

Leeman et al.

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- [21] Appl. No.: 84,367

- [57]
- ABSTRACT**

- Nov. 19, 1969** **Great Britain.....56,714/69**

- [52] U.S. Cl. 209/39, 209/172.5

- [51] Int. Cl. B03c 1/30

- [58] **Field of Search**.....209/39, 172.5, 12

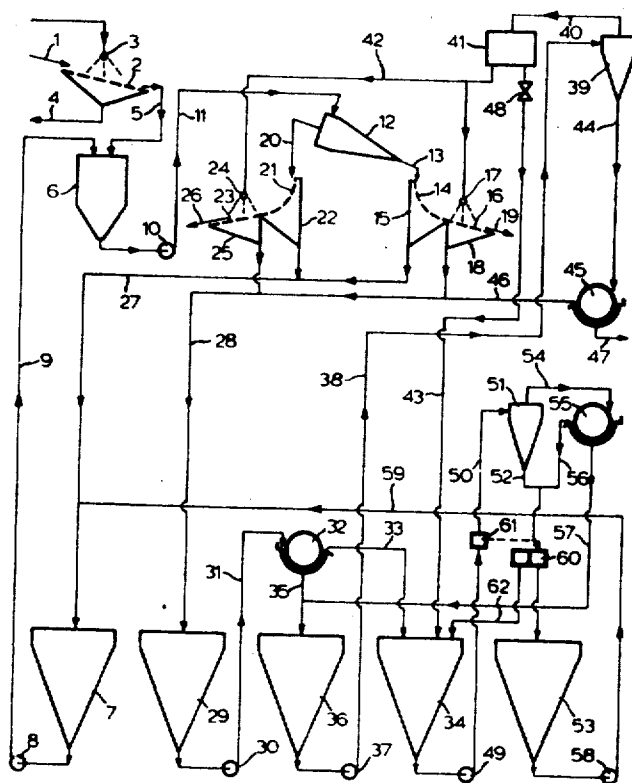
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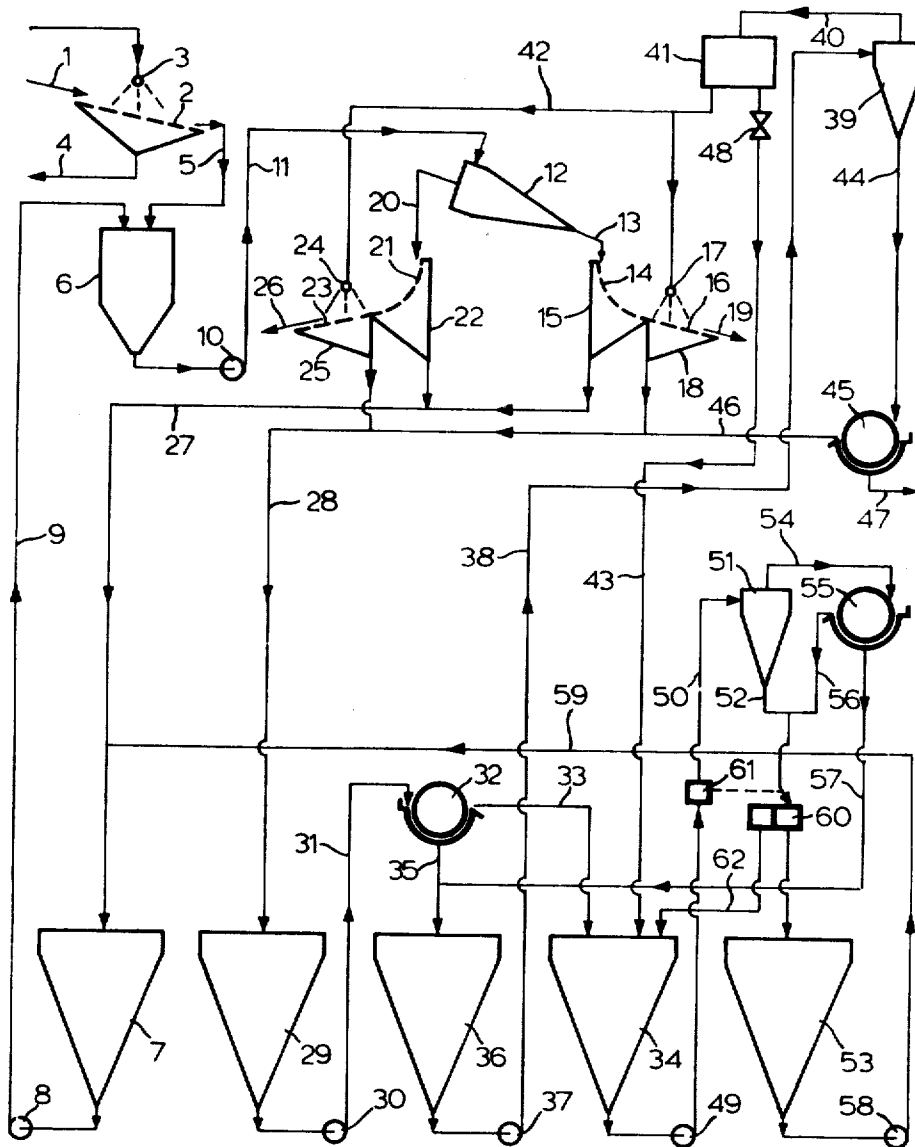
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A method for reconditioning a diluted suspension of fine magnetizable particles for reuse in a specific gravity separation process wherein the diluted suspension is first separated from any particulate impurities, then diluted and fed to a cyclone densifier wherein the coarser magnetizable particles of the suspension are concentrated and the fine particles are separated and fed to a magnetic separator, the fine particles are then combined with the suspension of concentrated relatively coarser particles.

