United States Patent

Iannicelli

[15] **3,667,688**

[45] **June 6, 1972**

[54] METHOD FOR SHEARING SOLIDS IN A SOLIDS-LIQUID SUSPENSION

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[22] Filed: **Nov. 16, 1970**

[21] Appl. No.: **89,973**

Related U.S. Application Data

[62] Division of Ser. No. 740,955, June 28, 1968, Pat. No. 3,556,416.

[52] **U.S. Cl.** **241/1,** 241/30

[51] **Int. Cl.** **B02c 19/00**

[58] **Field of Search** 241/1, 5, 15, 30

[56] **References Cited**

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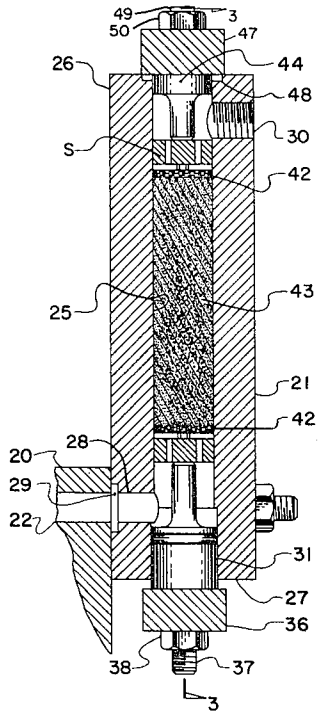
Primary Examiner—Granville Y. Custer, Jr.

Attorney—Harold H. Flanders

[57] **ABSTRACT**

A method for dis-aggregating solid particles in a slurry by pumping the slurry at pressures in excess of 1,000 p. s. i. through a column containing particulate media clamped in a fixed position is disclosed.

