

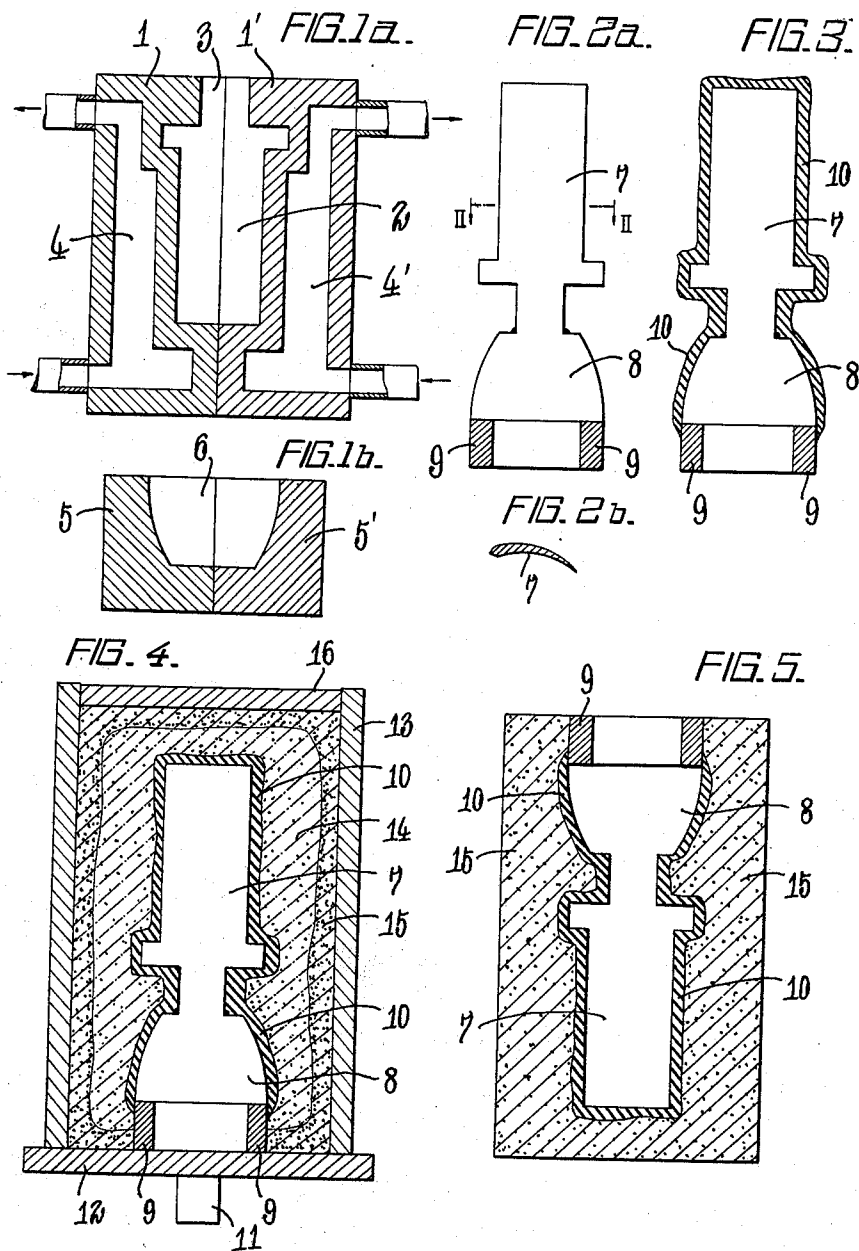
May 5, 1964

KAZURO SUZUKI ETAL

3,131,999

FUSIBLE SALT PATTERN COMPOSITION AND PROCESS OF MAKING MOLDS

Filed March 9, 1960



1

3,131,999

FUSIBLE SALT PATTERN COMPOSITION AND
PROCESS OF MAKING MOLDS

Kazuro Suzuki, Nishinomiya-shi, Hyogo-ken, and Osamu
Hiraiwa, Ibaragishi, Osaka-fu, Japan, assignors to Sumi-
tomo Kinzoku Kogyo Kabushiki Kaisha, Osaka-shi,
Japan, a corporation of Japan

Filed Mar. 9, 1960, Ser. No. 13,913

3 Claims. (Cl. 22-196)

This invention relates to precision casting processes,
and to novel fusible pattern material to be used in the cast-
ing processes.

Wax casting processes are well known and widely prac-
ticed in many countries, but the wax pattern used in the
process has defects which are inherent in the material.

In view of the fact that the dimensional precision of
the products has an immediate bearing on the precision
of the wax pattern used, a variety of different waxes of
differing characteristics are known in the art. Some com-
mercial wax products are shown in Table I.

