MOLD AND CORE COATING COMPOSITION FROM CALCINED HYDRATED ALUMINUM SILICATE, MICA, AND BENTONITE

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This invention relates to a coating composition which, when applied to surfaces of foundry sand molds and cores, improves the fluidity of molten metal cast against these surfaces, reduces chill in thin sections and improves the burn-in resistance of the coated surfaces. More particularly, the invention pertains to a foundry mold or core wash containing finely divided mica, calcined hydrated aluminum silicate and bentonite suspended in a liquid carrier. This coating composition may be beneficially applied to molds for casting gray cast iron, malleable iron, spheroidal graphite cast iron, aluminum alloy, magnesium and magnesium alloys to improve their casting surfaces.

In the past it was frequently impossible to successfully cast some thin sections of the aforementioned metals except by superheating the casting metal, preheating the mold and/or substantially increasing the metallostatic pressure. Obviously it is desirable to eliminate these procedures. A principal object of the present invention, therefore, is to provide a coating for foundry sand molds and cores which materially increases the fluidity of molten casting metals contacting such molds and cores without employing superheat, preheated molds or undesirably high metallostatic pressures. As a consequence, severe castings of very thin section can be formed by conventional procedures. The term “fluidity,” as used herein, refers to that property of molten metal in contact with a mold which allows the metal to flow into the mold and fill it before solidification obstructs further flow of the metal.

The above and other objects of this invention are attained with a foundry mold and core coating comprising a slurry of mica or vermiculite powder, finely divided calcined hydrated aluminum silicate, bentonite and a liquid carrier, such as methyl alcohol, ethyl alcohol, isopropyl alcohol, toluene, a chlorinated hydrocarbon, commercial mineral spirits or water. Small amounts of phenolic resin or sugar, sodium chloride and a wetting agent also may be beneficially included in the slurry. The coating composition thus provided is relatively inexpensive and can be readily applied to the mold surfaces by conventional means such as spraying, dipping or brushing.

It will be understood that the term “mold,” as hereinafter generally employed, means a casting form which includes both molds and cores, this invention not being limited to the former. Likewise, the word “sand” is used in its generic sense and is not restricted to silica particles.

The mica powder preferably constitutes approximately 20 to 60% of the solids content of the coating composition, although the amount of mica may vary from as low as about 10% to as high as 85% by weight. At least 10% by weight of calcined hydrated aluminum silicate or kaolinite is required where there is a problem of metal penetration into the mold, and the amount of this binder will provide adequate restraint up to about 50% of the solids in the slurry. We have found that optimum results are produced with a calcined hydrated aluminum silicate content of about 20% to 50% by weight. The phenolic resin or sugar, if either of these materials is included in the coating composition, should not exceed approximately 7% by weight of the solids present. For many applications, 2% to 5% by weight of phenolic resin is preferred, but even 0.5% by weight of the additional binder in the coating causes it to adhere more strongly to the mold.

Likewise, the bentonite should constitute no more than 15% by weight of the solids content of the slurry. We have found that a composition containing 3% to 7% bentonite on a solids basis provides particularly satisfactory results. The total amount of bentonite plus resin should not exceed approximately 20% of the weight of the solids in the slurry, and the combination of these two constituents should equal at least 5% by weight of the solids content. In general, the particle size of these various powdered constituents should be finer than 80 mesh, and much finer powders are preferred.

The presence of the calcined hydrated aluminum silicate greatly increases the burn-in resistance of a mold coating having the foregoing composition because it is a refractory material which does not fuse below approximately 3300°F. This constituent fills the porous surfaces of the mold to which the slurry is applied and mechanically stops the molten metal from penetrating these surfaces. Since the calcined kaolinite has a very low bulk density, it also thermally insulates the metal from the mold to some extent, thereby increasing the apparent fluidity of the molten metal.

The insulating film between the core or mold and the molten metal is provided principally by the mica powder in the coating, however. Mica is ideal for this purpose because it has a low thermal conductivity, high reflectivity for radiant heat and a very low bulk density. Nevertheless, an essentially mica coating is unsatisfactory for many applications due to its poor burn-in resistance resulting from its failure to penetrate the core surface because of the platelet shape of its particles. Consequently, it is necessary to add the calcined hydrated aluminum silicate to provide adequate burn-in resistance. Although the burn-in resistance of the coating increases appreciably as the calcined kaolinite content is raised, the mica cannot be eliminated. If the solids in the coating do not contain at least 10% mica, complete penetration of the calcined kaolinite into the mold will not provide any measurable film on the surface of the mold or properly insulate the molten casting metal from the mold unless the slurry is excessively viscous. Without such an insulating film the fluidity of the metal is significantly increased as a result of the heat loss.

