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MANUFACTURE OF ARTIFICIAL GRIND-
STONES FOR PULP GRINDING

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This invention relates to the manufacture of wood-pulp grind-stones this application being a continuation of the prior application Serial No. 469,931, filed July 22, 1930.

5 The manufacture of ground wood-pulp for paper requires grind-stones having characteristics difficult to obtain in the usual manufactured abrasive wheels. The manufacture of ground wood-pulp differs from the usual grinding operations in that its principal product is individual
10 fibres, or at least very small bundles of fibres, whereas the principal product of the usual grinding operation is the article from which small particles have been removed. In grinding wood to
15 make pulp for paper it is necessary to control the character of the grindings, but in smoothing surfaces or removing undesirable parts of articles it is necessary to control the shape of the piece being ground, while the nature of the grindings
20 is immaterial except insofar as it serves as an indication of the character of the surface produced on the article from which the particles were removed.

25 Until recent times all grind-stones for making wood-pulp have been of natural sandstone. The use of this material for pulp grinding persists today whereas in almost all other grinding operations manufactured abrasive wheels have supplanted natural sandstones. There are, perhaps,
30 many reasons for this continued use of natural sandstones, but one reason of great importance was the difficulty of manufacturing a stone that would produce fibres of good length and of such nature that they would mat well and form a
35 strong sheet of paper.

The sharpness and angularity of manufactured abrasive granules was a factor of great importance in the exploitation of manufactured abrasive articles but one which retarded the development of a satisfactory manufactured stone
40 for the production of good quality ground wood-pulp. Natural sandstones that are satisfactory for the manufacture of ground wood-pulp contain rounded particles of sand and there have
45 been many attempts to make artificial sandstones by bonding sand with such materials as Portland cement or other cold-setting bonds. These attempts have not met with success for several reasons, the principal ones being the absence of
50 the required strength and resistance to wear and the disintegrating action of hot water.

I have found that abrasive wheels with sufficient strength and resistance to wear and hot water, to be useful in pulp grinding, may be made
55 by bonding particles of sand with lime; more-

over, I have found that the grinding characteristics as well as the strength and resistance to disintegration can be controlled by the selection of a particular distribution of grit sizes of the silica used.

High purity silica sand, as required for bonding with lime, usually is found with a narrow range of particle sizes and an apparent density of approximately 1.68 grams per cubic centimeter; for example, 75% of the particles are from
34 mesh to 48 mesh.

I have found it desirable, in producing satisfactory pulp wheels by this method, to select a range and proportion of grit sizes whereby the wheel produced is relatively dense. At the same
15 time it is desirable that the wheel have a substantial proportion of relatively coarse grits of the rounded shape found in natural sand. The absolute size of the coarse grits will vary with reference to the character of the wood to be ground
20 and the character of pulp to be produced but it will in general be found to include at least a portion of the most frequently occurring grit sizes of natural sand.

I have found that particles of intermediate
25 size are useful in securing high apparent density; for example, a mixture comprising the grits available in natural sand of maximum apparent density is produced when coarse, medium and fine
30 particles are mixed in the approximate proportion of two volumes of coarse, one volume of medium and two volumes of fine, the groups being selected whereby the coarse particles in each group have a diameter between 2 to 3 times as
35 large as the fine particles in the group. There are an infinite number of combinations between this and the sand of uniform particle size mentioned above, and while the apparent density will not necessarily be different for each combination, the structural characteristics of wheels made
40 from these various combinations will differ and will produce different results in grinding. However, it is desirable in producing a well bonded wheel to include in the fine portion a substantial proportion of particles passing a 200 mesh
45 screen.

For the purpose of illustrating the method by which I make abrasive wheels, I will give a detailed explanation of one example. It is to be understood, however, that in so doing I do not in-
50 tend to limit my invention to the particular steps, sequence of steps nor to the specific materials or combination of materials given in the example.