The manufacture of large type monoblock castings such
as blades for turbines and jet engines is significantly affect-
ed by such characteristics of the wax pattern as moduli of
solidification, contraction, thermal expansion, deforma-
tion and the like, which results in dimensional errors.
For instance, in making a mold for a solid precision cast-
ing having a diameter of about 500 mm. by using an avail-
able wax of a minimum thermal expansion coefficient,
the thermal expansion required for heating the wax to a
temperature high enough to melt it away from the shell
mold amounts to 3 mm. before the softening begins.
Thus, the non-resilient refractory coating applied on the
surface of the wax pattern cracks with the result that
pouring is impossible.

These are exemplary of the disadvantages inherent in
the wax process which requires melting of a wax pattern
out of the shell by heating at 100 to 120° C. for 10 to 12
hours.

TABLE I
Characteristics of Wax

Kind	Melting point, ° C.	Trans- verse strength, kg./cm. ²	Surface hardness, Martens' tester Scratch- width, mm.	Thermal deforma- tion, 35° C.	Warp- age, mm./80 mm.	Crystal- linity	Thermal expansion, 15- 50° C., percent	Solidifi- cation contrac- tion, percent	Ash con- tent, percent
Inlay wax	76.8	2.14	0.16	Nil		No	0.64	1.58	0.114
Ceresin	81.9	1.85	0.20	Nil	0.60	No	0.64	0.95	0.015
Paraffin	61.6	1.16	0.36	Deformed		Yes	1.25	0.95	0.005
D-8210 Wax (G. Brit.)	70.0	1.77	0.14	Nil	0.70	No	1.26	1.44	0.106
Armowax (U.S.A.)	100.0	5.00	0.17	Nil		No	1.36		
No. 22 Yellow wax (U.S.A.)	69.8	1.26	0.23	Nil		No	2.04		
Casting wax (U.S.A.)	70.6	6.23	0.13	Nil		No	0.82		
D-144 Wax (U.S.A.)	77.7	2.07	0.12	Nil	0.85	No	1.00	2.02	0.016
Rice bran wax, refined	66.2	1.85	0.17	Nil		No	1.89	2.22	0.054
Wax, H-Co. (Japan)	77.0	1.25	0.24	Nil	1.05	No	1.30	1.38	0.019
Wax, K-Co. (Japan)	73.4	1.42	0.19	Nil	3.05	No	1.40		0.050

Wax patterns are usually made by pouring wax into a
metallic mold, solidifying and then taking the formed
pattern out of the mold. In such a process, it is necessary
to give careful consideration to the thermal expansion,
contraction, warpage, strain, etc. of the wax, so that a
number of tests are required to predetermine a correction
value of wax relative to the metallic mold into which wax
is poured. With all these laborious and time-consuming
efforts, the finished products are of uneven precision.

The present invention obviates all disadvantages of the
conventional wax process by providing patterns essentially
different from the known defective wax patterns for
casting.

2

An object of the present invention is to provide a new
fusible pattern material in substitution for wax.

It is another object of the present invention to provide
a precision casting mold and a process for making the
same by using the new fusible pattern material.

The above listed objects may be accomplished by using
a new fusible pattern material composed of a mixture of
organoalkali metal salt and alkali carbonate.

The organoalkali metal salt according to the present
invention is composed of one or more than two kinds of
salts selected from the group consisting of potassium salts
and sodium salts of acetic acid, formic acid, oxalic acid,
citric acid and tartaric acid. Sodium acetate is preferred.

The alkali carbonate used is either potassium carbo-
nate or sodium carbonate, the latter being more suitable.

The mixture is preferably composed of 80-60% by
weight of organoalkali metal salt and 20-40% by weight
of alkali carbonate. It is preferred to form a crystalline
hydrate by mixing an organoalkali metal salt containing
its water of crystallization with an anhydrous alkali car-
bonate.

This invention will now be illustrated, by way of ex-
ample, by the following description where crystalline so-
dium acetate (CH₃COONa·3H₂O) is mixed with anhy-
drous sodium carbonate (Na₂CO₃).

Crystalline sodium acetate when heated dissolves in its
own water of crystallization. By heating at a temperature
over its melting point of 58° C., crystalline sodium acetate
is turned completely into a solution. The solution is then
mixed with powdered anhydrous sodium carbonate in the
proportion of about 20-40% thereto and the mixture is
stirred well to obtain a pattern material.

The necessary conditions of pattern material to be used
for casting are enumerated as follows:

- (1) The melting point should be about 60-100° C.
- (2) No change in quality by heating.
- (3) Good pouring property.
- (4) Solidification with a minimum of shrinkage.