4 Claims, 10 Drawing Figures



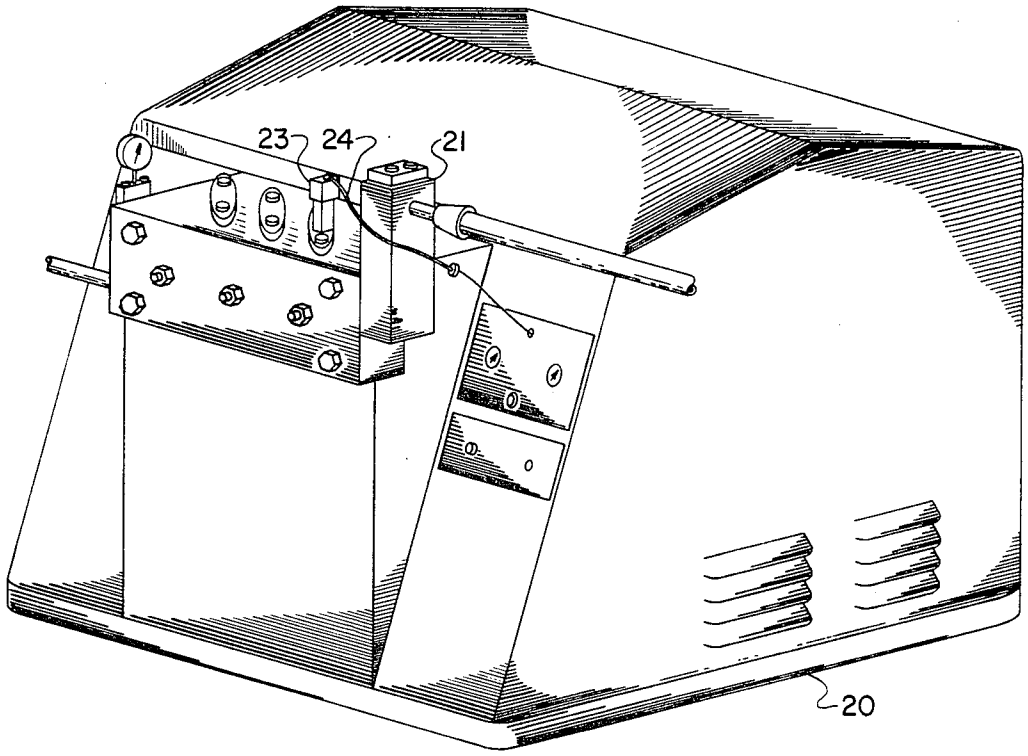


FIG. 1

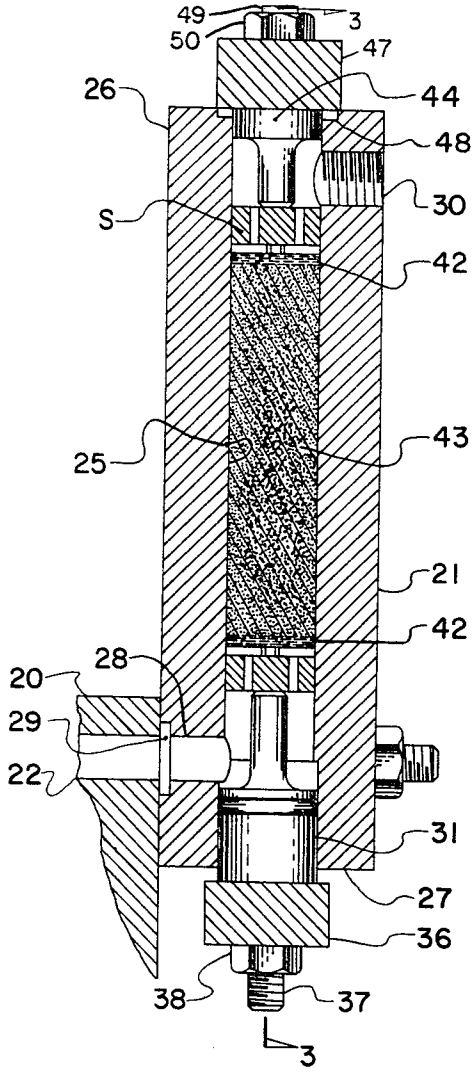


FIG. 2

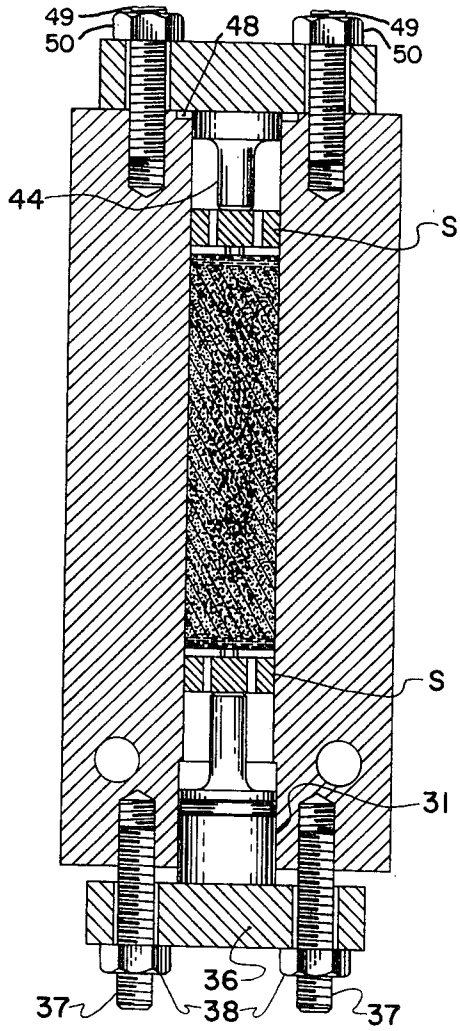


FIG. 3

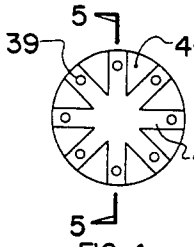


FIG. 4

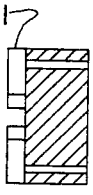


FIG. 5

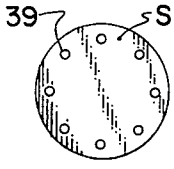


FIG. 6

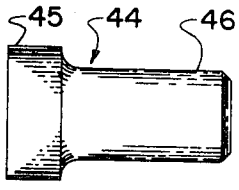


FIG. 9

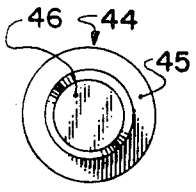


FIG. 10

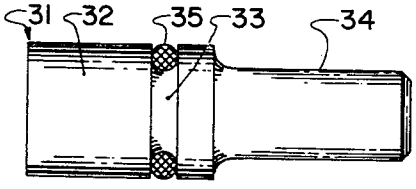


FIG. 7

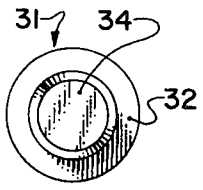


FIG. 8

METHOD FOR SHEARING SOLIDS IN A SOLIDS-LIQUID SUSPENSION

CROSS-REFERENCE TO RELATED APPLICATION

This is a division of application Ser. No. 740,955, filed June 28, 1968 now U.S. Pat. No. 3,556,416 issued Jan. 19, 1971.

BACKGROUND OF THE INVENTION

In general, the present invention relates to solid-liquid suspensions and more specially to a method for shearing solids in such suspensions.

In particular, the invention relates to the method for reducing the size of particles suspended in a slurry by forcing the slurry through a column packed with relatively coarse, hard, substantially non-deformable, non-flowable discrete aggregates including both abrasive as well as non-abrasive material in a wide variety of geometric shapes.

The high pressure pumping of slurries to shear the slurries and effect changes in the characteristics of the solids is, of course, well known. Such pumping has been used for processes such as homogenization, dispersion of solids in fluids, reduction in viscosity and reduction in particle size. In such uses, a resiliently biased orifice valve is used to retard the flow of slurry from the pump to build pressure in the pump and force the slurry at extremely high velocities through an orifice in a relatively thin film. In each of these uses the very high velocity of the slurry is such that the valve is quite quickly eroded away and must be replaced after a very short useful life.

Pumping as described above is, however, extremely efficient and even with the high maintenance cost in valve replacement is one of the most efficient shear apparatus now available.

