METHOD FOR PRODUCING PYRAMIDAL
SHAPED TUMBLING MEDIA

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4 Claims

ABSTRACT OF THE DISCLOSURE

Conical or pyramidal shaped ceramic or polymeric tumbling media having height about 0.75 to 1.5 times diameter formed by dropwise feeding from an orifice of a thixotropic composition having a viscosity between 500 and 30,000 poise, measured on a rotating spindle visco-
cometer at 2 r.p.m., and yield stress value of at least
15,000 dyes/cm², depositing droplets on a substantially
flat surface to form upwardly tapering shapes and harden-
ing shape to withstand a crushing force of at least 50 p.s.i.

This application is a continuation-in-part of our co-
pending application Ser. No. 487,721, filed Sept. 16, 1965,
and now abandoned.

This invention relates to tumbling media for industrial
finishing and a method for the formation thereof. More
particularly the invention relates to tumbling media con-
prising shapes of relatively uniform size and shape con-
taining abrasive particles and a binding material.

The mechanical finishing industry utilizes a wide variety
of media or shapes for the surface refinement and/or
deburring of metal and plastic parts. These media have
included natural or synthetic stone, porcelains, abrasive
filled clays, wood, leather, plastics and the like. The parts
to be refined or deburred are placed in a tumbling drum
together with the media which support the parts, prevent
undesirable carry-over and carry or supply the abrasive
which performs the deburring or cutting. Irregularly
shaped media such as natural stones can cause severe
production problems because of lodging—the tendency of
the shapes to jam into a slot, hole or undercut and
resist removal—over a wide range of slot dimensions.
Accordingly efforts have been made to provide media in
more precise uniform shapes.

Methods which have been used for forming suitable
media involve the casting of a slip or other casting com-
position into a plurality of cavities, dry pressing a powder
abrasive-containing composition, or injection molding
pastellike compositions. Each of these techniques entails
a large number of molds which, in addition to their high
cost, result in mold release problems, and/or require
elaborate high speed equipment in which wear problems
are high. Another method which is used involves extru-
sion and cutting to length of a suitable pastellike com-
position. This procedure also entails the use of costly
molding and cutting equipment. These problems are mag-
nified by the large number of uniform pieces required.
The individual pieces commonly weigh between 1 and 10
grams and are of such size that 2500 to 75,000 pieces
per cubic foot may be required. Industrial mechanical
finishing processes commonly range in size from 2 to 20 cubic feet. The manufacture of sharp
pointed tetrahedrons and cones has been particularly
costly and difficult.

The present invention has made possible the forma-
tion of finishing media very uniform in size, at high
production rates, and at a cost significantly less than
methods previously used. It has been discovered that by
using mixtures in a viscosity range intermediate to those
previously used for either extrusion or casting that shape-
able generally conical shapes can be formed by feeding
the composition dropwise out of an orifice or preferably
a plurality thereof onto a suitable substantially flat sur-
face such as an endless belt. Furthermore the invention
has made possible the economical formation at high pro-
duction rates on relatively simple apparatus of tumbling
media in essentially sharp-pointed conical or polyhedral
shapes. The present invention makes possible the tailoring of
a wide range of products from those designed for rapid,
coarse cutting to intermediate finishing to fine polishing.
The finishing characteristics of the media are easily con-
trolled by variation of the hardness, amount and size of
filler particles, the media size, and the hardness of the
binder composition.

The media of this invention comprises a plurality of
shapes each having a flat cast surface, the other surfaces
of each shape being smoothly tapered together toward a
point remote from the flat surface, the ratio of the distance
between the point and flat surface to the diameter of the
flat surface being between about 0.75 and 1.5. Conical,
tetrahedral, and pyramidal shapes are representative of
those which can be produced in accordance with the
invention. The shapes of this invention provide a plurality
of working edges and surfaces which can penetrate
into recesses or undercut portions of the parts being worked
and which are free of parallel surfaces or gradually tapered
contours which would tend to lodge in the parts being
finished.

Briefly summarized, the process of this invention in-
cludes the steps of providing a thixotropic flowable, per-
manently settable composition which has a viscosity be-
tween about 500 and 30,000 poise (measured on a rota-
ing spindle viscometer at 2 r.p.m.), the thixotropy of the
composition being sufficient to maintain a droplet thereof
supported on a flat surface at at least a height of 0.75
times the diameter of the droplet. It has been found that
most thin, flowable liquids which could be pumped through
an orifice cannot be used because they would slump over
into a flat "button" shape when deposited or dropped onto
a receiving surface. On the other hand, many viscous mate-
rials which would form slump resistant shapes cannot be
pumped out of an orifice and deposited as separate drop-
lets because their viscosity is too high. In accordance with
the present invention, these problems are overcome by
the use of a thixotropic material having a yield stress of
at least 15,000 dyes/cm² as measured on a Ferranti-
Shirley plate and cone viscometer. Liquids having this
characteristic in addition to the above defined viscosity
characteristic are both flowable through an orifice, sep-
arable under gravity into individual droplets, and capable
upon deposition by dropping onto a flat surface of maintain-
ing a shape having a height of at least 0.7 times the
diameter of the droplet. The yield stress value is the
force which must be applied to the material in order to
obtain flow thereof.