I have found, for example, that a mixture of approximately 52% by weight of particles rang-
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ing in size from those passing through a 20 mesh screen to those remaining on a 44 mesh screen, 21% by weight of particles ranging in size from those passing through a 44 mesh screen to those remaining on a 97 mesh screen, and 27% by weight of particles passing through a 97 mesh screen will, when properly bonded, provide a structure that is suitable for making one grade of ground wood-pulp for news print paper. It is to be noted that the range of particle sizes in each group is of the order of magnitude given above, i. e., from 1:2 to 1:3.

The screen sizes given in this example and the relative proportions of each group constitute one embodiment of the invention which includes a range of screen sizes and relative proportions of the defined groups. In general, it may be said that the coarse and fine particles should constitute the greater part of the mix. The coarse and fine particles may have a combined weight more than twice, for example four times, that of the medium size particles. It is also desirable to provide a substantial proportion of fines relative to the amount of coarse particles. For example, it has been found that good results are obtained by maintaining the weight of the fine group not less than one third that of the coarse group. The fine group need not, however, have a weight of more than three fourths that of the coarse group to produce a satisfactory wheel.

I add to the mixture of silica particles freshly slaked lime of high purity (e. g. 99% CaO) in the ratio of approximately 85 parts by weight of silica to 15 parts by weight of CaO, and mixed thoroughly with approximately 5 parts by weight of water. Other ratios of silica to lime may be used if desired, and the amount of water may be varied from approximately 3 parts by weight to approximately 7 parts by weight. The mixture of silica, lime and water may be allowed to stand for several hours to insure complete hydration of the lime before the mix is pressed or otherwise formed into a shaped article, although such procedure is not necessary usually.

In forming small articles, I place the damp mix in a mold of suitable size and shape and apply pressure to the movable member of the mold. A hydraulic press is satisfactory for this purpose but other methods may be employed to produce the required pressure. One of the advantages of a hydraulic press is the ease with which high unit pressures on the mixture may be obtained and controlled. I have found that pressures of 3000 to 5000 pounds per square inch produce the desired amount of compacting in most cases.

Large articles, such as wheels for grinding pulp, are compacted more conveniently and with equivalent thoroughness by jolting. In jolting the mix is placed in the mold and the mold and its contents subjected to a series of impacts. In the usual type of jolting machine, the mold table is alternately raised and permitted to drop against a firm base, whereby the mix in the mold on the mold table is subjected to a series of impacts. The intensity as well as the frequency of the impacts can be controlled.

Jolting the mix in the mold causes it to settle so that the particles of different sizes become arranged in a natural formation; that is, the smaller particles occupy the spaces between the larger particles. This natural formation is maintained during the jolting particularly well if some restraint is applied to prevent the uppermost part

of the mix from jarring loose and separating from the mix below.

Various forms of restraining devices may be used, although I prefer to use one comprising a hydraulic pressure cylinder and a movable piston in engagement with the movable plate of the mold. A device of this kind is particularly effective when means, such as a positive check valve, is provided to prevent egress of the water from the cylinder into the pipe line during the jolting. The check valve permits water to flow into the cylinder and prevents it from returning to the line, whereby the piston is caused to closely follow the movement of the mix as it becomes compacted.

Usually pressures of an order of magnitude of twenty-five to one hundred pounds per square inch are sufficient when a check valve or similar device is used to confine the water in the cylinder. Higher pressures may be used if required, for example, because of the violence of the jolting action. The pulpstone may be made in one piece or it may be made in the form of a plurality of rings or segments and the parts cemented together to form the stone preferably with a cement having a thermal coefficient of expansion of the same order of magnitude as that of the segments, etc.

After the article has been formed I harden the article by subjecting it to a temperature of approximately 120 pounds per square inch steam pressure, with the article exposed to the steam. Inasmuch as thorough curing throughout the mass of the piece is a time-temperature function, general directions can not be given for all sizes and shapes of wheels; however, I have found that a wheel 27 inches in diameter and 24 inches thick is cured throughout after 11 hours treatment at 120 pounds per square inch steam pressure. Smaller pieces require less time for heat penetration, whereas larger pieces require more time.