Accordingly, it is an object of the present invention to provide a new, highly effective method which overcomes the deficiencies of the prior art as described above while retaining at least a like efficiency of operation.

It is a further object of the present invention to provide a method which will reduce the cost of the shearing operation in a solid-liquid suspension.

Another object of the present invention is to provide a method of operation for achieving shearing in solid-liquid suspensions having increased reliability.

Other objects and a fuller understanding of the present invention may be had by referring to the following description and claims taken in conjunction with the accompanying drawings.

SUMMARY OF THE INVENTION

The present invention overcomes the deficiencies of the prior art and achieves its objectives by providing a packed column of hard substantially non-deformable, relatively coarse particle size aggregates which provide a plurality of tortuous passages through which a suspension of solids in a liquid is pumped at an inlet pressure in excess of 1,000 p. s. i. In passing through the tortuous passages a very rapid acceleration to very high velocities takes place. At the same time the suspension is exposed to an extreme turbulent condition combined with shear, cavitation and impact as it impinges on the surrounding aggregates. The process produces a dispersion of reduced particle size which in some materials such as kaolin clay may result from dis-aggregation and delamination.

BRIEF DESCRIPTION OF THE DRAWINGS

In order to facilitate the understanding of the present invention, reference will now be made to the appended drawings. The drawings should not be construed as limiting the invention, but are exemplary only. In the drawings:

FIG. 1 is a perspective view of a high pressure pump.

FIG. 2 is a vertical cross-section taken through the column.

FIG. 3 is vertical cross-section taken along the line 3—3 of FIG. 2 looking in the direction of the arrows.

FIG. 4 is a plan view of a screen support.

FIG. 5 is a vertical cross-section taken along the line 5—5 of FIG. 4 looking in the direction of the arrows.