6 Claims, 1 Drawing Figure





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RECONDITIONING OF SUSPENSIONS USED IN THE SEPARATION OF MINERALS

This invention relates to a method of reconditioning a diluted suspension of fine magnetizable particles and solid particulate contaminations in a liquid.

More specifically, the invention relates to a method for the reconditioning of suspensions which are rinsed off from products obtained in the course of the separation of minerals from tailings according to their specific gravity where a heavy medium comprising a suspension of magnetizable particles in a liquid is used.

This separation of the minerals from the tailings may be carried out in a float and sink bath or in a separator using centrifugal forces such as a cyclone washer. The heavy medium used in the separation may consist of a suspension of finely divided magnetite, ferrosilicon or a mixture of these magnetizable materials in water.

To remove the contaminations from the suspension which becomes diluted in the separation process, use is made of magnetic separators which separate the suspension into at least two fractions, one comprising the bulk of the magnetizable particles and the other comprising the bulk of the contaminations and the bulk of the water.

The cleaned magnetic fraction is obtained in a more or less concentrated state. In cases where the specific gravity at which the separation of the mineral is effected is relatively low, such as in the cleaning of coal, the specific gravity of the cleaned magnetic fraction is sufficiently high for this fraction to be used in the specific gravity separation system without first being subjected to a concentrating step. When separating heavy ores, such as iron ore, however, a further concentrating of the cleaned magnetic fraction is necessary to raise its specific gravity to the value required for reuse.

Accordingly, the method of the present invention is adapted to regulate the concentration of magnetic particles in the suspension used in a heavy ore mineral separation process so that the suspension will have a specific gravity value compatible with its intended use in the specific gravity separation system.

The concentrating of the cleaned magnetic fraction may be carried out in densifiers, such as spiral densifiers, static concentrators or cyclone densifiers. The use of cyclones for this purpose has the advantage as compared with other methods that the cyclones are cheaper in operation as they occupy less space and do not require mechanical devices for discharging the concentrates.

A cyclone densifier is an apparatus comprising a radially symmetrical vessel usually tapering towards one end and with a feed opening through which liquid medium containing suspended particles can be continuously supplied to create a vortex within the vessel and two opposed axial discharge openings through which fractions discharge from different parts of the vortex, one fraction (hereafter called 'the underflow') discharging through the apex opening and being more concentrated than the feed and the other fraction (hereafter called 'the overflow') discharging through the opening in the wider end of the vessel and being less concentrated than the feed.

