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INVESTMENT CASTING WAX

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ABSTRACT OF THE DISCLOSURE

An improved investment casting wax composition consisting essentially of about 35–65 weight percent refined petroleum wax, solid chlorinated polyphenyl, certain ester type montan waxes, Fischer-Tropsch wax, and a metal soap. Said composition has the advantage of low shrinkage, low penetration and rapid setup.

CROSS REFERENCES TO RELATED APPLICATIONS

This invention is related to that described and claimed in applicants' application Ser. No. 139,243, filed the same date as this application, and constitutes another improved investment casting wax containing a substatial amount of petroleum wax.

BACKGROUND OF THE INVENTION

This invention relates to an investment casting wax. More specifically, it relates to an investment casting wax containing a major amount of petroleum wax and smaller amounts of other materials. These materials are a solid chlorinated polyphenyl, certain ester type montan waxes, Fischer-Tropsch wax and a metal soap. The resulting composition, despite the large amount of petroleum wax, has low shrinkage, low penetration and other properties which give it utility as an investment casting wax.

Investment casting refers to a method of quantity production of parts, usually having an intricate shape. The parts are normally metal, e.g., brass, steel, zinc or lead and alloys thereof. The advantages of this method, for example, over ordinary sand casting, is that the metal part has an exceptionally good surface, sharp outline, and dimensional accuracy. Another advantage is that a metal part having dimensional accuracy and/or with an intricate shape is obtained without further machining.

In the simplest form of investment casting, a wax replica is made of the part to be reproduced. The wax replica is coated over or invested with a ceramic forming material, e.g., a sand-magnesia mixture. After the investment sets, the wax replica invested with the sand-magnesia mixture is heated to melt out the wax and then baked to fuse the sand-magnesia. The wax may be reused. After cooling, the resulting ceramic mold is strong enough to support the molten metal poured into the cavity of the mold. The hot metal is poured into the top vent of the mold; a bottom vent allows for air to escape. After the metal solidifies and cools, the cooled ceramic mold is removed, normally by breaking it away from the metal part. The metal reproduction usually needs no further machining except to trim off the metal that solidified in the vents.

To produce the aforementioned wax replicas, a die is required to make repetitions of the wax replica. This die, usually of metal, is machined or cast to match the part

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to be reproduced with precision. Into the cavity of this die the investment casting wax, as a slush, is injected. After cooling, the solid wax replica is removed from the die. This wax replica has the strength to be handled and invested, and when melted out of the ceramic investment, leaves behind little or nil ash which otherwise would cause imperfections on the surface of the metal reproduction.

An investment casting wax normally contains hard naturally occurring waxes such as candelilla or carnauba or mixtures of these waxes, said waxes having sharp melting points, with various resins. A petroleum wax may be present in the investment casting wax but only as a small percentage of the total blend.

Petroleum wax has not been extensively used in any commercial casting wax since it undergoes a marked volume change as it goes through its melting point and softens gradually up to its melting point. The converse; i.e., a gradual hardening of the petroleum wax as its temperature becomes less than its melting point, is also a problem. This gradual hardening is often referred to as slow setup. The disadvantage of a slow setup is that a substantial amount of time has to elapse before the wax becomes hard enough to be handled without damaging. By comparison, an operable investment casting wax has a rapid setup.

An article in a British trade journal, Foundry Trade Journal, December 1962, "Pattern Waxes for Investment Castings" by J. H. W. Booth, describes in greater depth the volume change of a petroleum wax. For example, it states that the expansion of a typical paraffin wax from 60° F. to its melting point is about 14%. Also, a petroleum wax is usually too soft at an elevated temperature, e.g., 100–110° F., to be used in the investment casting method. The ideal investment casting wax would undergo no volume change as it goes through its melting point. Also, the ideal casting wax would remain hard at elevated temperatures which are below its melting point.

SUMMARY OF THE INVENTION

The present invention is an improved investment casting wax composition consisting essentially of about 35–65 weight percent of refined petroleum wax, 25–55 weight percent of solid chlorinated polyphenyl, 5–15 weight percent of a certain ester type montan wax, 0.5–3.0 weight percent of Fischer-Tropsch wax, and 0.005–0.5 weight percent of a metal soap. The petroleum wax can be a paraffin or a microcrystalline wax or mixtures thereof. Despite the substantial quantity of petroleum wax, this improved investment casting wax has low shrinkage and low penetration as well as other desirable properties. The present invention also relates to a wax replica comprising the aforementioned wax composition.