FIG. 6 is a plan view of the face of the screen support opposite the face illustrated in FIG. 4.

FIG. 7 is a plan view of the lower clamp member shown partially in section for convenience of illustration.

FIG. 8 is an end view of the structure illustrated in FIG. 7.

FIG. 9 is a side elevation of the upper clamp member and FIG. 10 is an end view of the structure illustrated in FIG. 9.

Referring now to the drawings in detail wherein like reference characters indicate like parts throughout the several figures.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

An apparatus suitable for carrying out the present invention is shown generally in FIG. 1 in which the reference numeral 20 indicates generally a high pressure pump which may be used in accordance with the present invention.

The high pressure pump 20 may be of any type developing in excess of about 1,000 p. s. i. with the pump illustrated being a Sub Micron Disperser Model 2050–MC45–5TBS as manufactured by Manton-Gaulin Manufacturing Company, Inc., Everett, Massachusetts. The pump, shown here for purposes of illustration, is of a conventional piston cylinder type and has a column block 21 secured to the outlet 22 thereof. A bypass valve 23 communicates with the outlet end of the pump 20 and is controlled through a hydraulic line 24 to vary the pressure at which the bypass valve 23 will release. The bypass valve 23 is of conventional construction. The bypass or relief valve may be a hydraulically loaded homogenization type valve or a spring loaded release valve or similar device. Obviously, any suitable pump capable of achieving the desired pressures may be employed in accordance with the teachings of the present invention as a matter of choice. In particular, a piston cylinder type pump need not be employed. Other type pumps such as those of the gas pressure or of the centrifugal type may be employed so long as they produce adequate pressure for the desired application.

The column block 21 is of generally rectangular cross section and is provided with a central bore 25 extending completely through the top end 26 and the bottom end 27 of the column block 21. An inlet bore 28 extends horizontally from the central bore 25 through the side wall of the column block 21 near the bottom end 27 thereof. A recessed seal 29 is arranged at the outer end of the inlet bore 28 and seals the column block 21 to the pump 20.

A threaded outlet bore 30 extends horizontally from the central bore 25 through the side wall of the column block 21 near the top end 26 thereof. The outlet bore 30 extends through the opposite side of the column block 21 from the inlet bore 28.

A lower clamp member 31 has a generally cylindrical body 32 having an annular O-ring groove 33 formed therein. A reduced diameter extension 34 is integrally formed on the body 32 and extends coaxially therewith. The clamp member 31 is fitted with an O-ring seal 35 seated in the O-ring groove 33. The O-ring seal 35 engages the surface of the bore 25 below the inlet bore 28 to prevent escape of pressure through the lower end of the bore 25.

A plate 36 is positioned in engagement with the lower end of the clamp member 31 and is secured to the column block 21 by a pair of threaded studs 37 and nuts 38 as can be seen in FIGS. 2 and 3.

While the above description of the column block has been provided for purposes of illustration it will be obvious to those skilled in the art that many variations of the column block and its cross-section may be employed while retaining its essential functions and without departing in substance from the teachings of the present invention.

A generally cylindrical screen support S is mounted in the bore 25 in engagement with the upper end of the extension 34. The screen support S has a plurality of bores 39 extending therethrough with their axes parallel to the axis of the support

S. The bores **39** are arranged in a circle adjacent the cylindrical wall of the support S. One end face **40** of the support S is provided with a plurality of radially extending grooves **41** which each intersect one of the bores **39** and also intersect each other at the center of the support S.

A plurality of screens **42** of graduated mesh are mounted on the support S in engagement with the end face **40**.

A body of particulate media **43** fills the central portion of the bore **25** supported on the screens **42**. A second set of screens **42** and a support S engage the upper end of the body of particulate media **43**. An upper clamp member **44** has a cylindrical body **45** and a reduced diameter extension **46** integrally formed thereon and extending axially therewith.

