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GLYCERINE OR ETHYLENE GLYCOL IN FOUNDRY SAND MOLD FACING MIXTURES

A method of treating the surface of a sand mold with mixtures containing glycerine, ethylene glycol or the like, for the purpose of producing clean, sand free castings has been a result of the Bureau's experimentation with a sand tempering process patented by Harold E. Osborne and assigned to the American Magnesium Corporation. (U. S. Patent 1,533,892) in which molding sand is tempered with a binder containing glycerine instead of water. The prime object of such a bond in making molds for magnesium castings is to avoid attack upon the casting by steam from a water-tempered mold. It appeared of interest to determine how the glycerine bond would compare with water in various sands and for casting other alloys.

Before studying the behavior of glycerine bonded sands in the Bureau's regular casting work or testing the physical properties of glycerine bonded sands compared to water bonded sand, inquiry was made to the American Magnesium Corporation with respect to the sort of licensing arrangement would be made with commercial foundries that might be interested in the use of glycerine bonded sand.

In reply, the American Magnesium Corporation expressed their willingness to co-operate with the Bureau and stated that they had no objection to a licensing arrangement for the use of the patent in making castings of metals other than magnesium and its alloys. This would involve, they stated, only a nominal fee in recognition of the patent.

The Bureau then made a brief study of glycerine as a bond, and found, as Osborne stated, that the bond strength and permeability of sands so bonded can be made quite comparable to those bonded with water.

The decomposition of glycerine on heating, with acrolein, a gas irritating to the mucous membranes of the eyes, nose and throat, as a product of the decomposition, makes the use of the glycerine bond unpleasant when many large castings are poured at once, and adequate ventilation is required. The decomposition goes on to such a degree under temperatures at which brass, bronze, cast iron or steel are poured, that a layer of fine carbon or soot also appears at the surface of the mold in contact with the casting.

The formation of a layer of gas and of soot in such a case is quite analagous to that in the case of a mold oil used on metal molds. Oils do not lend themselves to use with sand as well as do compounds like glycerine.

For castings of metals other than magnesium alloys, the behavior of the glycerine bond at the mold surface appeared of more interest than its bonding properties throughout the body of the mold, since, presumably as a result of the gas and soot mentioned, it was found that castings in glycerine tempered sand were remarkably free from burnt-on sand.

Since glycerine mixes with water in all proportions, it seemed probable that a mold made from water-bonded sand and merely faced with glycerine, applied by spraying, would have this same desirable property, at a cost that might readily be balanced or over balanced by decrease in cost of cleaning castings from adhering sand. It is well known that burnt on sand is very hard on tools when "sandy" castings are machined, that steel castings are less uniformly heat treated if a layer of sand remains on them to act as a heat insulator, and that sea coal or graphite facings, used to avoid burnt-on sand reduce the permeability of the sand and may thus give rise to defective castings.

Attention was then turned from the use of glycerine as a bond for the whole mold, to its use as a facing only.

It was soon found that swabbing the mold or using a heavy spray that gives drops, instead of mist, was unsatisfactory and that application of the facing to the finished mold must be done with some type of sprayer or atomizer that will give so light a mist, that no drops form on the mold, else "blows" will result.

Obviously, the application of the spray to the mold face has a similar effect upon the bonding of the sand to an increase in the amount of water with which the sand is tempered. Hence, it is advisable to work sand to which such a facing is to be applied, rather on the dry side.(x)

The viscosity of the liquid to be sprayed, especially with the admixture of refractory "flour" should not be too high. Reduction of viscosity by dilution with water reduces the available amount of the active ingredient. Attempts to cheapen

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(x) A DeVilbliss Aeron type D paint sprayer, operated with 80 lbs. air pressure has been used in most of the work at the Bureau. Other sprayers which also give a drop-free mist would, of course, be applicable.

the facing by dilution with molasses water instead of water alone were not satisfactory. Unless the mixture sprayed is fairly viscous, it soaks away from the mold face by capillarity and again the amount of active agent at the mold face is reduced.

The best compromise appears to be to use ethylene glycol, which has a lower viscosity, instead of glycerine, and to increase its viscosity by the addition of a finely ground refractory, preferably of such a nature that it will not materially reduce the permeability of the mold.

Silica flour 200 mesh or zirconium silicate flour 200 mesh and graphite 200 mesh, give good results.