DESCRIPTION

A refined petroleum wax can be classified by the processes used to prepare the wax. These processes; i.e., distillation, solvent extraction, clay treating, hydrotreating, etc., are described in great detail in Chapter 5 of the Chemistry and Technology of Waxes, Albin H. Warth, Library of Congress, Catalog Card Number: 56–6695. A refined petroleum wax prepared by these processes can be a component of the investment casting wax composition defined herein.

A refined petroleum wax can be also classified by the relative size of the wax crystals. A macro crystal wax is normally referred to as paraffin wax; a micro crystal wax is normally referred to as a microcrystalline wax. These classes are defined in greater depth in the aforementioned reference. Paraffin wax or microcrystalline wax or mixtures thereof can be used as a component of the investment casting wax composition defined herein.

Refined paraffin waxes are available with a wide range of physical properties, e.g., melting points can be as low as 100° F. (AMP) or as high as 160° F. (AMP). While the lower melting point waxes can be used with this invention, it is preferred to use those paraffin waxes having a melting point in excess of 127° F. (AMP) and more preferable in excess of 129° F. (AMP). AMP refers to the American Melting Point which is an arbitrary figure 3° F. higher than the ASTM melting point. A preferred paraffin wax melting point range is 130° F.–156° F. (AMP). Penetration values, at 77° F. (ASTM D–1321), for paraffin waxes range from 40 to 5. A preferred penetration at 77° F. is less than 33; a more preferable penetration is less than 15. A preferred penetration range at 77° F. is 15–7. A highly preferred refined paraffin wax would be one having a melting point of 130° F.–156° F. (AMP) and a penetration at 77° F. of 15–7.

Microcrystalline waxes are available with a wide range of physical properties; for example, melting points can be as low as 140° F. or as high as 200° F. While the lower melting point microcrystalline waxes can be used with this invention, it is preferred to use those microcrystalline waxes having a melting point in excess of 151° F.; a more preferable one is in excess of 175° F. A preferred microcrystalline wax melting point range is 175° F.–197° F. The melting point temperatures for the microcrystalline waxes are determined by ASTM D–127. Penetration values at 77° F. (ASTM D–1321) for microcrystalline wax range from 25 to 3. A preferred penetration at 77° F. is less than 21; a more preferred penetration is less than 12. A preferred penetration range at 77° F. is 13–4. A highly preferred microcrystalline wax would be one having a melting point of 175° F.–197° F. and a penetration at 77° F. of 13–4.

The refined petroleum wax used in this invention can be a paraffin wax or a microcrystalline wax or mixtures thereof. While the weight ratio of microcrystalline wax to paraffin wax can range from 0 to 100, it is preferable that some microcrystalline wax be used. A preferred weight ratio of microcrystalline wax to paraffin wax is 0.05–1.0. A more preferable ratio is 0.2 to 0.60.

The term "paraffin wax" or "microcrystalline wax," as used herein, refers to a wax having a narrow boiling range, a broad boiling range, a mixture of 2 or more narrow boiling range waxes, or a mixture of narrow and broad boiling ranges, etc.

Generally, the amount of petroleum wax presented in the investment casting wax defined herein will be about 35–65 weight percent. A preferred range is about 40–60%, a more preferable range is about 45–55%.

"Chlorinated polyphenyl" refers to chlorinated biphenyl, terphenyls, higher polyphenyls and mixtures thereof. Normally, the commercial chlorinated polyphenyls are mixtures of chlorinated components rather than the individual isomers. Methods for preparing these chlorinated materials, and physical and chemical properties of these materials, are described in Volume 5, Kirk-Othmer Encyclopedia of Chemical Technology, 2nd edition, starting at page 289. These chlorinated materials are available as either liquids or solids at room temperature; however, only those chlorinated polyphenyls which are solid at room temperature are satisfactory as a component of the improved investment casting wax defined herein.

The amount of solid chlorinated polyphenyl admixed with the other components of the investment casting wax defined herein can constitute about 25–55 weight percent of the total. Preferably, the solid chlorinated polyphenyl constitutes about 35–45 weight percent of the total.

Typical range of physical properties for a suitable solid

chlorinated polyphenyl is as follows: specific gravity 1.470–1.811 (25°/25° C.); acidity 0.14–1.4 (maximum mgm. KOH/gm.).

Montan wax refers to a portion of mineral wax, the latter extracted from brown coals or lignites. After the crude montan wax has been extracted, it is refined by known processes to remove the resinous and asphaltic matters. A typical refined montan wax contains about 60–70% esters, 20–30% wax acids in the C_{23}–C_{33} range, and minor amounts of free alcohols, ketones and resins not entirely removed by ordinary purification.

