BALL AND SHOT MANUFACTURE BY
IMPACTING PROCESS

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This invention relates in general to an economical method and apparatus for mechanically producing small, substantially spherical balls from non-spherical metal blanks.

In general, there are two classes of methods by which shot or small metal balls are mainly produced today: (1) thermal and (2) mechanical.

In the thermal methods of producing shot, various operations are performed with the metal while the metal is in the molten or semi-molten state. The most common method is to pour the molten metal into a mold, which is then allowed to cool. The cooled metal is then machined into the desired shape.

In the mechanical methods of producing shot, various operations are performed on the metal while it is in the solid state. The most common method is to drop the solid metal into a mold, which is then allowed to cool. The cooled metal is then machined into the desired shape.

Although the cost of manufacturing lead shot by this process is low, the process is not adaptable for producing shot of different metals, e.g., iron, aluminum, etc. Iron, for example, has a high melting point and other properties which do not permit economical dropping. In addition, the shot produced by this process may be high in impurities, and may be contaminated with other materials, such as silicon, which may affect the properties of the metal.

Other thermal methods of producing shot include: (1) dropping the molten metal in an inert atmosphere, or (2) dropping the molten metal in a reducing atmosphere. There are also various other methods, such as the use of special materials to change the properties of the metal, or (3) directing a stream of air, water, steam, etc. at the molten metal to break the metal stream up into small particles.

In the mechanical methods of producing shot, some operation is performed on a solid pellet, slug or blank until the solid particle is rounded off into a substantially spherical shape.

It must be appreciated that the problem here is not merely to produce round shot. There are many methods shown in the prior art and in use today which will produce very fine, spherical metal balls from cylindrical or conical blanks. The problem is to produce very large quantities of satisfactory metal shot economically. It became apparent from the prior art that if the shot were produced economically at a permissible cost, a new concept of forming shot would be necessary.

The general object of this invention is to produce by novel and mechanical means substantially spherical balls from non-spherical, deformable, metallic pellets.

Another object of this invention is to provide a novel method of producing large quantities of shot efficiently and economically.

Another object of this invention is to provide a novel low-cost method of providing accurately-sized, substantially spherical shot of any desired diameter and composition, e.g., lead, steel, aluminum, etc.

Other objects and advantages of the invention will become apparent after reading the following specification, the claims, and the accompanying drawings in which:

FIGURE 1 shows a schematic of the rotating chamber with the impeller assembly inside.

FIGURES 2 and 3 are similar to FIGURE 1 except that the blanks are being hit at different points on the impeller with resulting different patterns.

FIGURE 4 shows a perspective view of a production model encompassing the invention.

FIGURE 5 shows a cross-sectional view taken on line 4—4 in FIGURE 4.

FIGURE 6 shows an end view of the discharge end of the drum container of FIGURE 4.

FIGURE 7 shows a drawing generally the relationship of impact speed, impact time and ball roundness.

In the following description of the present invention, reference will be made to the production of lead shot. It should be appreciated, however, that the process and apparatus is the same for other materials. As explained below, the speed of the rotating impeller will vary with the physical characteristics of the blanks but otherwise the following discussion will also apply to making steel, aluminum and other metallic shot.

The method of the present invention includes the feeding of non-spherical lead pellets into a substantially enclosed chamber, projecting the lead pellets into the path of a high-speed impeller mounted within the chamber, striking the shot particles against the chamber walls and thus deforming the blanks to form substantially spherical shot.

FIGURE 7 shows a drawing of generally the relationship of impact speed, impact time and ball roundness.

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The embodiment of FIGURE 1 shows a cylindrical container 10 in which one spherical ball blank 12 is placed. The blanks are preferably cylindrical although cubes also will perform satisfactorily. The container 10 is mounted by means not shown to rotate slowly about its longitudinal axis 14. Rigidly mounted on the inner wall 16 of the container 10 and rotating therewith are a plurality of scoops 18. As the blanks fall to the bottom of the container by gravity, the scoops 18 pick them up and elevate them to the 11 o'clock position shown in FIGURE 1 where the blanks fall by gravity into the central interior area of the container 10.

Centrally positioned within the container 10 to rotate therein at relatively high speed about the longitudinal center axis 14 of the container is a shaft 20 to which is secured an impeller assembly 22 having vanes or blades 24 and 26. Vanes 24 and 26 have rearwardly directed, streamlined end portions 28 and 30 for a purpose to be explained later.

As the blanks 12 fall from the scoops 18, they are impinged by the impeller 22 which is rotating at a predetermined high speed sufficient to deform the blanks to the physical characteristics described above and to form substantially spherical shot.