In practice, it has been found that if a cyclone densifier is fed with the cleaned magnetic fraction from the

magnetic separator, the amount of magnetizable material, particularly the finer parts thereof, which discharge in the overflow is quite appreciable and additional equipment of relatively large capacity is required to recover these particles and to concentrate this secondary magnetic fraction to a density sufficiently high for addition to the underflow from the cyclone densifier without diluting this latter fraction to an extent that renders it unusable in the mineral separation process.

The present invention provides a method of reconditioning a diluted suspension of fine magnetizable particles and contaminating solids in a liquid in which the magnetic fraction obtained from the magnetic separator is concentrated by means of a cyclone densifier and wherein the equipment for recovering the magnetizable particles discharged through the overflow of the cyclone may be of relatively small capacity.

The method according to the invention comprises the steps of magnetically separating the diluted, contaminated suspension into at least a first fraction which includes the bulk of the magnetizable particles and a second fraction which includes the bulk of the contaminating solids and the bulk of the liquid, then diluting said first fraction, concentrating the thus obtained diluted fraction in a cyclone densifier to a specific gravity exceeding that of said first fraction, magnetically separating at least the bulk of the magnetizable particles from the overflow of the cyclone densifier and combining the fraction containing such magnetizable particles with the concentrated underflow discharge from the cyclone densifier.

The invention is based on the discovery that by diluting the feed to the cyclone densifier, the percentage of magnetizable particles discharging through the underflow opening of the cyclone is increased, and, furthermore, the specific gravity and volume of the underflow are so high that the magnetic fraction which is recovered from the overflow by magnetic separation can be added to such underflow without first being concentrated.

The method of the present invention enables the use of very finely divided magnetizable particles, which do not settle at an acceptably high rate in the separating devices. The grain size of the magnetizable particles may be substantially smaller than 60μ . So called 'atomized' ferrosilicon is preferably used due to its spherical shape. However, finely ground ferrosilicon, magnetite or mixtures of these materials may be used.

The extent to which the first fraction can be diluted in any given case prior to the introduction of such fraction into the cyclone densifier depends on the nature of the magnetizable material, on the characteristics of the cyclone densifier used, and, of course, on the extent of concentration which is required in the separation process. For attaining a given specific gravity value for the underflow, the feed concentration must be lower for some magnetizable materials than for others. The appropriate feed concentration, however, can be determined by simple tests. By way of illustration, a conical cyclone densifier was fed at a pressure of 1.1 atmospheres with a suspension of ferrosilicon (specific gravity of solids 6.75) in water at a concentration of 750 grams per liter; the underflow had a specific gravity of 3.9 and contained 80 percent of the magnetizable

material. However, when using the same densifier, a magnetite suspension (specific gravity of solids 5.0) of 750 grams per liter (10 percent by volume) concentration, corresponding with a specific gravity of 1.4, could be concentrated to give an underflow with a specific gravity of 2.3 but even at that setting the solids recovery in the underflow was only 50 percent. When feeding a 50/50 mixture of ferrosilicon and magnetite at the same feed concentration, the underflow specific gravity was 3.3 and the solids recovery in the underflow was 65 percent. In the case of ferrosilicon suspension an underflow with a specific gravity above 3.9 and a solids recovery of 80 percent could be achieved with a feed concentration of 1,000 grams per liter (15 percent by volume), corresponding with a specific gravity of 1.86. In general, the optimum concentration of the feed in any given system will be found to lie in the range 5 to 20 percent by volume.

The invention will be further explained with reference to the embodiment shown by way of example in the accompanying drawing, which represents a diagrammatic flow sheet of a preparation plant for iron ore in which a cyclone washer is used.

The mineral material to be separated, for example, raw iron ore having a grain size of 0 - ½ inch, is supplied with water through a launder 1 onto a desliming screen 2. On this screen the raw material is rinsed with water by means of sprayers 3. Particles smaller than 0.5 mm pass through the screen and are discharged as underflow through a conduit 4 for further treatment, such as froth flotation. The deslimed ore having a grain size larger than 0.5 mm is fed through a conduit 5 to a tank 6, in which it is mixed with a separating suspension.