The various processes for separating into or converting the solid refined montan wax into a montan acid is described in the aforementioned text by Warth, Chapter 4, and in Kirk-Othmer, Encyclopedia of Chemical Technology, 2nd edition, Volume 22, "Waxes," pages 168–169, also volume 12, "Lignite and Brown Coal," pages 406–409. Montan acid can also be defined as a long chain hydrocarbon carboxyl acid. It can be further defined as a C_{28}–C_{32} carboxyl acid.

"Ester type montan wax" as used herein refers to ethylene glycol esters of montan acid. Surprisingly, the ester of said acid and a C_3 or a C_4 diol is not compatible with the other components of the investment casting wax defined herein. Ethylene glycol esters of montan acid are known; see the aforementioned encyclopedia, vol. 22.

The amount of ester type montan wax admixed with the other components of the investment wax defined herein can constitute about 5–15 weight percent of the total. Preferably, the ester type montan wax constitutes about 8–12 weight percent of the total. Ranges of typical properties of an ester type montan wax, which are satisfactory as components of the casting wax, are as follows: drop point of 172–181° F. (ASTM D–566–49); congealing point of 160–169° F. (ASTM D–938–48); acid value of 25–35 (ASTM D–1386–557); saponification values of 135–155 (ASTM D–1387–557).

Fischer-Tropsch wax refers to a synthetic hydrocarbon wax of a very high molecular weight and melting point, and of great hardness. This synthetic wax is obtained via the reaction of carbon monoxide and hydrogen in the presence of a suitable catalyst. The Fischer-Tropsch process is described in great depth in the aforementioned text by Warth, Chapter 6.

Fischer-Tropsch waxes have molecular weights ranging from about 400 to about 1000. While the aforementioned waxes are operable, it is preferable to use a Fischer-Tropsch wax having a molecular weight of about 500–800. These waxes have a melting point of about 157–195° F.

The amount of Fischer-Tropsch wax admixed with the other components of the investment wax defined herein can constitute about 0.5–3.0 weight percent of the total. Preferably, the synthetic wax constitutes about 1–2 weight percent of the total.

"Metal soap" as used herein refers to either a single metal salt or a mixture of metal salts of a long chain monocarboxylic acid and/or a mixture of acids. The metal can be a Group 1 metal; i.e., lithium, sodium, potassium, rubidium and cesium or a Group 2 metal; i.e., beryllium, magnesium, calcium, strontium and barium. A mixture of soaps is preferred, more preferred is a mixture of calcium and magnesium soaps. A preferred ratio range of calcium soap to magnesium soap is 50/1 to 200/1; a more preferred range is 75/1 to 150/1; a highly preferred range is 90/1 to 110/1. The monocarboxylic acid can contain about eight to twenty carbon atoms; a preferred range being C_{12}–C_{18}.

The amount of soap admixed with the other components of the investment wax defined herein can constitute about 0.005–0.5 weight percent of the total weight. Preferably, the soap constitutes about 0.01–0.10 weight percent of the total weight.

The components of the investment casting wax defined herein are uniformly distributed throughout the petroleum wax. Conventional processing can be used to achieve this uniform distribution.

TABLE

Composition and properties of casting wax

Composition:	Weight percent
Microcrystalline wax [1]	20.9293
Paraffin wax,[2] M.P. 156° F.	5.0000
Paraffin wax,[3] M.P. 145° F.	25.0000
Chlorinated polyphenyl	38.0000
Ester type Montan wax [4]	10.0000
Fischer-Tropsch wax	1.0000
Calcium soap	0.0700
Magnesium soap	0.0007
Total	100.0000
Properties:	
Penetration, 100 g., 77° F.	1
(D-1321): [5]	
100° F.	7
110° F.	15
130° F.	132
SUS/210° F. (D-446)[5]	69
Melting point, ° F. (D-127)[5]	176
Expansion, percent	8.1
Percent ash, wt.	0.03
Modulus of rupture, p.s.i. (D-2004)[5]	1000

[1] Sun Oil Company, microcrystalline wax 985B.
[2] Sun Oil Company, paraffin wax 5512.
[3] Sun Oil Company, paraffin wax 4412.
[4] Ester prepared from montan wax acid and ethylene glycol.
[5] ASTM Standard Test Methods.

The following example illustrates this invention.