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3 and rotated slowly by a chain 40 which is connected to a power means (not shown) and which operatively engages a sprocket 42 mounted at one end 44 of the drum.

Extending through the drum on the longitudinal axis thereof is a shaft 46 which is rotatably mounted in bearing blocks 48 and 50. Attached to the shaft 46 in order to provide rigidity thereto is a spider member 52 on which are mounted impeller vanes 54, 56, 58, and 60 having arcuate end portions 54a, 56a, 58a, and 60a. The shaft and impeller assembly are rotated independently of the drum by belt 62.

The arcuate end portions of the impeller vanes have been found to be necessary in order to prevent marking of the finished ball which would be caused by any sharp corners of the impacting vanes travelling at high speed. The degree of curvature of the vane end portions can be varied to control the direction in which the blank is projected after being hit by the rotating impeller. However, in order to prevent marking of the ball when hit by the impeller, the radius of curvature of the rounded vane end portion must be greater than the maximum radius of ball which is to be produced.

A feed hopper 64 is positioned at one end of the drum with a mouth portion 66 extending into the interior of the drum. At the opposite end of the drum, an opening 68 is provided in the drum end plate 70 for withdrawing the finished shot from the drum. It can be seen that non-spherical blanks can be fed continuously to the drum through hopper 64 and finished balls withdrawn through opening 68.

It should be appreciated that it is possible to provide more or fewer impeller vanes as well as scoop elevating means than are shown in the drawings. The resulting results are characteristic of what was achieved by processing various samples of metallic blanks with the apparatus shown in FIGURES 1–3 using a 9 inch diameter impeller and with the drum rotating at 36 r.p.m. at room temperature. The percent sphericity is arbitrarily defined as

\[
\text{maximum diameter minus minimum diameter} \times 100 \text{ maximum diameter}
\]

The yield strengths are typical values of similar material tested under static tensile conditions at 0.2% offset and are not necessarily the actual yield strengths of the material under the conditions within the impact drum. Yield strengths for lead and zinc are not given since they are under creep conditions and are not true. Obviously, the results can be varied by varying any of the following: the diameter of the impeller, the number of impeller vanes; and the speed of the rotating drum container.

<table>
<thead>
<tr>
<th>Metal</th>
<th>SAE</th>
<th>Yield strength, b.p.s.</th>
<th>Impeller speed, r.p.m.</th>
<th>Time (min.)</th>
<th>Percent sphere</th>
<th>Original shape and dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead</td>
<td>1010</td>
<td>80,000</td>
<td>1,000</td>
<td>200</td>
<td>7.0</td>
<td>cyl. 0.015 x 0.125</td>
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<tr>
<td></td>
<td>1018</td>
<td>40,000</td>
<td>1,000</td>
<td>200</td>
<td>6.8</td>
<td>cyl. 0.012 x 0.125</td>
</tr>
<tr>
<td></td>
<td>1020</td>
<td>40,000</td>
<td>1,000</td>
<td>200</td>
<td>6.5</td>
<td>cyl. 0.010 x 0.125</td>
</tr>
<tr>
<td></td>
<td>1024</td>
<td>40,000</td>
<td>1,000</td>
<td>200</td>
<td>6.3</td>
<td>cyl. 0.008 x 0.125</td>
</tr>
<tr>
<td></td>
<td>1025</td>
<td>40,000</td>
<td>1,000</td>
<td>200</td>
<td>6.2</td>
<td>cyl. 0.007 x 0.125</td>
</tr>
<tr>
<td>Steel</td>
<td>330</td>
<td>60,000</td>
<td>1,000</td>
<td>200</td>
<td>5.4</td>
<td>cube 0.250</td>
</tr>
<tr>
<td></td>
<td>4139</td>
<td>40,000</td>
<td>1,000</td>
<td>200</td>
<td>5.4</td>
<td>cube 0.250</td>
</tr>
<tr>
<td></td>
<td>52,100</td>
<td>40,000</td>
<td>1,000</td>
<td>200</td>
<td>5.4</td>
<td>cube 0.250</td>
</tr>
<tr>
<td></td>
<td>1100</td>
<td>5,500</td>
<td>1,000</td>
<td>10</td>
<td>8.9</td>
<td>cyl. 0.010 x 0.125</td>
</tr>
<tr>
<td></td>
<td>1105</td>
<td>4,500</td>
<td>1,000</td>
<td>10</td>
<td>8.9</td>
<td>cyl. 0.010 x 0.125</td>
</tr>
<tr>
<td>Aluminum</td>
<td>1097</td>
<td>10,000</td>
<td>1,000</td>
<td>10</td>
<td>7.7</td>
<td>cube 0.175</td>
</tr>
<tr>
<td></td>
<td>3415</td>
<td>10,000</td>
<td>1,000</td>
<td>10</td>
<td>7.7</td>
<td>cube 0.175</td>
</tr>
<tr>
<td></td>
<td>2044</td>
<td>11,000</td>
<td>1,000</td>
<td>10</td>
<td>8.3</td>
<td>cube 0.187</td>
</tr>
<tr>
<td></td>
<td>2045</td>
<td>11,000</td>
<td>1,000</td>
<td>10</td>
<td>8.3</td>
<td>cube 0.187</td>
</tr>
<tr>
<td></td>
<td>2051</td>
<td>11,000</td>
<td>1,000</td>
<td>10</td>
<td>8.3</td>
<td>cube 0.187</td>
</tr>
<tr>
<td>Zine</td>
<td>6001</td>
<td>8,000</td>
<td>1,000</td>
<td>10</td>
<td>7.3</td>
<td>cyl. 0.020 x 0.215</td>
</tr>
<tr>
<td></td>
<td>6002</td>
<td>8,000</td>
<td>1,000</td>
<td>10</td>
<td>7.3</td>
<td>cyl. 0.020 x 0.215</td>
</tr>
<tr>
<td></td>
<td>6003</td>
<td>8,000</td>
<td>1,000</td>
<td>10</td>
<td>7.3</td>
<td>cyl. 0.020 x 0.215</td>
</tr>
</tbody>
</table>