Ethylene glycol gives some formaldehyde or other aldehydes on heating, which is an irritant to the mucous membranes, but not so strong an irritant as acrolein. With ordinarily good ventilation the odor of formaldehyde has not been found troublesome.

It would also be possible to use a layer of sand tempered with glycerine or glycol as facing over the pattern, backing it up by water tempered sand. In molds with deep pockets that cannot be reached with the spray, such a method may have to be resorted to.

It must be remembered that glycerine and ethylene glycol boil at about 290°C (555°F) and 198°C (388°F). It is therefore useless to spray a mold and then bake it at a temperature which will drive off the glycerine or glycol. These materials should be present on the surface of the mold when the hot metal hits them. They then vaporize, and decompose simultaneously forming a thin gas blanket and a layer of soot. Experiments indicate that many castings that could not be cast in a green sand mold water tempered, can be cast in green glycerine or glycol bonded sand, and under some conditions, which have to be worked out for each particular case, a water-bonded, glycerine or glycol-faced green sand appears promising for castings ordinarily made in dry sand.

When dry sand molds are to be used, the mold must be allowed to cool before spraying. Spraying should, in such cases, preferably be done just before closing and pouring the mold so that capillarity may not draw the liquid too far from the surface for enough to be left to perform its function. It appears that a very thin layer of refractory flour plus the gas blanket and coating of soot so protects the surface that even if the backing sand is so poorly refractory that it would sinter onto the casting surface without such protection, clean castings, peeling nicely from the sand, result.

A number of mixtures have been used in this investigation as mentioned below and will hereafter be referred to by number. Percentages of mixtures refer to weight basis.

1. Glycerine (commercial grade)
2. Ethylene glycol (Trade name "Prestone")
3. Sprayed glycerine
4. Sprayed glycol
5. 50% glycerine-50% ethylene glycol (sprayed)
6. 75% glycerine-25% molasses water(1) "
7. 50% glycerine-50% molasses water "
8. 50% ethylene glycol-50% molasses water "
9. 50% glycerine-25% ethylene glycol-25% molasses water(sprayed)
10. 45% ethylene glycol-50% silica flour(2)-5% " " "
11. 48% ethylene glycol-50% silica flour-2% " " "
12. 49% ethylene glycol-50% silica flour-1% " " "
13. 49% ethylene glycol-48% silica flour-3% sodium silicate "
14. 50% ethylene glycol-50% silica flour "
15. 75% ethylene glycol-25% silica flour "
16. 25% ethylene glycol-75% silica flour "
17. 50% ethylene glycol-50% zirconium silicate flour(3) "
18. 75% ethylene glycol-25% zirconium silicate flour "
19. 25% ethylene glycol-75% zirconium silicate flour "
20. 50% ethylene glycol-25% silica flour-25% zirconium silicate flour (sprayed)
21. 30% ethylene glycol-70% graphite(4)
22. 30% molasses water-70% silica flour

(1) Molasses water; 100 parts water, 15 parts strap molasses.
(2) Silica flour; 96% passes, #200 sieve.
(3) Zirconium silicate flour; 80-90% passes, #200 sieve.
(4) Graphite; 75% passes, #200 sieve.

Such mixtures as mentioned above have been investigated on ferrous and non-ferrous sand molds producing castings weighing from 10 lbs. to 2000 lbs.

Mixtures Investigated.

1. Sands tempered with glycerine can be made to possess the same physical properties, with respect to permeability, compressive and transverse strength, as sand tempered with water. The molding properties of this sand are exceptionally good, in that the sand feels very smooth, does not adhere to wood pattern, and wood patterns are not affected by glycerine as is the case with water tempered sands.

Castings of brass, bronze and iron weighing from 2 lbs. to 10 lbs. have been produced in this sand mixture with no "burnt on" sand. Castings weighing over 10 lbs. to 15 lbs. were not free from "burnt on" sand.

2. Sand tempered with ethylene glycol does not possess the good molding properties of the glycerine tempered sand, this difference being due to the difference in viscosity between glycerine and ethylene glycol.

Castings made in ethylene glycol tempered sand were not so good as those made in glycerine sand in that the castings contained more "burnt on" sand.

3. Glycerine sprayed.

Glycerine sprayed onto the surfaces of dry sand molds produced the same results as mixture No. 1. However, the amount of acrolein gas given off was less and not so irritating. Castings from 2 lbs. to 10 lbs. satisfactory.