EXAMPLE

A typical microcrystalline wax, used along with the other components mentioned herein for illustrative purposes, had a melting point of 195° F. (ASTM D-127), a viscosity of 210° F. of 84 SUS, a penetration of 77° F. of 5 and an oil content of 0.4%. One typical paraffin wax had a melting point of 156° F. (AMP), a viscosity at 210° F. of 44.8 SUS, a penetration at 77° F. of 9 and an oil content of 0.2%. Another typical paraffin wax had a melting point of 145° F. (AMP), a viscosity at 210° F. of 40 SUS, a penetration of 77° F. of 9 and an oil content of 0.2%. The chlorinated polyphenyl had a softening point of 208-222° F. and a specific gravity at 25° C./25° C. of 1.670. The magnesium soap used was a readily available commercial grade. The ester type montax wax had a drop point of 172-181° F. (ASTM D-566-49), a congealing point of 160-169° F. (ASTM D-938-48), acid value of 25-35 (ASTM D-1386-557) and a saponification value of 135-155 (ASTM D-1387-557). The Fischer-Tropsch wax used was a C_{45} wax of a readily available commercial grade.

The ASTM tests for the aforementioned properties are as follows unless otherwise noted: penetration—D-1321; oil content—D-721; viscosity—D-446.

The composition, shown in the accompanying table, was prepared by accurately weighing the amounts shown in the accompanying table. The components were the aforementioned typical materials. These accurately weighed materials were placed in a container. The container was then placed into an oven maintained at 250° F. When all the components were melted, the container was removed and the material in the container was stirred to insure a homogeneous blend. The container and its contents were then allowed to cool to 175° F. with constant stirring. The molten blend was then poured into a pressure casting cylinder. The latter is a pressure vessel with a movable piston. The application of pressure on the piston forces the blend in the vessel out through an opening which has a shut off device. The cylinder and its contents were maintained overnight at 136-140° F. in an oven.

A mold was placed in a suitable laboratory press and clamped with a force of 10,000 p.s.i.g. to prevent the mold from separating during casting. The pressure casting cylinder was removed from the oven and screwed into the mold. The cylinder was pressurized to 150 p.s.i. and was maintained at that pressure for 30 seconds. The pressure was then reduced and the casting cylinder was removed. The mold was taken out of the press and opened. The molded article had excellent surface finish and mold detail. The entire procedure; i.e., injection and cooling, required only 55 seconds.

The data in the accompanying table demonstrate that the refined petroleum wax can be used as a major component of investment casting wax. Furthermore, the data indicate that despite the substantial amount of refined petroleum wax in the casting wax, the penetration at 100° F. of the latter is below 15 and the expansion is below 10%. Such a low penetration value indicates that the wax article is hard at a warm temperature and therefore can be handled and invested with ceramic forming materials without causing deformations on the wax surface. Low shrinkage means minimum dimension corrections are necessary when preparing the wax article.

The melting points and viscosities shown in the accompanying table indicate that the compositions are suitable for use in injection equipment.

However, surprisingly the substitution of certain apparently similar waxes for the ester type montan wax used in the composition shown on the accompanying table resulted in an unsatisfactory wax mixture.

The apparently similar, but unsatisfactory, waxes which were substituted for an equal amount of the ester type montan wax shown in the accompanying table are as follows: (1) acid type montan wax having an acid value of 115-130; (2) an ester type montan wax, said wax being the ester of a C_3 diol and a montan acid; (3) an ester type montan wax, said wax being the ester of a C_4 diol and a montan acid; (4) an ester of montan wax which has been partially saponified with calcium hydroxide. These substitutes were all unsatisfactory in that when one of the aforementioned four waxes was admixed with the other molten components, clumps of an unknown material formed and sank to the bottom of the container. Thus it was not possible to obtain a wax mixture having a uniform composition or a viscosity suitable for use in injection type equipment when using any one of the four aforementioned waxes.

Satisfactory investment casting waxes can be prepared containing other quantities of refined petroleum waxes and other components; i.e., solid chlorinated polyphenyls, the aforementioned ester type montain waxes, Fischer-Tropsch waxes, metal soaps, within the limits herein specified, with similar results being obtained.

The invention claimed is:

1. An investment casting wax composition consisting essentially of:

(a) 35-65 weight percent of a refined petroleum wax selected from the following group: paraffinic wax, microcrystalline wax, or mixture of paraffinic wax and microcrystalline wax;

(b) 25-55 weight percent of solid chlorinated polyphenyl selected from the following group: chlorinated biphenyl, terphenyls and higher polyphenyls or mixtures thereof;

(c) 5-15 weight percent of ester type montan wax, said wax being the ester of ethylene glycol and a montan acid;

(d) 0.5-3 weight percent of Fischer-Tropsch wax; and

(e) 0.005-0.5 weight percent of a metal soap, said soap being a single metal salt or mixture of metal salts of a long chain monocarboxylic acid or a mixture of said acids and the metal selected from the following group: lithium, sodium, potassium, rubidium, cesium, beryllium, magnesium, calcium, strontium and barium;

said composition having low shrinkage and low penetration.