Bentonite is included in the coating composition to improve the slurry suspension, aid in bonding the mica and kaolinite particles together, and provide the coating with improved burn-in resistance. However, both bentonite and phenolic resin tend to reduce the fluidity of the molten casting metal, and it is therefore desirable to use only relatively small amounts of these materials.

The phenolic resin functions as a binder to form a hard, adherent coating on the mold. A water-dispersible phenolic resin, such as phenol-formaldehyde resin, has proved to be highly satisfactory for use in a coating in which water is employed as a liquid carrier. Sugar is another resinous material which has been used successfully as a binder constituent in place of the phenolic resin. Of course, the coating should not be removed by normal handling nor should it be blown off with a high pressure air blast. Consequently, the minimum amount of resinous binder which should be included in the slurry is that which will provide adequate restraint and adhesion. A coating composition containing approximately 2% to 4% by weight of phenolic resin binder normally has excellent resistance to rubbing and air blasting.

Sodium chloride or hydrochloric acid may be included in the coating slurry to promote its thixotropic properties and thereby improve dipping characteristics. The amount of sodium chloride or HCl to be used depends upon the
mineral content and pH of any water in the slurry. If the mineral content of the water is high or its pH is low, the addition of the salt or HCl becomes relatively unimportant. In general, the sodium chloride should constitute about 0.05% to 3% of the solids content of the coating composition. Approximately 0.15% to 0.3% of a 20% hydrochloric acid solution has proved to be successful in increasing the thixotropy of the slurry without attendant foaming.

The coating slurry preferably is applied to green sand molds by a spraying procedure, and when this is done it is advantageous to mix the above-described powdered constituents with a volatile organic liquid, such as commercial methyl alcohol, ethyl alcohol, isopropyl alcohol, toluene, a chlorinated hydrocarbon or naphthalene spirits. A slurry of this type also can be used to spray baked sand molds and cores, or water may be employed as a less expensive carrier if the molds and cores are subsequently reheated to dry the coating. Of course, in the case of baked sand cores, it is inconvenient to apply a water slurry by a dipping operation. When alcohol is used as the liquid carrier, any excess alcohol can be readily burned off.

When a water suspension is used in a dipping operation, it may be desirable to include a small amount of wetting agent if it is necessary to improve the penetration of the slurry into the mold. A low-foaming, nonionic wetting agent is preferred for this purpose. Examples of such a wetting agent are those available under the trade names "L-62 Pluronic" and "L-61 Pluronic," products of the Wyandotte Chemical Company, Wyandotte, Michigan. Normally, as little as about 0.1% by weight of wetting agent, based on the solids content of the slurry, is beneficial in this respect; and the amount of wetting agent used ordinarily will be appreciably less than 1%.

The above-described mold coating compositions may be prepared in the following manner: First, the bentonite is mixed with approximately 15% of the total amount of water used in the slurry. This mixture should be permitted to stand for at least four hours so that a gel is formed. The remaining water, mica and the calcined hydrated aluminum silicate are added to the gel, and these constituents are thoroughly mixed to produce a smooth slurry. If resin or sugar is to be included in the composition, this constituent should then be added to the slurry in a manner to provide minimum agitation, thereby reducing any foaming tendency. Next, the hydrochloric acid or sodium chloride, if either is to be used, is introduced and the resultant liquid composition stirred for an additional five to ten minutes. If NaCl is used it should be dissolved in a small quantity of water before being added to the slurry. When this slurry is about to be used, it should again be thoroughly agitated, and the specific gravity of the mix adjusted to provide the desired consistency.

It is also possible to prepare the coating composition by first dry blending the bentonite with about 20% to 30% of the kaolinite. This mixture may then be added to the water and the slurry stirred until smooth. Next the mica powder and the balance of the kaolinite are mixed with the slurry to produce a smooth, lump-free slurry. The resinous binder or binders, the NaCl and the HCl, if used, then can be added in the manner described above. Normally the coating slurry is applied to the casting-defining surfaces of the mold at room temperature.