A plate **47** is positioned against the upper end of the column block **21** and engages the upper end of the clamp member **44** and a recessed seal **48**. The plate **47** is secured to the column block **21** by a pair of stud bolts **49** and nuts **50**. The upper clamp member **44** bears against the upper screen support S to position it within the bore **25**. Adjustment of the lower plate **36** by means of the nuts **38** exerts varying clamping pressure on the particulate media **43** and may be tightened as required by the conditions.

The above description of an apparatus suitable for carrying out the present invention utilizing support screens should not be understood to limit the present invention to such an arrangement. Specifically, in many applications it will suffice to order the particle size of the particulate media in a decreasing manner toward the center of the column from each end, with the larger particles at each end of the column serving wholly or in part to restrain the central particles of the column. In general, any suitable clamping or restraining means may be utilized in lieu of the screens to function in accord with the present invention. Further, as will become increasingly clear, the present invention is in no way limited by the details of the pump and clamping mechanisms disclosed above, by way of example, but any similar suitable means may be employed to a like end.

In carrying out the method of the present invention the pump **20** is operated in a normal manner to pump a fluid dispersion of particulate solid through the column **21** of packed particulate media **43** at a predetermined pressure. The individual particles of the dispersed particulate solid are reduced in size by attrition, fracturing and delamination.

The method of the invention is practiced generally by selecting a particulate media suitable for the purpose and packing the column block **21** with this media. The clamp member **31** is tightened until the media is clamped sufficiently tight to prevent virtually all motion between particles of the media during the practice of the invention.

A particulate solid dispersed in a fluid is then pumped at a pressure in excess of about 1,000 p. s. i. through the particulate media in the column block **21**. The operation may be repeated for as many passes through the particulate media as is required to produce the desired properties in the end product.

The following examples teach several of the preferred embodiments of the invention.

EXAMPLE I

A 68.5 solids slurry of coarse filler grade clay having a particle size of 32.1 percent − 2 microns, 36 percent + 5 microns and, 16.49% + 10 microns was pumped at 1,000 p. s. i. through a column packed with spherical alumina ceramic beads of 12 to 18 mesh in size.

The resulting clay product had a particle size of 37.6 percent − **2** microns, 32.8 percent + **5** microns and **13.7** percent + **10** microns.

The following table illustrate additional examples showing the materials used and the results obtained.

In Table I above the reference letters are explained as follows:

A. Tumblex **12** XM: A highly abrasive ceramic frit obtained from the Norton Company.

B. Tumblex TL: A high alumina prism approximately one-fourth inch per side and three thirty-seconds inch thick obtained from the Norton Company.

C. LC. Tumblex TL: Ceramic cylinders ⅛ × ⅛ obtained from the Norton Company.

D. Plexiglass Rods: Cylinders ⅛ × ⅛ inch obtained from Rohm & Haas.

E. 20 – 25 Mesh Ottawa Sand: Obtained from Ottawa Silica Company, Ottawa, O.

F. 7 –12 Mesh Alundum Beads: Alumina spheres obtained from Minnesota Mining and Manufacturing.

G. Talc: Equal parts of Nytal 200 and Nytal 300 talcs obtained from Gouvenuer Talc Company.

Tables I and II illustrate the reduction in particle size of the

TABLE I

Example	Material treated	Percent solids	Particulate media	Pressure p.s.i. 1st pass	2nd pass	3rd pass	Percent −2 microns at beginning	Percent −2 microns at finish
II	Kaolin coarse filler grade	70	Tumblex 12 XM (A)	3,300			31.1	39.2
III	do	70	Tumblex TL (B)	2,200			31.1	37.0
IV	do	70	Tumblex TL (C)	1,200			31.1	36.1
V	Product from Example IV	70	do		1,400		36.1	37.1
VI	Product from Example V	70	do			1,550	37.1	38.1
VII	Kaolin coarse filler grade	70	Plexiglass Rods (D)	2,300			31.1	32.7
VIII	Product from Example VII	70	do		1,700		32.7	34.3
IX	Product from Example VIII	70	do			1,400	34.3	35.9
X	Kaolin coarse filler grade	30	20–25 mesh Ottawa sand (E)	3,000			31.1	37.1
XI	Talc (G)	10	7–12 mesh alundum beads (F)	900			16.1	12.6
XII	do	10	do		900		16.2	16.4
XIII	do	10	do			900	16.4	16.7