The separating suspension is supplied from a tank 7 by means of a pump 8 through a conduit 9 to the mixing tank 6. The suspension consists of atomized ferrosilicon, 95 percent of which is smaller than 40 μ . The specific gravity of the suspension is about 3.2. The specific gravity of the separating medium has to be so high, on the one hand, because it is diluted in the mixing tank 6 by the incoming wet ore and, on the other hand, because of the high specific gravity of the tailings which are to be separated from the ore.

The mixture of raw iron ore and separating medium is fed by means of a pump 10 and a conduit 11 to a hydrocyclone washer 12, where it is separated into an ore fraction and a tailings fraction. The clean ore fraction is discharged from the cyclone 12 through a conduit 13 and supplied to a draining screen 14. Here the suspension oozes out of the ore mass and is collected in a reservoir 15. Subsequently the ore passes over a washing screen 16 where the suspension still adhering to the ore particles is sprayed off by means of sprayers 17. The thus diluted suspension passing through screen 16 is collected in a reservoir 18, whereas the cleaned ore is discharged at 19.

The tailings fraction is discharged from the cyclone washer 12 through a conduit 20 and supplied to a draining screen 21. The suspension drained from the tailings is collected in a reservoir 22. Suspension still adhering to the tailings is sprayed off on washing screen 23 by means of sprayers 24. The diluted suspension passing through screen 23 is collected in a reservoir 25, whereas the tailings are discharged at 26.

The undiluted suspension collected in the reservoirs 15 and 22 may be reused without further treatment and is passed through a conduit 27 to the storage tank 7.

The diluted suspension collected in the reservoirs 18 and 25 not only contains the ferrosilicon particles but also those particles of the separated fractions which have a size smaller than the mesh of screens 16 and 23. This diluted suspension flows through a conduit 28 to a diluted media tank 29. From this tank 29, the diluted suspension is pumped by means of a pump 30 through a conduit 31 to a magnetic separator 32. In this magnetic separator a concentrated ferrosilicon suspension is recovered, which may have a specific gravity of about 2.7. This fraction flows through a conduit 33 to a collecting tank 34.

A dilute nonmagnetic fraction is separated off in the magnetic separator 32, which fraction is discharged through a conduit 35 into a tank 36. From this tank 36, the suspension is fed by means of a pump 37 and through a conduit 38 to a clarifying cyclone 39. The clarified overflow from this cyclone discharges via a conduit 40 into a reservoir 41 from which it is partly returned to the cleaning system through a conduit 42 leading to the sprayers 17 and 24 and partly to the collecting tank 34 through a conduit 43 as described hereinafter. As the concentrated apex discharge of cyclone 39 may still contain a small portion of the ferrosilicon particles, this discharge is fed through a conduit 44 into a magnetic separator 45. The magnetic particles recovered in this separator may be fed through a conduit 46 into the dilute medium tank 29 as shown in the drawing or returned to the collecting tank 36. The tailings from this separator are discharged through a conduit 47.

The magnetic fraction from the magnetic separator 32, which has a specific gravity of about 2.7 is diluted in the collecting tank 34 by the addition of clarified water through conduit 43. The amount of water is controlled by means of a valve 48 in such a way that the medium in the tank has a specific gravity of about 1.86 which corresponds with 1,000 g ferrosilicon in one liter suspension or about 15 percent by volume of solids in the suspension.

The medium from the collecting tank 34 is supplied by means of a pump 49 through a conduit 50 into a cyclone densifier 51. The concentrated apex underflow discharge of this cyclone has a specific gravity of about 3.8 and is led through a conduit 52 into an overdense medium tank 53. The overflow of the cyclone contains about 250 g/l ferrosilicon and is fed through a conduit 54 into a magnetic separator 55.