In the drawings:
FIG. 1 is a schematic side view showing apparatus which
can be used for carrying out the method of the present
invention;
FIG. 2 is a perspective view of a shape formed in
accordance with the invention, and
FIG. 3 is a perspective view of a shape formed in
accordance with a further embodiment of the invention;
and
FIG. 4 is a perspective view of a shape formed in
accordance with another embodiment of the invention.

Referring more particularly to the drawings where there
is seen a flowable composition I comprising a suitable
fluid settable binding material and abrasive particles if
desired contained in a suitable vessel 2. An agitator 3 can be used to maintain uniform mixing of the composition. The composition is carried through pipes or tubing 4 by pump 5 to a manifold 6, from which it passes into a plurality of tubes 7 having orifices at the ends thereof. The composition is pumped at a speed sufficient to assure a characteristic conical shape upon impact on an endless belt 9 of stainless steel, fiberglass, or the like. Belt 9 driven by motor 10 conveys the conically-shaped particles through a shaping chamber 11 which may be an oven or drying chamber depending on the nature of the binding material used. The hardened shapes are then collected in a receiving receptacle 12. Shapes containing vitrifiable ceramic or clay-like binders are then fired, for example, in a rotary kiln while shapes containing resins or binding materials are ready for packaging.

Pump 5 should be of a type which is not a positive displacement type. Rather, it has been found that optimum droplet formation is achieved by the use of a pump which permits liquid to flow out more rapidly than the pumping rate as a drop is pulled away from the orifice by gravity. In a preferred embodiment of the invention, a gear pump, which is quieter and more durable, and another suitable pumps will be apparent to those skilled in the art.

The abrasive inorganic filler particles used in forming the media of the present invention may be finely divided material including such known types as alumina, silicon carbide, titanium carbide, zirconia, silica, metals (such as steel, zinc, or tin), chalk, or talc. It will be understood that for fast cutting rates the filler particles should be hard; while for fine cutting or polishing, soft particles such as metals, chalk, or talc are preferred. The particles of this material are often angular in shape to provide abrasive action. It is preferred to use compositions consisting of 30 to 75 percent by weight of inorganic abrasive particles.

Various settable binding materials can be used. As noted above, vitrifiable ceramics such as clays or frit containing compositions are suitable in which the ceramic and abrasive particles, if desired, are mixed with water or a fugitive organic binder to the desired consistency prior to use. The shapes are dried after formation to harden them sufficiently to permit firing in a kiln. The shapes are generally fired to the softening point of at least some of the constituents of the ceramic composition in order to cause some degree of vitrification. Other suitable settable binders include the cementitious type such as portland cement which attain a permanent set on air curing. The inorganic compositions in themselves contain "filler particles" which provide the media with abrasing or polishing qualities, but if desired, harder abrasives can be added. The vitrified portion of the ceramic composition acts as a binder for the media.

Suitable resins binders include materials such as polyester resins and preferably polyester-styrene copolymers, phenolics, epoxy resins, etc. Such resinous materials are generally mixed with the abrasive particles and a suitable catalyst shortly before drop formation and may be either self-hardening or hardening may be accomplished by passing the shapes through a heated oven, irradiating chambers or by other means. When the resinous constituent is polymerized or cross-linked.

The settable binding materials useful in forming the shapes of the invention are herein defined as "permanently settable." This term as used herein is intended to include thermosetting resins, vitrifiable ceramics and moisture curable curable resins, all of which, after setting are insoluble in hot water, even under alkaline or acidic conditions in a pH range of about 1.5 to 12 and resist permanent deformation at pressures of at least about 50 p.s.i.

It has been found that in order to form individual drops which are shape-stable prior to curing or hardening of the binding material that the viscosity of the mixture measured at 2 r.p.m. on a rotating spindle viscometer must be between about 500 and about 30,000 poise. Since the materials involved are thixotropic and/or pseudoplastic in nature, the viscosity readings measured over a longer period of time or at a higher r.p.m. will be lower. At the lower limit useful shapes are produced by mixtures having viscosities of approximately 500 poise by deposition through an orifice no larger than about 0.1" which is a practical lower size limit for the shapes. If the viscosity of the mixture is too low, flat button-like shapes will be produced which will wear excessively thus greatly increasing the cost of the tumbling media. On the other hand compositions having a viscosity greater than about 30,000 poise will not easily form droplets that can be deposited on a collecting surface such as a belt. Compositions having viscosities of this magnitude are useful only with orifices about 1.5" or more in diameter and will form only large shapes. Shapes having diameters as large as 4 inches or more are possible in accordance with the invention.