The following Table 1 lists specific examples of coating compositions prepared in accordance with the present invention:

<table>
<thead>
<tr>
<th>Example I</th>
<th>Example II</th>
<th>Example III</th>
<th>Example IV</th>
<th>Example V</th>
<th>Example VI</th>
<th>Example VII</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mica Powder</td>
<td>Calcium Aluminate</td>
<td>Neoprene Resin (20% solids)</td>
<td>Neoprene</td>
<td>Neoprene</td>
<td>Neoprene</td>
<td>Neoprene</td>
</tr>
<tr>
<td>50 lbs.</td>
<td>65 lbs.</td>
<td>5 lbs.</td>
<td>1 lbs.</td>
<td>1 lbs.</td>
<td>1 lbs.</td>
<td>1 lbs.</td>
</tr>
<tr>
<td>40 lbs.</td>
<td>55 lbs.</td>
<td>6 lbs.</td>
<td>2 lbs.</td>
<td>2 lbs.</td>
<td>2 lbs.</td>
<td>2 lbs.</td>
</tr>
<tr>
<td>10 lbs.</td>
<td>25 lbs.</td>
<td>8 lbs.</td>
<td>3 lbs.</td>
<td>3 lbs.</td>
<td>3 lbs.</td>
<td>3 lbs.</td>
</tr>
<tr>
<td>50 lbs.</td>
<td>30 lbs.</td>
<td>35 lbs.</td>
<td>40 lbs.</td>
<td>45 lbs.</td>
<td>50 lbs.</td>
<td>55 lbs.</td>
</tr>
<tr>
<td>50 lbs.</td>
<td>20 lbs.</td>
<td>15 lbs.</td>
<td>20 lbs.</td>
<td>25 lbs.</td>
<td>30 lbs.</td>
<td>35 lbs.</td>
</tr>
<tr>
<td>50 lbs.</td>
<td>15 lbs.</td>
<td>10 lbs.</td>
<td>15 lbs.</td>
<td>20 lbs.</td>
<td>25 lbs.</td>
<td>30 lbs.</td>
</tr>
</tbody>
</table>

The quantity of liquid carrier used should be sufficient to provide a slurry which can be readily applied to the mold. If it is desired to dip the mold, the ratio of the liquid carrier to the solids content of the coating composition may vary between approximately 2 to 1 and 5 to 1. On the other hand, this ratio may be as low as 1 to 1 for spray coatings. Thus it will be seen that the amount of liquid in the slurry may constitute about 50% to 83% of the total weight of the slurry, but a coating having a water content of approximately 65% to 75% is generally preferred.

In addition to the above-described constituents or as a substitute for a portion of the phenolic resin, urea formaldehyde or other soluble resins may be included in the slurry to further increase the hardness and durability of the dried coating. A relatively small amount of other binders for protective layers also may be added to the slurry to improve the adhesion of the coating to the sand mold if the binder is soluble or properly dispersible in the liquid carrier. Among these binding agents are thermoplastic resins such as polyvinyl chloride, vinylidene chloride, polyvinyl alcohol and polyvinyl acetate, and thermosetting resins such as melamine formaldehyde. Of course, more than one polymeric binder may be used in the coating composition, but the total amount of this binder normally should not exceed about 7% by weight of the solids in the coating material.

Each of the above coating compositions had excellent dipping characteristics, dried in a reasonable period of time and was hard and durable upon drying. In addition, the coatings substantially reduced chill in thin sections and materially aided in the cleanup of the castings. Use of these coatings also significantly decreased metal penetration into the mold and/or cores, thereby improving the surface finish of the castings in their as-cast condition. Furthermore, the coatings listed in Table 1 are less expensive than the commercially available coatings generally employed.

When dry sand test molds were coated with the above-described slurries, the fluidity of gray cast iron, malleable iron, spheroidal graphite cast iron and aluminum poured at normal casting temperatures into these molds was increased appreciably as compared with the use of similar molds which were uncoated. The fluidity of the molten metals in the molds was determined by means of a double spiral fluidity test mold in which one spiral is coated with the mold wash while the other remains uncoated, both being fed by the same pouring basin and down spout. The relative distances the metal travels in the spiral is a measure of the improvement in fluidity.

The following Table 2 shows the results of the fluidity tests using a 133 mm gray cast iron in each instance. The coatings used in the test are the same coatings listed.
8,243,397

in Examples II through VII of Table 1 and are correspondingly identified in Table 2:

<table>
<thead>
<tr>
<th>TABLE 2 Spiral Length</th>
<th>Uncoated, in.</th>
<th>Coated, in.</th>
<th>Fluidity Increase, per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example II</td>
<td>174</td>
<td>205</td>
<td>100</td>
</tr>
<tr>
<td>Example IV</td>
<td>103</td>
<td>121</td>
<td>110</td>
</tr>
<tr>
<td>Example V</td>
<td>18</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td>Example VI</td>
<td>28</td>
<td>30</td>
<td>20</td>
</tr>
<tr>
<td>Example VII</td>
<td>195</td>
<td>20</td>
<td>25</td>
</tr>
</tbody>
</table>

The microstructure of the 1/4-inch thick sections of gray iron castings poured into the coated mold portions was slightly more refined than the microstructure of gray iron specimens cast into the 3/4-inch thick uncoated portions of the same mold. No primary carbide was evident in either section.

