

1

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MOULDS FOR PRECISION CASTING

Adam Dunlop, Gosforth, Newcastle-upon-Tyne, England,
assignor to Rolls-Royce Limited, Derby, England, a
British company

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In what has now become recognised as the conventional method of making moulds for investment casting using an expendable pattern such as wax or plastic, the mould is produced by a two stage process. The first involves a relatively thin coating of the pattern assembly by spraying, painting or dipping and the second the final investment of the coated pattern in a suitable container by a slurry or refractory suspended in a liquid binding medium, the final consolidation of the mould being obtained by vibration.

When the liquid binding medium has hardened by chemical action, the expendable pattern is melted out by heating at 100–150° C. for several hours. Following this, the mould is gradually raised to a temperature in the range 850–1100° C. to remove completely the last trace of wax and volatile constituent of the binder medium. This requires several hours heating.

The process of consolidating the slurry by vibrating requires from 1 to 4 hours, thus where a high mould output is required, many vibrating tables are necessary. 8 to 10 hours are generally required for both the removal of the main bulk of the expendable pattern and for the heating to the high temperature. Again where a large output is being handled, large ovens and mould firing furnaces are needed.

I am aware that there has been previously described a process for precision casting by the lost wax process in which a wax pattern of the object to be cast is provided with an initial refractory coating conveniently applied by spraying, and then with a multiplicity of superimposed dip coatings such as to result in the pattern being invested with a substantial shell of refractory material namely of the order of from 1/4 inch to 1/2 inch thick (according to the size and shape of the wax pattern): after formation of the shell investment it is contemplated to remove the wax pattern, preferably by the use of a suitable hot solvent, and then to complete the forming of the mould by surrounding the shell with a supporting packing of dry sand.

According to this invention a multi-layer shell mould is formed around an expendable pattern by a process which includes dipping alternately in an acid and an alkaline solution of a sodium silicate, and including a finely ground refractory material suspended in the solution, the normality of the alkaline solution being greater than that of the acid solution, each successive, single dipping being followed by the application of a stucco material to the wet mould.

By this means a sufficiently rigid shell can be formed around the pattern to form a mould which can be used with an investment which is much simpler, cheaper and more quickly provided than is the conventional method and will have other advantages as below stated.

The normality of the alkali solution must be considerably greater than the normality of the acid solution to ensure rapid gelling when the two are brought together on the shell. I prefer to keep the ratio about 2–3:1.

2

Preferably before the application of the layers of the shell proper the pattern is given an initial refractory coating by dipping in or spraying with a solution of the type used in the conventional method.

The shell mould may be built up as follows: An initial coat is formed on the pattern by spraying with or dipping in a refractory solution of known composition. Suitable solutions to form the initial coat are as follows:

(a) Applied by spraying

10	(1) Soap solution (1%)	ml.	320
	Sodium silicate	ml.	160
	Hydrochloric acid, 10%	ml.	36
	Flint powder	gm.	1000
15	(2) Ethyl silicate containing 2% piperidine	ml.	160
	Methylated spirits	ml.	320
	Flint powder	gm.	1000
	(3) Ethyl silicate	ml.	70
20	Methylated spirits	ml.	425
	Water	ml.	5
	Flint powder	gm.	1000

(b) Applied by dipping

	(1) Water	ml.	2160
25	Sodium silicate	ml.	1800
	Glycerine	ml.	600
	Hydrochloric acid, 10%	ml.	650
	Ammonium alginate, 10% sol.	ml.	150
30	Octyl alcohol	ml.	5
	Sulphucrex (wetting agent)	ml.	75
	Flint powder	lb.	23
	(2) Water	ml.	4530
	Gelatine	gm.	40
35	Glycerine	ml.	350
	Sodium silicate	ml.	2000
	Hydrochloric acid, 10%	ml.	950
	Octyl alcohol	ml.	90
	Sulphucrex (sodium lauryl sulphate)	ml.	150
40	Flint powder	lb.	32
	(3) Ethyl silicate	ml.	1350
	Methylated spirits	ml.	3720
	Hydrochloric acid, 10%	ml.	250
45	Water	ml.	80
	Flint powder	lb.	23

The flint powder may be replaced in both dipping and spraying mixtures by such refractories as finely ground alumina, sillimanite, zirconia, zircon and the like.

If the primary coating is applied by dipping the coating while still wet is "stuccoed" by dusting with a somewhat coarse grained refractory.

The shell is next formed on the primary coating by dipping the coated pattern alternately in an acid and an alkali solution of sodium silicate including a refractory with an application of stucco after each type of dip.

A suitable acid suspension is the following:

55	Sodium silicate	ml.	790
	Water	ml.	1450
	Concentrated nitric acid	ml.	260
60	Flint powder	lb.	10

This mixture is 0.44 normal acid and is made by mixing some of the water and acid and pouring the diluted silicate slowly into the acid solution with vigorous stirring to prevent it gelling. Instead of nitric acid other mineral acids such as hydrochloric and sulphuric could be used.

A suitable alkali suspension is the following:

65	Sodium silicate	ml.	790
70	Water	ml.	1710
	Flint powder	lbs.	10

This mixture is 0.88 normal alkali.

In the acid and alkali suspension mentioned above the flint powder may be replaced partly or wholly by other refractories such as finely ground alumina, sillimanite, zirconia, zircon and the like.

The silicate content of both solutions may be the same and with a grade of sodium silicate commonly used the final silica content of each dipcoat liquid will be about 7.5 percent, but the silica content of these solutions can be varied and useful results have been obtained in a range from 3 to 15 percent. When an adjustment to the silica content is made, it is done in such a way that the first solution is always acid and the second always alkaline. The acid normality of the former should be in the range of 0.2 to 0.85 normal and the alkaline normality of the second should be in the range 0.4 to 1.7 normal, to preserve the desired ratio of 1:2-3.

