METHOD OF FORMING REFRACTORY MOLD SHAPES

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The present invention relates to the casting of refractory shapes, and more particularly, to the solid (as opposed to hollow) casting of refractory shapes of high purity and high density.

In the casting of refractory shapes from finely divided refractory materials, it is a general practice to mix the refractory material with a binder and a suitable amount of a tempering agent, such as, water. The tempering agent is necessary so that the mixture will readily flow into the mold and to enable formability of the mixture. After the shape has been molded, it is usually fired at an elevated temperature to drive off the tempering agent and other volatiles, thus resulting in a relatively porous product. In many applications, high density refractory shapes are required; thus, reduction of the amount of tempering agent necessary for the mixture would be extremely helpful in increasing the density of the final product.

Another problem that has arisen in the casting of refractory shapes, especially when employing such contemporary methods as vibration casting, is the difficulty of removal of the shape from the mold cavity. Quite often, the green refractory shape has a tendency of adhering to the mold walls thus destroying the shape contours upon removal.

Concerning other applications, industry demands precision casting of many items. Some of these items are cast from chemically active and corrosive exotic metal alloys. It has been conventional for the casting of these alloys to provide a mold having a lining fabricated of finely divided refractory material shaped to provide a smooth molten metal contacting surface. The finely divided refractory, from which the smooth surface is fabricated, conventionally is mixed with a binder material which is capable of bonding to provide a substantially impermeable interface against which the molten metal may solidify.

The problems of fabricating a mold of a plurality of different layers of material is obvious from a labor and expense standpoint. Some have suggested various organic lubricating compositions, such as, waxes and the like, which can be applied to the surface of the back up material in place of the finely divided refractory material. However, the mold must be cleaned and the material reapplied after each use. This is a satisfactory arrangement, but still requires an undesirable expenditure of labor and time.

Accordingly, it is an object of this invention to provide for the casting of dense refractory shapes.

Another object of the invention is to provide a method of fabricating refractory molds.

Still another object of the invention is to provide for greater facility for casting molten metal.

Other objects of the invention will appear hereinafter.

Briefly, in one embodiment, the invention resides in the discovery that the addition of a useful amount of a selected silicone emulsion (from 2 to 1000 parts per million parts of a finely divided refractory material) has remarkable effects in casting operations. In a preferred embodiment, from 5 to 150 parts per million parts of refractory material is employed.

Among other things, a small and useful amount of a selected silicone emulsion, according to this invention, allows the effective use of cationic dispersants, apparently by reducing the surface tension thereof. Also, because of its effect on the surface tension of certain dispersants, only limited amounts of a tempering agent, such as, water, need be added to the mixture which is to be cast. Further, the addition of useful amounts of a selected silicone emulsion facilitates the removal of a refractory shape from the mold in which it is cast.

Previously, it was thought necessary to include various inorganic fluxes and binding agents which only serve to lessen the purity of the mold which resulted after firing. Certain organic binding materials have been suggested. But porosity problems as opposed to purity problems are even more evident when using certain organic binder materials, because they tend to burn out at higher temperatures leaving undesirable void areas.

The present invention may be employed with any refractory material where a dense product is desired. Particularly good results have been obtained where the refractory material was one of the group of stabilized zirconia containing 93% ZrO₂ + CaO, zircon containing 66% ZrO₂ and 32% SiO₂, alumina containing 90% Al₂O₃ and dead burned magnesite containing 95% MgO, all on an oxide basis.

A typical screen analysis for zirconia, alumina and magnesia is as follows: 30% of —4 on 10 mesh, 35% of —10 on 28 mesh, 35% of —65 with 52% of the material being —325 mesh. For zircon, a typical analysis is 10% of —4 on 10 mesh, 10% of —10 on 28 mesh, 10% of —28 on +65 and 50% of —65 on +200 mesh.

The term silicone extends to silicon polymers containing silicon-oxygen-silicon linkages and containing a significant proportion of organic groups directly attached to silicon. Silicone fluids can be emulsified to form stable oil in water emulsions. Fluids of various viscosities and compositions are used in the commercially available emulsions. These generally contain about 5% to 50% water, with the remainder being water, a small amount of emulsifying agent, and a rust inhibitor. Examples of silicone emulsion employed successfully in accordance with the invention are "Antifoam A," "Antifoam B," "20 Emulsion," and "772" emulsion, proprietary products of the Dow-Corning Corporation of Midland, Michigan. The proportion of the above materials is listed in the table below.