One method of curing that I have found satisfactory comprises the use of an autoclave into which steam may be introduced to raise the temperature to the desired point. The water saturated atmosphere produced in this manner inhibits the evaporation of water from the article and thereby permits the bond to be fully hydrated.

The use of steam in direct contact with the article, however, introduces another difficulty. The steam condenses upon the article during the earlier part of the heat-treatment, when the article is cold, and this excess water causes the structure to be weak and to crack. I have found that this difficulty is obviated if the heating, at least during the raising of the temperature, is done by other means than by steam, while the atmosphere in the chamber is maintained at such a moisture content that there is little or no evaporation from the article undergoing treatment. Steam coils or electrical heaters within the chamber are suitable for this purpose.

Articles made in accordance with the above disclosure have a tensile strength of approximately 500 pounds per square inch and increase in physical strength of immersion in hot water. This is a valuable property of a pulpstone as they are ordinarily used immersed in hot water. On the other hand, natural sandstone has a tensile strength of 300 pounds per square inch when dry and approximately one-half as much when wet.

While the above disclosure has been specific to the manufacture of pulp grinding wheels, the material is useful for other abrasive purposes; for example, hones for razors and other sharp instru-

ments made of very fine sand; (e. g. 200-300 mesh) produce results not possible with hones made of the harder and sharper manufactured abrasives, such as silicon carbide or fused alumina.

Wheels of this material are also superior for polishing glass and for grinding cutlery. The invention is also useful in the production of other wear resistant articles such as tiles where the relatively dense nature of the articles produced give them strength and lasting qualities.

I claim:

1. A silica-lime abrasive article comprising a mixture of silica particles varying in size from coarse to fine, with the coarse, medium and fine particles in proportions of approximately two, one and two respectively by volume measured separately, the coarse particles in each of said coarse, medium and fine groups having a diameter of approximately 2 to 3 times the diameter of fine particles in the same group, and the fine group having a substantial proportion of particles passing through a 200 mesh screen.

2. A silica-lime pulp grinding wheel comprising a mixture of silica particles bonded by the reaction product of hydrated lime and silica, said mixture comprising approximately 52% by weight of particles ranging in size from those passing through a 20 mesh screen to those remaining on a 44 mesh screen, approximately 21% by weight of particles ranging in size from those passing through a 44 mesh screen to those remaining on a 97 mesh screen, and approximately 27% by weight of particles ranging in size downward from those passing through a 97 mesh screen including a substantial proportion of particles passing through a 200 mesh screen.

3. A pulp grinding wheel comprising silica granules bonded by the reaction product of hydrated lime and silica, the granules being relatively evenly distributed throughout each of three ranges of grit sizes; namely, coarse, medium and fine, in the approximate proportions of 2 parts coarse, 1 part medium and 2 parts fine by volume, the limits of said ranges being such that the largest particles in the medium group have a diameter from 2 to 3 times that of the largest particles in the fine group, and the largest particle in the coarse group have a diameter from 2 to 3 times that of the largest particles in the medium group, the fine group having a substantial proportion of particles passing through a 200 mesh screen.

4. An abrasive wheel for grinding wood pulp consisting of silica particles graded so that the greater part is of particle sizes coarser than 44 mesh and finer than 97 mesh and bonded by the reaction product of hydrated lime and silica, and characterized by a tensile strength which is greater than that of the usual natural sandstones and which is not appreciably weakened by immersion in hot water, the particles retained by a 97 mesh screen having the rounded shape characteristic of natural silica sand.