Each layer or coat of the shell is produced by one dip in each separate solution, each dip being followed by the "stuccoing" operation.

Any time up to about one hour may elapse between the dips in the acid and alkali solutions as long as the former has not dried because it must be wet in order that the gelling reaction will follow. The dipping may, however, take place without any interval of time at all and I prefer that that interval be not more than two or three minutes.

The second and succeeding dips in acid solution can be made at any convenient interval after the preceding alkali dip, from 1/4 to 3 hours being generally most suitable.

A variety of refractory materials can be used for the stuccoing operation such as silica, sillimanite, firebrick grog (crushed firebrick), zirconia, zircon and the like. I prefer firebrick grog.

The grain size of the refractory used is important and the following range is suitable:

Sieve size	Percent retained by weight
-16 + 30	30-40
-30 + 52	35-39
-52 + 72	15-19
-72 + 100	12-16
-100	0

The stucco may be applied by holding the shell still wet from the dipping under a "shower" of dry particles turning it by hand (or otherwise) to make sure that all surfaces are exposed to the shower.

A number of alternate acid and alkali dips are applied, each followed by the appropriate "stuccoing," until a shell about 1/4 inch thick is produced. (This normally requires 3 or 4 dippings in each solution.) The expendable pattern is now removed by causing it to liquify (by melting or preferably by a suitable solvent).

The shell mould with pattern removed is next placed in a suitable box and invested with dry sand, care being taken to prevent any loose sand from entering the shell mould.

The dry sand will be a sufficient "backing up" of the shell for normal casting. If, however, pressure casting is to be used a firmer support may be required and in that case the same may be caused to set by incorporating in it a "fritting" material. Various fritting materials may be used such as anhydrous sodium silicate, sodium nitrate, sodium silico-fluoride. These frit at different temperatures and one should be chosen which will frit at the temperature at which the mould is to be heated.

When the shell has been suitably invested the metal may be poured in (or forced in) and the casting completed.

The advantages of this invention are in the saving of time and expense in comparison with the conventional method, and in the production of better castings. The materials employed are much cheaper than in the con-

ventional method. The vibrating equipment necessary in that method to consolidate the investment material is unnecessary. If the pattern is to be removed by heating it, the heating time required is much less (of the order of one hour or less as compared with 8 to 10 hours for the conventional method.) Alternatively if the pattern is removed by a solvent the time for removal is reduced owing to the rapid permeation of the solvent through the wall of the shell. Finally the shell is much more permeable to air than is the mould backed by a solid investment. Air can therefore escape from the mould through the shell when casting is taking place and this enables thinner sections to be cast and also avoids faulty castings due to air being trapped in the mould.

I claim:

1. The method of forming a multi-layer shell mould around an expendable pattern which includes preparing two solutions of sodium silicate each containing a finely ground refractory material suspended therein and one being alkaline and the other having an acid material added to make the same acid but of a normality less than the normality of the alkaline solution, and then applying to the pattern alternately the acid and the alkaline solutions and stuccoing a finely ground refractory material to the wet shell after each application, said alkaline solution always being applied while the shell is still wet with said acid solution.

2. The method of forming a multi-layer shell mould around an expendable pattern which includes preparing two solutions of sodium silicate each containing a finely ground refractory material suspended therein and one being alkaline and the other having an acid material added to make the same acid but of a normality less than the normality of the alkaline solution forming an initial refractory coat on the pattern according to the conventional practice of precision casting, then applying to the coated pattern alternately the acid and the alkaline solutions and stuccoing a finely ground refractory material to the wet shell after each application, said alkaline solution always being applied while the shell is still wet with said acid solution.

3. The method of forming a multi-layer shell mould around an expendable pattern which includes preparing two solutions of sodium silicate of a silicate content ranging from 3% to 15% each containing a finely ground refractory material suspended therein and one being alkaline with an alkaline normality ranging from 0.4 to 1.7 normal and the other having an acid material added to make the same acid with an acid normality ranging from 0.2 to 0.85 normal but of a normality less than the normality of the alkaline solution forming an initial refractory coat on the pattern according to the conventional practice of precision casting, then applying to the coated pattern alternately the acid and the alkaline solutions and exposing the wet shell after each application to a shower of finely ground refractory material said alkaline solution always being applied while the shell is still wet with said acid solution.

4. The method of claim 3 wherein ground flint powder is the refractory material suspended in said solutions.

5. The method of forming a multi-layer shell mould for precision casting which comprises: forming an initial refractory coat around an expendable pattern; then alternately applying to the coated pattern an alkaline and an acid solution of sodium silicate, each solution having a finely ground refractory material suspended therein, said acid solution being of an acid normality less than the alkaline normality of said alkaline solution, said alkaline solution always being applied while the shell is still wet with said acid solution; stuccoing a finely ground refractory material to the wet shell after applying each solution; after each solution has in turn been applied at least three times causing the pattern to liquify and flow out of the shell; and investing the shell in dry sand.

6. The method of claim 5 wherein the alkaline nor-

5

malinity of the alkaline solution is in the range of 0.4 to 1.7 normal; wherein the acid normality of the acid solution is in the range of from 0.2 to 0.85 normal; and wherein the alkaline normality of the alkaline solution is at least twice the acid normality of the acid solution. 5

7. The method of claim 5 wherein the sand has incorporated therein a material capable of fritting at elevated temperatures.

8. The method of claim 5 wherein each solution is applied by dipping and wherein the stuccoing operation 10 comprises showering dry material on the wet shell.

6

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