It should be appreciated that the above data are not intended to indicate the optimum conditions under which shot can or would be made. For each type of material, an optimum speed can be determined which will produce a substantially spherical ball. Obviously, various combinations are also possible whereby the initial rounding of the ball can be achieved by running the impeller at very high speeds and then running at lower speeds for the final rounding off.

Experience has shown certain physical relationships which permit a certain degree of predictability in regards to the forming of metallic shot by the impact process of the present invention. For example, the higher the yield strength, the higher the impact velocity and time required to deform the blanks.

It is known that a higher impact velocity will produce larger flat areas on a metallic blank than a lower impact velocity. It is also known (see FIGURE 7) that a blank impacted at high velocity will reach substantial sphericity sooner than a blank impacted at low velocity. However, the ultimate degree of sphericity of the high-velocity produced ball will be lower than the low-velocity produced ball.

It was found that certain defects existed in balls formed by the present method which was objectionable for some uses. These defects, "leafing" and "poling," are caused by the mechanical movement of the metal in being transformed from a cylindrical or cubical blank into a rounded ball. The "leafing" results in thin laminations of metal on the outer ball periphery which can be peeled off much like layers of skin and is believed to be caused by the skidding action of the blanks on the inner wall of the drum walls. The "poling" is caused when angular corners are impacted together so that two masses of metal are physically forced together without being fused together. For a ball formed from a cylindrical blank, two lines or "poles" can be seen under a microscope whereas a cubical blank produces six. (Thus, the preference for using cylindrical blanks.) Either of these defects may be prevented the user of the balls (in some instances) while they obviously are satisfactory for many other uses.

Since it was believed that the skidding action of the blank on the drum walls was causing the undesirable "leafing," various efforts were made to eliminate or at least to lessen the skidding. One effort which was suc-
cessful in greatly reducing the "leaching" was the introduction of lubricating oil in the drum so that the blanks would be deformed by the direct impacts of the impeller and the drum but the abrasive action of the skidding blanks would be eliminated or substantially decreased.

The "poling" situation was materially improved by impacting aluminum blanks at elevated temperatures. Since it would be difficult to heat the blanks and maintain them at a constant temperature, the drum or container was heated and kept at approximately 850°F. and the impacting carried out as previously explained. It was found that the impacting process at higher temperatures does not only eliminate the "leaching" but also greatly reduces the size of the voids in the "pole" areas.

Many aluminum blanks were found to produce a thin oxide layer on the surface of the balls, which resulted in a dark color finish instead of the bright shiny finish produced by the cold impacting. However, if this is found to be undesirable for any reason, the blanks can be impacted at elevated temperatures in an inert atmosphere in order to eliminate this discoloration.

Although the heating of the drum is not shown on the drawing, this could be done by any means well known today. For example, cement kilns and other drums are kept at constant elevated temperatures.