In the magnetic separator 55, a magnetic fraction is recovered which has a specific gravity of about 2.35 and is discharged through a conduit 56. This fraction is combined with the concentrated fraction flowing through line 52 and introduced into the tank 53. The specific gravity of the combined medium in this tank amounts to about 3.5. The nonmagnetic fraction from the magnetic separator 55 is fed through a conduit 57 into tank 36.

As the overflow of the cyclone 51 mainly contains the finest particles of the magnetizable material and the apex discharge the coarser particles of this material, these fractions have to be combined so that the suspension recirculated to the gravity separation process will

include the whole size range of the magnetizable particles.

In the example given above, about 75 percent of the magnetizable particles in the suspension fed into the cyclone densifier 51 is discharged in a concentrated condition through the apex outlet (underflow) of the cyclone. By increasing the solid content of the input of the cyclone so that it consists of more than 20 percent by volume of solids, the amount of magnetizable material discharged through the overflow of the cyclone can be markedly increased. As a consequence, less concentrated medium is discharged through the apex opening of the cyclone, whereas the amount of magnetic suspension obtained from the magnetic separator 55 increases.

As a result, on the one hand, the specific gravity of the suspension obtained by combining these fractions is decreased whereas, on the other hand, the capacity of the secondary separation unit 55 has to be increased to handle the greater amount of suspension discharged through the overflow of the cyclone densifier.

The suspension in the overdense medium tank 53 is pumped by means of a pump 58 and a conduit 59 to the medium storage tank 7. As this suspension is mixed with the suspension drained from the fractions separated by the washing cyclone and the latter suspension is constantly diluted by water adhering to the raw ore due to the spraying action on the desliming screen 2, the specific gravity of the suspension returned through line 59 to the gravity separation system has to be in excess of that in the specific gravity separation system.

When the concentration of the input of the cyclone densifier 51 falls below a certain critical value, which may be 5 percent of solids by volume, the specific gravity of the combined fractions introduced through line 52 into the tank 53 will fall below the value required for the separation process. This decrease in concentration may be caused by the fact that the amount of ore being treated has decreased considerably so that less magnetizable particles are rinsed off and passed over the magnetic separator 32 into the tank 34. To prevent the suspension in the overdense medium tank 53 from being diluted by the incoming medium a splitter box 60 is provided in conduit 52, which splitter box is adjusted by means of a specific

gravity control device 61 in such a way that the medium is recirculated through a conduit 62 to the tank 34 when the concentration of the feed to the cyclone densifier falls below a certain value.

It will be appreciated from the foregoing that the present invention provides a method for reconditioning a suspension of fine magnetizable particles as well as regulating the concentration of the suspension within a range whereby the suspension may be employed at nearly optimum efficiency in a separation process.

The invention is not restricted to the separation of iron ore as described in the example. Other minerals such as lead-zinc ore, uranium ore, tungsten ore, magnesite, etc., may be separated by using the method according to this invention. WE CLAIM:

1. A method of reconditioning a diluted suspension of fine magnetizable particles and contaminating solid particles in a liquid, which comprises the steps of magnetically separating the diluted suspension into at least a first fraction which includes the bulk of the magnetizable particles and a second fraction which includes the bulk of the contaminating solid particles and the bulk of the liquid, diluting said first fraction, concentrating the thus obtained diluted fraction in a cyclone densifier to a specific gravity exceeding that of said first fraction, magnetically separating at least the bulk of the magnetizable particles from the overflow of the cyclone densifier and combining the fraction containing such magnetizable particles with the concentrated discharge from the cyclone densifier.

2. A method according to claim 1, in which the first fraction is diluted prior to its introduction into the cyclone densifier to such an extent that the volume of the solids in the suspension varies from 5 to 20 percent.

3. A method according to claim 1, which comprises clarifying the second fraction and diluting the first fraction with part of said clarified second fraction.

4. A method according to claim 1, in which the combined fraction is recirculated to the diluted first fraction when the concentration of the infeed of the cyclone densifier falls below a predetermined value.

5. A method according to claim 1, in which the grain size of the magnetizable particles is substantially smaller than 60 μ .

6. A method according to claim 1, in which atomized ferrosilicon is used as the suspension material.

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