- (5) It is readily removable from the mold and does not
act upon a mold releasing agent.
- (6) No deformation or softening at room temperature
as well as having sufficient hardness and strength.
- (7) A small thermal expansion coefficient.
- (8) It does not act upon a mold binder.
- (9) It is easily and promptly dissolved and removed.
- (10) It is inexpensive.

These conditions are perfectly met by aforementioned mix-
ture of salts according to the invention.

The character of the pattern made of the mixed salt is
shown in Table II.

TABLE II

Properties of Pattern Made of the Mixed Salt (i.e. a Mixture of 70% Crystalline Sodium Acetate and 30% Anhydrous Sodium Carbonate)

Transverse strength, kg./cm. ² ----	3.15.
Surface hardness, Martens' tester, scratch width/mm-----	0.07.
Viscosity, Redwood/sec-----	65 (90°).
Solidification expansion, percent--	0.05 (value relative to the metallic mold).
Thermal expansion (15-55° C.) percent -----	0.25.
Melting point-----	58° C.
Velocity of dissolution in a dilute acid, mm./min-----	6.0 (10% HCl).

For making a pattern from said material, 60-80% of crystalline sodium acetate is placed in a vessel and dissolved in its water of crystallization by means of a hot bath, and then 20-40% of powdered anhydrous sodium carbonate is added thereto. The mixture is amply stirred and then poured at about 90-95° C. into a metallic mold. In 1-2 minutes after pouring, the pattern formed can be easily removed. For making a number of patterns, a cooling means is provided for the heated metallic mold, so that the mold can be continuously operated to form a pattern every 1-2 minutes. At the time of pouring, the material, i.e. the mixed salt needs no pressure as required in the stage of pouring or solidifying wax. In addition, the pattern thus obtained has advantages in that it accurately conforms to the metallic mold and doesn't contract.

In the manufacture of a precision casting mold by making use of the pattern produced as stated above, the pattern is first coated with a slip of refractories containing silica sol as a binder. The coating is promptly hardened with an alkaline gas such as carbon-dioxide or ammonia to form a shell. If desired, the shell can be reinforced. The mixed salt melts away by dipping the coated pattern in an acid liquid thereby obtaining a casting mold having a precision cavity.

As aforementioned, the pattern material of the present invention is a mixed salt composed of an organoalkali metal salt soluble in its own water of crystallization and an alkali carbonate capable of being neutralized with acid, such as a fused mixture of 60-80% $\text{CH}_3\text{COONa} \cdot 3\text{H}_2\text{O}$ and 20-40% Na_2CO_3 . This mixed salt is neutralized with an acidic liquid and disappears, generating carbon dioxide gas. The velocity of dissolution in 10% HCl is approximately 6.0 mm./min. as shown in Table II. Thus, according to the present invention a casting mold having a precision cavity can be manufactured with great ease.

The following example for production of a mold for a turbine blade is given to illustrate the process of the present invention with reference to the accompanying drawings in which:

FIG. 1a is a sectional elevation showing one form of a metallic mold for making a pattern;

FIG. 1b shows in sectional elevation another form of mold;

FIG. 2a is a sectional elevation showing an assembly of the pattern;

FIG. 2b is a cross section on line II-II of FIG. 2a.

FIG. 3 is a sectional elevation of the pattern coated with an investment material;

FIG. 4 is a sectional elevation illustrating one form of the production of a casting mold;

FIG. 5 is a sectional elevation of a finished casting mold.

Referring to FIG. 1a, therein is shown a metallic mold for a blade type pattern, which comprises a slit mold 1, 1', a pouring chamber 2, an inlet 3 and cooling chambers 4, 4'. Firstly, a pattern is made of a mixed salt. For example 70% of crystalline sodium acetate is placed in a vessel and dissolved in its own water of crystallization by

means of a hot bath and then mixed with 30% of powdered anhydrous sodium carbonate, and amply stirred. The mixed salt is poured at about 90-95° C. into said metallic mold and set in 1-2 minutes. Then, the split mold 1, 1' is separated to take out a blade type pattern formed.

In making a number of patterns by a continuous operation, the metallic mold becomes heated, whereupon the mold is cooled by a cooling liquid running through the chambers 4, 4'. The pattern made of the mixed salt differs from conventional wax patterns in that no pressure is required in the pouring and setting stage and no error is caused by expansion due to heating or contraction due to setting, thus rendering it unnecessary to correct the metallic mold. Thus, patterns true to the mold are obtained. In FIG. 1b is shown a metallic mold for making a pattern of a feeder head, which comprises a slit mold 5, 5' and a pouring chamber 6. By pouring said mixed salt into the chamber 6, a feeder head type pattern is obtained.