TABLE II

Example	Material treated	Solids, percent	P.s.i.	Number passes	Particulate media	Percent −2 microns at beginning	Percent −2 microns at finish
IX	Talc	36.45	2,700	1	Tumblex 12 XM	9.9	14.7
			2,075	4	do	14.7	15.2
			1,900	7	do	15.0	16.2
			1,700	10	do	16.2	18.5
X	Feldspar	31.2	2,650	1	Tumblex 12 XM	8.5	9.8
			2,000	4	do	9.8	12.2
			1,750	7	do	12.2	12.5
			1,625	10	do	12.5	13.9
XI	Calcium carbonate	36.3	1,650	1	Tumblex 12 XM	11.4	11.9
			1,550	4	do	11.9	12.1
			1,500	7	do	12.1	12.5
			1,450	10	do	12.5	12.9
XII	Nepheline syenite	37.2	2,700	1	Tumblex 12 XM	11.2	13.4
			2,275	4	do	13.4	15.3
			2,000	7	do	15.3	18.1
			1,900	10	do	18.1	20.0

TABLE III

Example	Material treated	Percent solids pumped	P.s.i.	Number of passes	Particulate media	70% Solids consolidated method viscosities					
						As is			.025% Soda ash added		
						Brookfield cps. 20 r.p.m. No. 1 spindle	Hercules dyne units/ r.p.m.*	Stormer sec. per 100 revolutions 150 g. wt.**	Brookfield cps. 20 r.p.m. No. 1 spindle	Hercules dyne units/ r.p.m.*	Stormer sec. per 100 revolutions 150 g. wt.**
XIII	Hydrasperse (No. 2 coating grade clay) kaolin clay control		0	0		178	18/670	13.6	192	18/660	14.2
XIV	Hydrasperse kaolin clay	69.32	3,700	1	Diamonite ¼" (H)	174	18/845	12.8	191	18/815	13.3
XV	do	69.0	2,800	2	do	168	18/910	12.3	183	18/855	12.7
XVI	do	69.47	3,000	1	Hi-density ¼" cyl (I)	164	18/945	12.0	186	18/840	12.6
XVII	do	69.0	2,900	2	do	164	18/870	12.0	181	18/815	13.0
XVIII	do	69.37	2,900	1	Stainless steel balls ¼" (J)	170	18/935	12.7	184	18/850	13.2
XIX	do	69.00	2,300	2	do	168	18/915	12.6	181	18/850	13.0
XX	Hydrasperse kaolin clay control	70.0	0	0		174	18/750	13.0	194	18/705	13.6
XXI	Hydrasperse kaolin clay	69.47	4,000	1	Lucite balls 3/16" (K)	170	18/940	12.3	188	18/910	12.8

*18 dyne units is maximum torque recorded on viscometer; higher r.p.m. at 18 dyne units represents lower viscosity.
**Lower time units per 100 r.p.m. represents lower viscosity.

material treated with wide variations in the pressures, solids content, particulate media and of the material treated.

Table III illustrates the reductions in viscosity which result from the practice of the invention.

In Table III the reference letters are explained as follows:

H. Diamonite one-fourth inch: one-fourth inch hi-density radius - end fused alumina cylinders obtained from U. S. Stoneware.

I. Hi-Density one-fourth inch Cyl: one-fourth inch fused alumina hi-density flat end cylinders obtained from U. S. Stoneware.

J. Stainless Steel Balls one-fourth inch: one-fourth inch spheres of stainless steel obtained from U. S. Stoneware, Akron, O.

K. Lucite Balls three-sixteenths inch: three-sixteenths inch spheres of polymethylmethacrylate obtained from Ace Plastic Co., Inc.