2. Composition according to claim 1 wherein the composition contains about 40–60 weight percent of the refined petroleum wax.

3. Composition according to claim 1 wherein the composition contains about 45–55 weight percent of the refined petroleum wax.

4. Composition according to claim 1 wherein the penetration at 100° F. of said investment casting wax composition is less than 15.

5. Composition according to claim 4 wherein the expansion of said investment casting wax composition is less than 9%.

6. Composition according to claim 1 wherein the Fischer-Tropsch wax has a molecular weight of 500–800.

7. Composition according to claim 6 wherein the ratio of the paraffin wax to the microcrystalline wax in said mixture is about 0.05–1.0.

8. Composition according to claim 7 wherein the refined petroleum wax is selected from the following group: paraffin wax with a melting point of 130–156° F; microcrystalline wax with a melting point of 175–197° F.; mixture of said paraffin wax and said microcrystalline wax.

9. Composition according to claim 7 wherein the melting point of the paraffin wax is at least 127° F. and the melting point of the microcrystalline wax is at least 151° F.

10. Composition according to claim 9 wherein said paraffin wax's penetration at 77° F. is less than 33 and said microcrystalline wax's penetration at 77° F. is less than 21.

11. Composition according to claim 9 wherein the ester type montan wax's drop point is 172–181° F.

12. Composition according to claim 11 wherein the ratio of the paraffin wax to the microcrystalline wax in said mixture is 0.2–0.6.

13. Composition according to claim 1 wherein the composition consists essentially of:

(a) 40–60 weight percent of a refined petroleum wax selected from the following group: paraffin wax having a melting point of 130–156° F., microcrystalline wax having a melting point of 175–197° F., a mixture of said paraffin wax and said microcrystalline wax wherein said mixture the ratio of paraffin wax to microcrystalline wax is 0.2–0.6;
(b) 35–45 weight percent of solid chlorinated polyphenyl selected from the following group: chlorinated biphenyl, terphenyls and higher polyphenyls or mixtures thereof;
(c) 8–12 weight percent of ester type montan wax having a drop point of 172–181° F.;
(d) 0.75–2 weight percent of Fischer-Tropsch wax having a molecular weight of 500–800; and
(e) 0.01–0.10 weight percent of a metal soap, said soap being a single metal salt or mixture of metal salts of a long chain monocarboxylic acid or a mixture of said acids and the metal selected from the following group: lithium, sodium, potassium, rubidium, cesium, beryllium, magnesium, calcium, strontium and barium.

14. Composition according to claim 13 wherein said paraffin wax's penetration at 77° F. is less than 15 and said microcrystalline wax's penetration at 77° F. is less than 12.

15. Composition according to claim 13 wherein said metal soap is a mixture of calcium and magnesium soaps.

16. Composition according to claim 15 wherein the ratio of calcium to magnesium soap is 50/1–200/1.

17. A wax replica consisting essentially of:

(a) 35–65 weight percent of a refined petroleum wax selected from the following group: paraffinic wax, microcrystalline wax, or mixture of paraffinic wax and microcrystalline wax;
(b) 25–55 weight percent of solid chlorinated polyphenyl selected from the following group: chlorinated biphenyl, terphenyls and higher polyphenyls or mixtures thereof;
(c) 5–15 weight percent of ester type montan wax, said wax being the ester of ethylene glycol and a montan acid;
(d) 0.5–3 weight percent of Fischer-Tropsch wax; and
(e) 0.005–0.5 weight percent of a metal soap, said soap being a single metal salt or mixture of metal salts of a long chain monocarboxylic acid or a mixture of said acids and the metal selected from the following groups: lithium, sodium, potassium, rubidium, cesium, beryllium, magnesium, calcium, strontium and barium;

said replica having a penetration at 100° F. of less than 15.

18. The wax replica of claim 17 wherein the replica consists essentially of:

(a) 40–60 weight percent of the refined petroleum wax;
(b) 35–45 weight percent of the solid chlorinated polyphenyl;
(c) 8–12 weight percent of the ester type montan wax;
(d) 0.75–2 weight percent of Fischer-Tropsch wax having a molecular weight of 500–800; and
(e) 0.01–0.05 weight percent of the metal soap.

19. The wax replica of claim 18 wherein the metal soap is a mixture of calcium and magnesium soaps.

20. The wax replica of claim 19 wherein the ratio of calcium to magnesium soap is 50/1–200/1.

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