The wearing characteristics of the shapes are improved by lowering the surface area-to-volume ratio which can be done in the case of a cone by increasing the height-to-diameter ratio. There are practical limits, however, as to how high a cone can be made by the process due to the tendency for the shape to fall over thus greatly reducing the uniformity of the shapes. Height-to-diameter ratios ranging to about 0.75 and about 1.5 have been found useful. It will be understood that shape having other than a flat bottom can be produced by the use of irregularly surfaced collecting belt. Irregularity may be desirable in some cases in order to prevent sticking of the tumbling shapes to the walls of the tumbling drum by suction. Any described texture can be provided on the bottom surface of the shapes by providing a belt surface which is quilted, ribbed, dimpled, or corrugated. A deeply textured surface is not desirable, however, since release problems from the belt can be created. By "substantially flat" as the term is employed herein it is meant a surface not having voids or cavities which form more than one generally planar surface of the shapes.

Shapes other than conical can be formed by the use of orifices having configurations other than circular, for example, rectangular, triangular, elliptical, indented, or other orifice cross sections can be employed to form a variety of desirable shapes. For example, it has been found that the use of an orifice which is generally triangular but with indented sides will produce shapes of the general type shown in FIG. 3, having good properties for finishing internal surfaces such as holes and undercuts. Other nonconical shapes can be produced by inclining the surface of the belt to produce a shape such as that shown in FIG. 4 which has a more rounded top surface.

The following examples, in which all proportions are given in parts by weight unless otherwise indicated, will serve to illustrate, but not limit, the invention.

**EXAMPLE I**

A pastelike composition was formed by mixing 100 parts of a resin system comprising 36% styrene monomer and 64% unsaturated polyester-resin (resin polyester resin by weight of 50% benzoyl peroxide paste catalyst, 150 parts 200 mesh silica. Several portions of this mixture were made up containing varying amounts of finely divided fire-dry pyrogenic silica (available under the trade name Cab-O-Sil) to give compositions having varying viscosities. These compositions were slowly metered through 1/4 inch, 3/8 inch, and 3/4 inch 1-D, 2-D, and 3-D, drop heights, onto a horizontal surface of an endless belt. The results of these experiments are set forth in Table 1 including the dimensions of the essentially conical shapes
formed. The viscosities reported were measured on a Brookfield RVF viscometer, No. 7 spindle, at 2 rpm and 22–23° C.