The examples demonstrate that the high pressure pumping of solids dispersed in a fluid through a column packed with particulate media will reduce the particle size of the dispersed solid and also reduce the viscosity of the treated material.

In carrying out the invention any material exhibiting suitable properties of hardness, substantial non-deformability and available in durable, relatively coarse particle sizes may be employed to provide the plurality of tortuous passages through which the solid-liquid suspension is passed. Typical materials of suitable hardness include ceramic frits, alumina, sands, stainless steels, Lucite, Plexiglass, silicon oxides, tungsten carbide, titanium nitride, zirconium carbide, beryllium carbide, titanium carbide, silicon carbide, aluminum boride, boron carbide and the like.

The shape of the particles of the particulate media will generally be spherical, quasispherical, spheroidal, or polyhedral and should not, in general, have many jagged edges since such edges lead to a knitting effect which increases the pressure requirements. This latter consideration is not intended to exclude, however, the use of such materials under certain operating conditions for specific suspensions where the knitting effect is not significant or the increased pressure requirements are not significantly objectionable. Further, nothing above is meant to exclude any shape of particulate material which otherwise meets the needs of the present invention as disclosed herein. For example, certain geometric combinations of tetrahedras, in addition to those naturally occurring, have been found quite satisfactory as a shape for the individual particles of the media in the operation of the present invention.

The length of the column through which the suspension is to be passed is proportionally related to the initial pressure and the amount of pressure drop across a given length of the column, with a large portion of the work on the solids in suspension believed to be performed in the initial portions of the column.

In addition to the single column shown, several obvious variations to one of ordinary skill in the art may be employed. For example, a single elongated column with decreasing particle size throughout may be used. Alternatively a single high pressure pump may be employed to force the suspension through a plurality of individual columns in a serial arrangement with each column packed with particles of decreasing size. Another alternative is the provision of a plurality of pumps each pump being placed just prior to respective members of a plurality of columns. An additional alternative is the provision of a plurality of columns in a parallel arrangement for funneling the suspension through one or more columns of finer particle size. Any combination of the above arrangements may be employed or modified to meet the needs of the particular materials and exigency of the occasion.

As many passes of the material through a given column as are desired or required may be made to achieve the desired particle size and/or viscosity; however, in general, an excessive reduction in particle size by continued repeated passes will result in an undesirable increase in viscosity.

While the invention has been described with reference to its preferred embodiments, it will be understood by those skilled

in the art that various changes may be made and equivalents substituted for elements and steps thereof without departing from the true spirit and scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from its essential teachings.

WHAT IS CLAIMED IS:

1. The method of reducing the particle size of a solid dispersed in a slurry comprising pumping the dispersion at a pressure in excess of 1,000 p.s.i. through a clamped body of a particulate media.

2. The method of claim 1 wherein the percent solids in the dispersion is in a range of from about 10 to about 80 percent.

3. The method of shearing and reducing the particle size of solids dispersed in a slurry by dis-aggregation, attrition, fracturing and delamination of the solids comprising:

a. providing a solids-liquid suspension wherein the percentage of solids is in the range of from about 10 to about 80 percent and wherein at least 8.5 percent of the solids have a particle size less than 2 microns and a predominant portion of which have a particle size less than 10 microns;

b. restraining a particulate media comprising a plurality of hard, durable, substantially non-deformable, non-flowable discrete particles a substantial portion of which have dimensions on the order of the particle size range of from about 25 mesh to about one-fourth inch within the central bore of a column; and

c. pumping said solids-liquid suspension at an inlet pressure in excess of 1,000 pounds per square inch through the central bore of said column to force said solids-liquid suspension through the body of said particulate media wherein said discrete particles provide a plurality of tortuous passages producing high shear on said solids as said suspension is pumped through the column.

4. The method of claim 3 further including adjusting the restraining pressure on said particulate media so as to prevent substantially all movement by the particles of said media when subjected to the flow of said suspension.

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