It was found that some blanks, which were made by chopping extruded or drawn wire into small slugs, were difficult to impact into substantially spherical balls. This problem was attributed to the difficulty in reshaping the metal blanks which had been impacted to a greater degree in the axial direction than in radial or transverse direction during the wire-forming operation.

This situation was improved, however, by heating the blanks to a sufficiently high temperature prior to impacting in order to relieve the internal stresses caused by the wire drawing. The annealing of the blanks can be done prior to cold impacting or hot impacting for improved results.

Although the specification shows and explains one experimental model and one production embodiment, it is obvious that the inventive concepts expressed herein can be utilized in various other embodiments.

What is claimed is:

1. Apparatus for forming substantially spherical balls from non-spherical deformed blanks comprising: an elongated drum mounted to rotate at a relatively slow speed on its axial center line, carrier means rigidly mounted on the inside wall of the drum to move with the drum and lift the blanks to an elevated position until the blanks fall by gravity into the path of impeller means which had been impacted to a great degree in the axial direction and magnitude of the velocity of the blanks and causing the blanks to undergo a series of impacts against the inside wall of the container, and means to draw off the rounded balls.

2. In apparatus for forming balls from angular, deformed blanks, the combination comprising means to feed the deformed blanks to a relatively slowly rotating cylindrical container, means within said container and rotating therewith to elevate the blanks to a point where the blanks fall by gravity into the path of impeller means rotating at a relatively high speed within said container whereby said impeller means impinges and changes both the direction and magnitude of the velocity of the blanks to cause the blanks to undergo a series of impacts against the inside wall of the container, and means to draw off the rounded balls.

3. The combination recited in claim 2 wherein said impeller means includes radially extending vane means having end portions which are curved rearwardly, said curved portions having a radius of curvature greater than the maximum radius of ball to be produced.

4. Apparatus for mechanically forming shot from non-spherical deformed blanks comprising an elongated, cylindrical container which revolves at a relatively slow speed on its axial center line, scoop means mounted on the inside wall of said container and adapted to pick up and elevate said blanks from a point near the lower end of a circle formed by the revolving container to a point near the top of the circle where the blanks fall by gravity into the interior of the container, and impeller means rotatable within said container on said axial center line of said container at a predetermined relatively high speed to strike the blanks and change both the direction and magnitude of the velocity of said blanks and cause the blanks to be impacted at high velocities against the inside container wall and become rounded off.

5. Apparatus as recited in claim 4 wherein means are provided to heat the rotating container and the blanks therein to an elevated temperature greater than normal room temperature but less than the melting point of the metal balls.

6. An apparatus for mechanically rounding off non-spherical deformed particles comprising a substantially enclosed chamber having an inlet whereby non-spherical particles are continuously fed into said chamber and an outlet whereby rounded balls are continuously withdrawn, elevating means within said chamber to continuously pick up, elevate and discharge said particles into the path of a continuously-rotating, high-speed vane assembly which throws the particles against the inside chamber wall, thus rounding off said non-spherical particles and resulting in substantially spherical balls.

7. The apparatus recited in claim 6 wherein means are provided to maintain the blanks at an elevated temperature above room temperature but below the melting point of the blanks while being impacted.

8. In an apparatus for mechanically forming shot by impacting non-spherical blanks in order to produce rounded balls, the combination of a cylindrical container, means to elevate and recirculate the blanks within said container, and rotatable impact means within said container to change the direction and provide a velocity of sufficient magnitude thereto to deform the blanks upon being impacted against the container inner wall.

9. The combination recited in claim 8 wherein said elevating means comprises at least one scoop attached to the inner container wall to pick up, lift and discharge by gravity the balls into the interior of said container whereby said impact means strikes the blanks and changes both the direction and magnitude of the velocity thereof.

10. The combination recited in claim 9 wherein said means within the container to change both the direction and magnitude of the velocity of the blanks comprises a vane assembly which rotates at high speed on the same axis as the rotating container.

11. The combination recited in claim 10 wherein said rotatable vane means includes a curved end portion which is swept back opposite to the direction of vane rotation in order to prevent marking of the finished ball.

12. The combination recited in claim 9 wherein said drum rotates at a relatively slow speed and said elevating means comprises scoop means mounted on said rotatable drum.

References Cited by the Examiner

UNITED STATES PATENTS
1,601,252 9/26 Lines.
2,759,360 8/56 Shutter 29-1.22
2,815,560 12/57 Boston 29-1.22
2,946,115 7/60 Firm.

FOREIGN PATENTS
13,537 6/11 Great Britain.
75,373 7/49 Norway.

OTHER REFERENCES
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