Likewise, tests were conducted on molten aluminum using the above-described double spiral fluidity test mold. Aluminum 356 alloy was found to have an apparent fluidity increase of approximately 225% when poured into contact with a test mold coated with the slurry of Example IV above.

Additional tests under production conditions also showed that use of the new mold coating, by improving the surface finish of the castings, greatly reduced the amount of labor necessary in cleaning operations. Moreover, the coating prevented misruns and cold shuts. As a consequence, leakers were eliminated, and the scrap rate due to such defects was appreciably lowered. Furthermore, the molten coating described herein has a relatively short drying time and a wide drying temperature range. For example, a coating on port cores for gasoline engine cylinder head castings was dried in only about three minutes at 500°F. without blistering. This coating composition also has good dipping characteristics and is uniform in thickness both before and after drying, as well as being relatively inexpensive to use.

While our invention has been described by means of certain specific examples, it is to be understood that its scope is not to be limited thereby except as defined by the following claims.

We claim:

1. A slurry for coating casting-defining surfaces of foundry sand molds, said slurry being formed from a dry blend comprising approximately 10% to 85% by weight of mica powder, 10% to 86% by weight of calcined hydrated aluminum silicate and 3% to 15% by weight of bentonite to which has been added a liquid carrier in an amount sufficient to constitute about 50% to 83% of the total weight of the slurry, the particle size of the solid constituents in said slurry not exceeding approximately 80 mesh.

2. A coating slurry for application to casting-defining surfaces of a foundry mold, said slurry consisting essentially of a liquid carrier and a dry blend comprising about 40% to 75% by weight of mica powder, 10% to 50% by weight of finely divided calcined hydrated aluminum silicate and 3% to 15% by weight of bentonite, said liquid carrier being selected from the group consisting of methyl alcohol, ethyl alcohol, isopropyl alcohol, toluene, mineral spirits and water in proportions such that said dry blend constitutes approximately 17% to 50% of said slurry, the particle size of the solid constituents in said slurry not exceeding approximately 80 mesh.

3. A coating slurry for application to casting-defining surfaces of a foundry mold, said slurry consisting essentially of about 30% to 83% by weight of water and about 17% to 30% weight of a dry blend comprising approximately 10% to 85% by weight of mica powder, 10% to 86% by weight of finely divided calcined hydrated aluminum silicate, 3% to 15% by weight of bentonite and 0.5% to 7% by weight of phenol-formaldehyde resin, the combined amount of bentonite plus phenol-formaldehyde resin not exceeding 20% of the weight of the dry blend, the particle sizes of the solid constituents in said slurry not exceeding approximately 80 mesh, said slurry containing about 0.1% to 1% by weight of wetting agent.

4. A coating composition for application to casting-defining surfaces of a foundry sand mold, said composition consisting essentially of a suspension of a powder in acidic water, said powder having a particle size less than approximately 80 mesh and comprising, by weight, about 10% to 85% mica, 10% to 86% calcined hydrated aluminum silicate and 3% to 15% bentonite, said suspension containing a polymeric organic binder in an amount not in excess of about 7% of the weight of said powder.

5. A coating slurry for application to casting-defining surfaces of a foundry mold, said slurry consisting essentially of about 50% to 83% by weight of water and about 17% to 50% by weight of a dry blend comprising approximately 10% to 85% by weight of mica powder, 10% to 86% by weight of finely divided calcined hydrated aluminum silicate, 3% to 15% by weight of bentonite and 0.5% to 7% by weight of a resinous binder, the combined amount of bentonite plus resinous binder not exceeding 20% of the weight of the dry blend, the particle sizes of the solid constituents in said slurry not exceeding approximately 80 mesh, said slurry containing sufficient hydrochloric acid to make said slurry acidic.

6. A coating slurry for application to casting-defining surfaces of a foundry sand mold to permit molten casting metal in contact with said mold to more readily flow into the mold cavity and fill it before solidification obstructs further flow of said metal, said coating slurry consisting essentially of an aqueous dispersion containing approximately 17% to 50% by weight of a finely divided powder comprising about 40% to 75% by weight of mica, 20% to 50% by weight of calcined hydrated aluminum silicate and 3% to 15% by weight of bentonite, the water in said slurry containing at least one dissolved compound which makes said slurry sufficiently acidic to promote thixotropy of the bentonite, the particle sizes of the solid constituents in said slurry not exceeding approximately 80 mesh.

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