### Table I

<table>
<thead>
<tr>
<th>Parts finely divided silica per 100 parts resin</th>
<th>Viscosity, poise</th>
<th>Chip weight, gm.</th>
<th>Drop height, in.</th>
<th>Diameter, in.</th>
<th>Height, in.</th>
<th>Diameter/Height ratio</th>
<th>Shape</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.9</td>
<td>2,000</td>
<td>.38</td>
<td>2</td>
<td>.38</td>
<td>.20</td>
<td>.51</td>
<td>Button.</td>
</tr>
<tr>
<td>0.9</td>
<td>2,000</td>
<td>.38</td>
<td>2</td>
<td>.38</td>
<td>.20</td>
<td>.51</td>
<td>Button.</td>
</tr>
<tr>
<td>0.9</td>
<td>2,000</td>
<td>.47</td>
<td>8</td>
<td>.67</td>
<td>.28</td>
<td>.42</td>
<td>Button.</td>
</tr>
<tr>
<td>0.9</td>
<td>2,000</td>
<td>1.20</td>
<td>10</td>
<td>.66</td>
<td>.28</td>
<td>.42</td>
<td>Button.</td>
</tr>
<tr>
<td>0.9</td>
<td>2,000</td>
<td>3.83</td>
<td>2</td>
<td>1.00</td>
<td>.26</td>
<td>.51</td>
<td>Button.</td>
</tr>
<tr>
<td>2.9</td>
<td>4,000</td>
<td>.50</td>
<td>8</td>
<td>.47</td>
<td>.49</td>
<td>.85</td>
<td>Conical.</td>
</tr>
<tr>
<td>2.9</td>
<td>4,000</td>
<td>3.46</td>
<td>8</td>
<td>1.06</td>
<td>.31</td>
<td>.29</td>
<td>Button.</td>
</tr>
<tr>
<td>2.9</td>
<td>4,000</td>
<td>3.22</td>
<td>10</td>
<td>1.00</td>
<td>.25</td>
<td>.51</td>
<td>Button.</td>
</tr>
<tr>
<td>2.9</td>
<td>4,000</td>
<td>.96</td>
<td>2</td>
<td>.34 (22 x 130)</td>
<td>.25</td>
<td>.25</td>
<td>Tear drop-fell over.</td>
</tr>
<tr>
<td>2.9</td>
<td>4,000</td>
<td>1.04</td>
<td>10</td>
<td>.71</td>
<td>.36</td>
<td>.71</td>
<td>Do.</td>
</tr>
<tr>
<td>2.9</td>
<td>4,000</td>
<td>2.03</td>
<td>2</td>
<td>.62</td>
<td>.44</td>
<td>.66</td>
<td>Conical.</td>
</tr>
<tr>
<td>2.9</td>
<td>4,000</td>
<td>1.80</td>
<td>8</td>
<td>.62</td>
<td>.44</td>
<td>.66</td>
<td>Conical.</td>
</tr>
<tr>
<td>2.9</td>
<td>4,000</td>
<td>1.86</td>
<td>10</td>
<td>.70</td>
<td>.37</td>
<td>.53</td>
<td>Button.</td>
</tr>
<tr>
<td>2.9</td>
<td>4,000</td>
<td>5.74</td>
<td>2</td>
<td>.59</td>
<td>.60</td>
<td>.69</td>
<td>Top spires.</td>
</tr>
<tr>
<td>2.9</td>
<td>4,000</td>
<td>5.06</td>
<td>8</td>
<td>1.00</td>
<td>.57</td>
<td>.57</td>
<td>Button.</td>
</tr>
<tr>
<td>3.8</td>
<td>8,500</td>
<td>5.23</td>
<td>10</td>
<td>1.18</td>
<td>.40</td>
<td>.48</td>
<td>Do.</td>
</tr>
<tr>
<td>3.8</td>
<td>8,500</td>
<td>1.28</td>
<td>2</td>
<td>.23 (23 x 1.3)</td>
<td>.25</td>
<td>.25</td>
<td>Fall over.</td>
</tr>
<tr>
<td>3.8</td>
<td>8,500</td>
<td>1.34</td>
<td>8</td>
<td>.49</td>
<td>.41</td>
<td>.66</td>
<td>Conical.</td>
</tr>
<tr>
<td>3.8</td>
<td>8,500</td>
<td>1.33</td>
<td>16</td>
<td>.53</td>
<td>.55</td>
<td>1.04</td>
<td>Do.</td>
</tr>
<tr>
<td>3.8</td>
<td>8,500</td>
<td>4.47</td>
<td>2</td>
<td>.40 (4.2 x 1.5)</td>
<td>.25</td>
<td>.25</td>
<td>Fall over.</td>
</tr>
<tr>
<td>3.8</td>
<td>8,500</td>
<td>3.81</td>
<td>8</td>
<td>.77</td>
<td>.73</td>
<td>.66</td>
<td>Conical.</td>
</tr>
<tr>
<td>3.8</td>
<td>8,500</td>
<td>3.88</td>
<td>10</td>
<td>.80</td>
<td>.60</td>
<td>.79</td>
<td>Do.</td>
</tr>
<tr>
<td>3.8</td>
<td>8,500</td>
<td>9.60</td>
<td>8</td>
<td>1.18</td>
<td>.53</td>
<td>.74</td>
<td>Conical.</td>
</tr>
<tr>
<td>3.8</td>
<td>8,500</td>
<td>8.77</td>
<td>15</td>
<td>1.19</td>
<td>.65</td>
<td>.65</td>
<td>Button.</td>
</tr>
</tbody>
</table>

**EXAMPLE II**

94 grams diethylene triamine
93.8 grams silicon carbide, 1000 mesh
76.8 grams liquid epoxy resin (epichlorohydrin-bisphenol a type having an epoxy equivalent of about 190)

The ingredients listed above were blended together and pumped through a .75" I.D. tube, vertically mounted about 8" from the bench. Drops falling formed conical shapes and after curing 30 minutes at 150° F. were about .50" high by .69" diameter.

**EXAMPLE III**

25 gm. Tennessee Ball Clay #5
50 gm. flint, 200 mesh
25 gm. feldspar, 200 mesh
75 ml. water

This blended mixture was allowed to drop from 1/2" I.D. tube from a height of 2'". The shapes were dried 16 hours at 150° F. and fired to cone 10 down in an electric kiln. White, very smooth, conical shapes resulted having a .43" height by .62" diameter.

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U.S. Cl. X.R.