In FIG. 2a is shown an assembly of the patterns removed from the molds of FIG. 1a and FIG. 1b. 7 is the blade type pattern and 8 is the feeder head type pattern. Both patterns are perfectly adhered to each other by the same mixed salt as a binder. A gate 9 made of chamotte, for example, is fitted to the feeder head type pattern by using the same mixed salt. The chamotte gate is useful for the pattern of the mixed salt to prevent its immediate contact with a hot iron plate as described afterwards.

The next step is to coat the pattern of FIG. 2 with an investment material of refractories. For this purpose, the method for rapid setting of investment material (as disclosed e.g. in Japanese Patent No. 240,080) is most suitable, because the pattern is water-soluble. To prepare an investment, 50 cc. of ethyl silicate are stirred and then 10 cc. of a dilute solution of 0.5% hydrochloric acid are added thereto thereby making a silica sol. By adding about 100 cc. of water to the sol, an aqueous plastic sol is formed. A slurry of refractories, i.e. a mixture of said plastic sol and about 600 gms. of powdered aluminium oxide, is applied to the surface of the pattern by dipping or coating. This slip is immediately gelated and set within 10 seconds by contacting with gaseous ammonia. The operation is repeatedly carried out, until a shell of suitable thickness is formed on the surface of the pattern. FIG. 3 shows, in cross-section, a refractory shell 10 thus formed over the pattern 7, 8.

If desired, the pattern coated with the investment can be reinforced with so-called "backup." As shown in FIG. 4, a base plate 12 is adapted to be longitudinally vibrated by means of a shaking device 11. The pattern is placed on said plate 12 with the chamotte gate 9 facing down, and surrounded by a metal flask 13 in which the sand 14 mingled with organic synthetic resin is filled while the plate 12 is longitudinally vibrated. The plate 12 and the flask 13 are heated at 230°-280° C. so that a portion of the sand 14 comes in contact therewith and is promptly set. On touching a pressing plate 16 similarly heated, a portion of the sand 14 is also set. Thus, the set sand layer 15 is formed around the shell, and then the plate 12, the pressing plate 16 and the flask 13 are removed from the position.

For removal of the pattern made of the mixed salt, the mold thus reinforced is placed upside-down and dipped in a vessel containing a 10% hydrochloric acid solution at normal temperature. Thereupon the sodium carbonate contained in the mixed salt melts due to neutralization and generates carbon dioxide gas, leaving a cavity inside the shell. The time required for melting a pattern of the blade type, about 180 mm. long, is approximately 30 minutes.

To remove the sodium chloride and ash content produced by the neutralization of sodium carbonate, the mold is washed in water. The time required for washing is

5

approximately double the time for dipping in an acidic solution.

The washed mold is dried at about 200 to 250° C. The necessary time for drying the mold of said type is about 2 hours, but, of course, it varies with the size of mold. During the course of drying, a still unset portion 14 of the reinforcement sand (FIG. 4) is finally set. The finished casting mold is shown in FIG. 5.

As clearly seen from what has been described, the present invention is superior to the prior art, in that a pattern perfectly true to the original metallic mold can be manufactured with great ease, without producing any error with respect to expansion, shrinkage, strain etc. Furthermore a pattern can be made in 1-2 minutes without requiring pressure and promptly coated with an investment. Moreover, the dissolution of the pattern thus made, and the washing and drying of the finally formed casting mold can be effected in such a short time and in such a simple way as cannot be expected from the known art while finally the final product excels the known products in dimensional precision.

What is claimed is:

1. A composition of fusible and soluble pattern material for making precision casting molds, said composition consisting of a mixture of 60 to 80% by weight of

6

crystalline sodium acetate and 20 to 40% by weight of anhydrous sodium carbonate.

2. A process for the production of precision casting molds comprising mixing 60 to 80% by weight of crystalline sodium acetate and 20 to 40% by weight of anhydrous sodium carbonate, pouring the thusly obtained mixture into a metallic mold and solidifying the mixture to form a pattern corresponding in shape to that of the mold, removing the pattern from the mold and coating the pattern with a refractory shell, and dissolving said pattern to leave the refractory shell in the form of the mold.

3. A process as claimed in claim 2, wherein the refractory shell is formed by coating the surface of the pattern with a slurry of refractories which contains silica sol as a binder, and then setting said coating by contacting the same with an alkaline gas.

References Cited in the file of this patent

UNITED STATES PATENTS

20	2,136,077	Bartlett	Feb. 28, 1956
	2,754,570	Crawford	July 17, 1956
	2,992,995	Arden	July 18, 1961

OTHER REFERENCES

25	Transaction of the American Foundrymen's Society, vol. 64, May 3-9, 1956, pages 504-508.
----	--