5. An abrasive wheel for grinding wood pulp consisting of a mixture of various sizes of silica particles bonded by the reaction product of hydrated lime and silica, said mixture of silica particles being graded so that the combined weight of the particles passing a 20 mesh screen and retained on a 44 mesh screen and of the particles passing a 97 mesh screen is approximately four times that of the particles passing a 44 mesh screen and retained on a 97 mesh screen, and characterized by a tensile strength which is greater than that of the usual natural sandstones

and which is not appreciably weakened by immersion in hot water, the particles passing a 97 mesh screen including a substantial proportion of particles passing a 200 mesh screen.

6. An abrasive wheel for grinding wood pulp consisting of a mixture of various sizes of silica particles bonded by the reaction product of hydrated lime and silica, said mixture of silica particles being graded so that the combined weight of the particles passing a 20 mesh screen and retained on a 44 mesh screen and of the particles passing a 97 mesh screen is more than twice that of the particles passing a 44 mesh screen and retained on a 97 mesh screen, the particles passing a 97 mesh screen including a substantial proportion of particles passing a 200 mesh screen.

7. An abrasive article comprising a mixture of coarse, medium and fine particles of silica sand bonded by the reaction product of hydrated lime and silica, the larger particles in each of the groups of coarse, medium and fine particles having a diameter approximately 2 to 3 times that of the smaller particles of the same group, and said mixture being proportioned as to the coarse, medium and fine groups whereby each group is present in substantial proportion and the combined weight of the coarse and fine groups is a major proportion of the total weight, the fine group including a substantial proportion of particles passing a 200 mesh screen.

8. An abrasive wheel for grinding wood pulp consisting of silica particles graded whereby the greater part is composed of particle sizes comprising the most frequently occurring grit sizes of natural sand and fine particles passing through a 97 mesh screen and including a substantial proportion of particles passing a 200 mesh screen and bonded by the reaction product of hydrated lime and silica, and characterized by a tensile strength greater than that of the usual natural sandstones and which is not appreciably lessened by immersion in hot water.

9. As a new article of manufacture, a sand-lime grinding wheel for the production of ground wood pulp comprising coarse, medium and fine particles, the quantity of medium size particles being less than that of either the coarse particles or the fine particles, and the fine particles all being of a size to pass through a 97 mesh screen and including a substantial proportion of particles passing through a 200 mesh screen.

10. A silica-lime abrasive article comprising a mixture of coarse, medium and fine particles of silica, the coarse particles in each of said coarse, medium and fine groups having a diameter approximately 2 to 3 times that of the fine particles of the same group, the said coarse and medium groups comprising particles having the rounded shape characteristic of natural silica sand and the fine group comprising a substantial proportion of particles passing a 200 mesh screen and said mixture being so proportioned as to the coarse, medium and fine groups that the combined weight of the coarse and fine groups is a major proportion of the total weight.

11. A silica-lime abrasive article comprising a mixture of coarse, medium and fine particles of sand, the coarse particles in each of said coarse, medium and fine groups having a diameter approximately 2 to 3 times that of the fine particles of the same group, the said coarse and medium groups comprising particles having the rounded shape characteristic of natural silica sand and the fine group comprising a substantial propor-

tion of particles passing a 200 mesh screen, said mixture being so proportioned as to the coarse, medium and fine groups that the combined weight of the coarse and fine groups is a major proportion of the total weight and the said coarse and fine groups are so proportioned that the weight of the fine group is not less than one third that of the coarse group.

- 10 12. A silica-lime abrasive article comprising a mixture of coarse, medium and fine particles of sand, the coarse particles in each of said coarse, medium and fine groups having a diameter approximately 2 to 3 times that of the fine particles of the same group, the said coarse and medium

groups comprising particles having the rounded shape characteristic of natural silica sand and the fine group comprising a substantial proportion of particles passing a 200 mesh screen, said mixture being so proportioned as to the coarse, medium and fine groups that the combined weight of the coarse and fine groups is a major proportion of the total weight and the said coarse and fine groups are so proportioned that the weight of the fine group is not less than one third nor more than three-fourths that of the coarse group.

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