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<th>TABLE</th>
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<tr>
<td>Color</td>
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<tr>
<td>Density</td>
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</table>

In use, whether casting a solid (as opposed to hollow) refractory shape or an investment mold for subsequent use in casting metals, the refractory material is mixed with from about 2 to 1000 parts, by weight, of a silicone emulsion per million parts of refractory materials. A sufficient amount of a tempering agent, such as, water, is added to the mixture. The mixture is introduced into a mold cavity. After setting, the resulting shape is separated from the mold easily, and without adherence to the mold walls, to produce a relatively dense refractory product having smooth surfaces.

A higher density may be obtained in the final refractory product since the addition of a silicone emulsion decreases the amount of tempering agent necessary for the mix. Thus, when the refractory shape is fired at an elevated temperature, a smaller number of voids occur.

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Also, the silicone emulsion greatly facilitates the removal of the shape from the mold cavity. The following examples are illustrative of the teachings of the invention.

**Example I**

"Antifoam A" was added with water in the proportions indicated below to finely divided refractory batches of stabilized zirconia, zircon, magnesia, and alumina.

<table>
<thead>
<tr>
<th>Mix, Type</th>
<th>Zirconia</th>
<th>Zircon</th>
<th>Magnesia</th>
<th>Alumina</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Required to Cast Experimental Mix Containing Silicone Emulsion, percent</td>
<td>6</td>
<td>8.5</td>
<td>5</td>
<td>9.3</td>
</tr>
<tr>
<td>Composition of Tempering Fluid, Water, percent</td>
<td>5.98</td>
<td>5.49</td>
<td>4.98</td>
<td>9.27</td>
</tr>
<tr>
<td>Antifoam &quot;A&quot;, percent</td>
<td>0.02</td>
<td>0.01</td>
<td>0.02</td>
<td>0.03</td>
</tr>
</tbody>
</table>

The resulting mixture was introduced into a plaster of paris mold. The results indicate that "Antifoam A" successfully lowered the proportion of tempering fluid needed for casting. Also, the resulting shapes were released from the molds without the adherence thereto of any refractory material.

**Example II**

"Antifoam B" silicone emulsion was added in the same proportions to the refractory mixes of the above example. The results obtained were similar to Example I.

**Example III**

Dow-Corning “772” and “20 Emulsion” were employed with each of the refractory materials of Example I. Test results indicated that both emulsions aided in the release of the refractory shapes from the mold, but in other respects were slightly inferior to “Antifoam A” emulsion. In addition the “772” emulsion increased the hydration resistance of magnesia when coated on a cast brick therefrom.

It is intended that the foregoing description be construed as illustrative and not in limitation of the invention.

We claim:

1. A method of casting refractory shapes consisting essentially of mixing a refractory material selected from the group consisting of zirconia, zircon, alumina, and magnesia with from 2 to 1000 parts, by weight, of a silicone emulsion containing a maximum of about 50% silicone, per million parts of refractory material and a sufficient amount of tempering agent, introducing the mixture into a mold cavity and subsequently separating the resulting shapes and mold, the silicone emulsion being characterized by having the propensity for facilitating removal of the shape from the mold cavity and for decreasing the amount of tempering agent necessary to cast.
2. The method according to claim 1 in which the cast shapes are fired.
3. The method according to claim 1 in which the silicone emulsion is present in amounts between about 5 and 150 parts, by weight, per million parts of refractory material.
4. The method according to claim 1 in which the tempering agent is water.
5. A refractory batch consisting essentially of a mixture of a refractory material selected from the group consisting of zirconia, zircon, alumina, and magnesia, from 2 to 1000 parts per million of a silicone emulsion containing a maximum of about 50% silicone, per million parts of refractory material and a sufficient amount of tempering agent, the silicone emulsion being characterized by having the propensity for facilitating the removal of a shape made from the batch from a mold cavity and for decreasing the amount of tempering agent necessary without said emulsion.

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MARCUS U. LYONS, Primary Examiner.