4. Ethylene glycol sprayed.

Ethylene glycol sprayed onto surfaces of dry sand molds did not produce very good results as the ethylene glycol, owing to its lower viscosity, penetrated into the mold, leaving only slight film on mold surface. Casting had sand "burnt on".

5. 50% glycerine-50% ethylene glycol.
This mixture produced results same as No. 3.

6. 75% glycerine-25% molasses water.
Mixture fairly good, blow holes.

7. 50% glycerine-50% molasses water.
Mixture no good, blow holes.

8. 50% ethylene glycol-50% molasses water.
Mixture no good, blow holes.

9. 50% glycerine-25% ethylene glycol-25% molasses.
Mixture no good.

10. 45% ethylene glycol-50% silica flour-5% molasses water.
This mixture produces good results providing mold was dried before spraying.

11. 48% ethylene glycol-50% silica flour-2% molasses water.
Same as mixture No. 10.

12. 49% ethylene glycol-50% silica flour-1% molasses water.
Better than mixtures Nos. 10 and 11.

13. 49% ethylene glycol-48% silica flour-3% sodium silicate.
Not so good; "burnt on" and blow holes.

14. 50% ethylene glycol-50% silica flour.

This mixture produces very good results. Castings have been made weighing from 2 to 2000 lbs. with no "burnt on" sand at all. (This mixture will be referred to later).

15. 75% ethylene glycol-25% silica.
Not so good as No. 14.

16. 25% ethylene glycol-75% silica flour.
Difficult to apply, too thick. Not so good as No. 14.

17. 50% ethylene glycol-50% zirconium silicate flour.
This mixture is very good, equal to No. 14; to be referred to later.

18. 75% ethylene glycol-25% zirconium silicate flour.
Mixture works well, not so good as mixture No. 17.

19. 25% ethylene glycol-75% zirconium silicate flour.
Mixture works similar to mixture No. 16.

20. 50% ethylene glycol-25% silica flour-25% zirconium silicate flour.
Mixture as good as No. 14.

21. 30% ethylene glycol-70% graphite.

This mixture produces very good results. Castings of iron weighing 80 lbs. produced with no "burnt on" sand. (This mixture will be referred to later).

22. 30% molasses water-70% silica flour.
This mixture produces fairly good results. Not so good as No. 21.

From results of mixtures investigated, further work has been carried on with mixtures 14, 17, 20, and 21 as these mixtures seem to produce the best results.

These mixtures have been applied to dry sand molds producing iron and steel castings weighing up to 80 lbs. with no"burnt on" at all.

In experiments at the Washington Navy Yard, a dry sand mold made of Lumberton sand producing a 2000 pound, 30 per cent semi-steel projectile, was coated with mixture No. 14 and produced a casting with no sand "burnt on", also dry molds sprayed with mixtures Nos. 14 and 17 producing steel castings weighing approximately 250 pounds had very little "burnt on" while castings made in molds without treatment, had sand "burnt on" badly.

Another mold facing, titanium nitride, has been discussed by Bichowsky(x), and a little work has been done with this facing at the Bureau. The supply of titanium nitride available has so far not been sufficient to allow any exhaustive study, but further work is in progress.

The commercial utility of the glycerine or glycol facings cannot be satisfactorily determined in the Bureau laboratories alone, for it is impossible to study there all the variables involved in the use of different sands, and the production of castings of various shapes and sizes. Study fully applicable to any given foundry would have to be made in that foundry. Appraisal of the value or lack of value of the facings cannot be made without trials of them under commercial conditions. Visitors to the Bureau have been much interested in the way castings peel from the sand when these facings are used and inquiries come in to the Bureau for information. To answer such inquiries this letter circular has been prepared, in place of more formal publication of the results because of the incompleteness of the investigation, and because it appears that not much more can be economically done at present in the Bureau laboratories. The Bureau's experience with these facings indicates that they are at least worth a trial, but does not justify any sweeping statements as to definite reduction in cost of cleaning or of machining.

It is hoped that those foundrymen who may experiment with these facings will notify the Bureau of their experience with them, whether it is favorable or unfavorable.

Comments sent to the Metallurgical Division, Bureau of Standards, Washington, D. C. will be appreciated.

(x) Bichowsky, F.V.,(Titania Corp., Glendale, Cal.) Putting titanium nitride into commercial production, Chem. & Met. Eng., 33, 1926, p. 749.

LETTER CIRCULAR NO. 231, "Thermal Properties of Petroleum Products", was never issued. The number has been cancelled.