprising inserting the drill cuttings and/or Low Specific Activity into the inlet (5;6;18) as defined in either of claims 1 or 12 and disposing of the ground drill cuttings and/or Low Specific Activity which exit the outlet (5;6;18) as defined in either of claims 1 or 12.

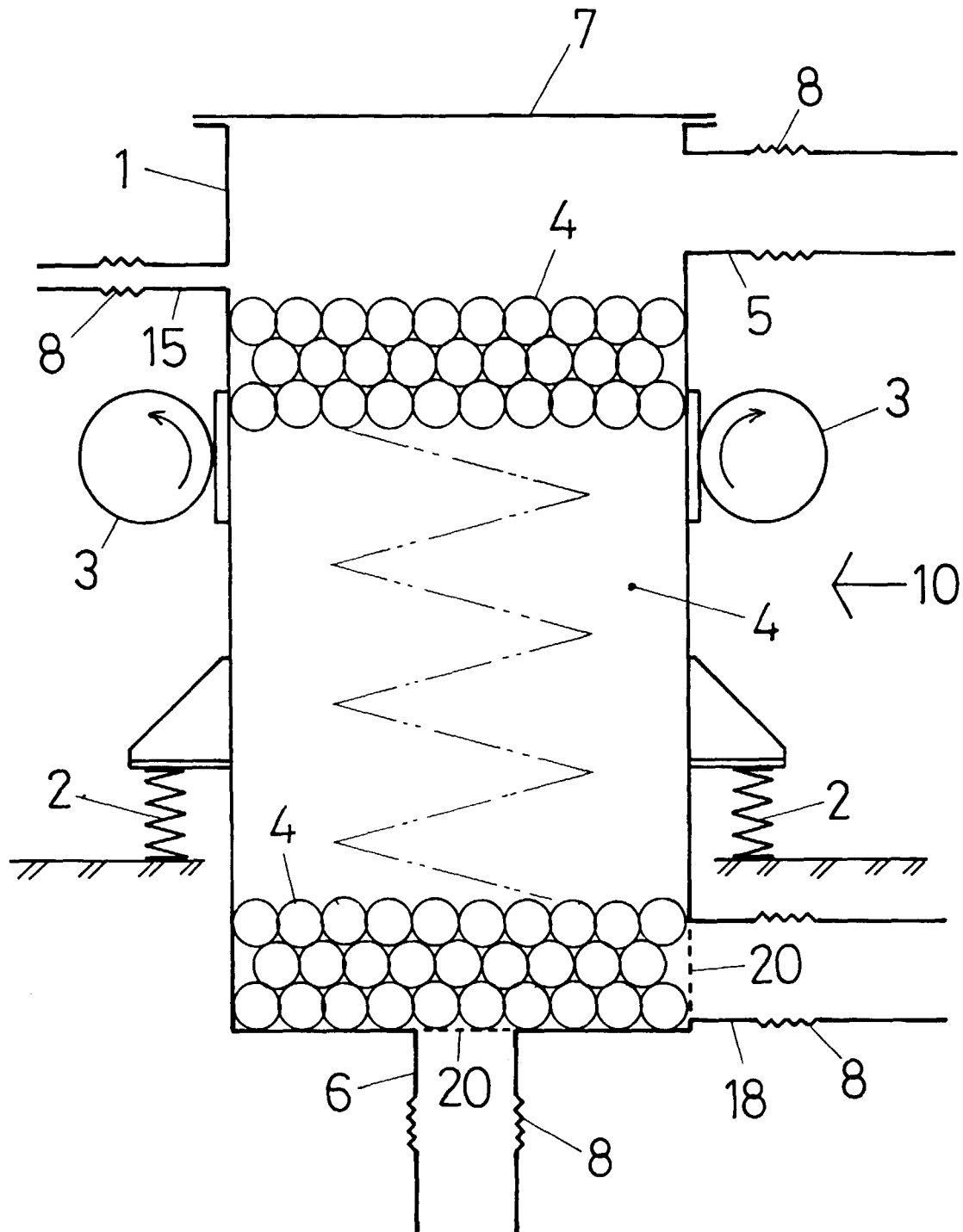


FIG. 1