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[54] **PROCESS OF DIE CASTING OF BRASS**

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[*] Notice: The portion of the term of this patent subsequent to Apr. 11, 1989, has been disclaimed.

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 37,340, May 14, 1970, Pat. No. 3,654,985, which is a continuation-in-part of Ser. No. 684,497, Nov. 20, 1967, abandoned.

[52] **U.S. Cl.**.................. **164/72,** 117/5.3, 106/38.22
[51] **Int. Cl.**.. **B22c 3/00**
[58] **Field of Search**.................. 164/14, 33, 37, 40, 164/41, 72, 113, 119, 267, 303; 117/5.3; 106/38.22

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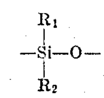
[57] **ABSTRACT**

The disclosure solves a persistent problem in die casting of brass alloys, wherein lubrication of the steel die or mold is generally difficult. In accordance with the disclosure, the surfaces of the mold to come in contact with the molten brass are coated with a film of a phenyl-methyl silicone fluid which is a linear polymer having repeating units of the element



wherein R_1 is methyl and wherein R_2 is chosen selectively to be either methyl or phenyl, so that the resulting polymer has a phenyl:methyl ratio of between about 0.30:1.0 and about 0.85:1.0 and a viscosity at 77° F. of from about 50 to about 1,000 centistokes. The fluid may be applied in the form of a dilute aqueous dispersion, or as a dilute solution in a suitable solvent such as petroleum naphtha.

7 Claims, No Drawings

PROCESS OF DIE CASTING OF BRASS

This application is a continuation-in-part of my copending application, Ser. No. 37,340, filed MaY 14, 1970, now U.S. Pat. No. 3,654,985, which in turn was a continuation-in-part of application Ser. No. 684,497, filed Nov. 20, 1967, which was co-pending with said application Ser. No. 37,340 and is now abandoned.

This invention relates to the die casting of brass alloys and more particularly, to an improved lubricant for the metal mold used in this process.

The die casting of metals is a well-developed art, and it is described, inter alia, in the book *Die Casting* by H. H. Doehler, New York, 1951, the contents of which are hereby included herein by reference. Alloys commonly used for the production of die castings are most often formed from alloys having a base of zinc, aluminum or magnesium. Less frequently, brass alloys are used; these, as is well known, being predominantly alloys containing a major proportion (about 57 percent to about 83 percent) of copper, with zinc forming the balance except for much smaller amounts of other elements such as lead, tin, and silicon. These are described on pages 324–334 of the book by Doehler already cited and are hereinafter referred to simply as "brass," this being in accordance with common terminology.

A characteristic of brass die casting alloys is the substantially higher melting point than alloys based on the other metals mentioned. Thus, zinc-based die casting alloys commonly melt at between 700° F. and 750° F., and aluminum-based alloys commonly melt in the approximate range of 1,065° F. to 1,150° F. In contrast, brass die casting alloys melt in the range of about 1,500° F. to about 1,650° F. This led to considerable difficulties in properly lubricating the molds, which because of the high temperatures involved must be made of the finest alloy steels and especially well finished and fitted. The standard lubricant for brass die casting is graphite, generally dispersed in a suitable liquid vehicle such as petroleum solvent, or other organic solvent, or water. The resistance of graphite to oxidation, while recommending it for many lubricating tasks, is actually a disadvantage in brass die casting since it tends to build up on the die, thereby changing the dimensions of the castings produced. Further, while it is thermally stable in the injection temperatures of brass, generally 1,600° F. to 1,800° F., it may not completely resist the eroding action of the injected molten brass, particularly since injection pressures are commonly as high as 14,000 lbs. per square inch. This may lead to entrainment of graphite in the metal as well as impingement of molten brass against the bare spots of the die metal. Small points of brass can adhere to the bare spots of the die, and thus contribute to subsequent erosion of the die, as by becoming bonded to the next casting and taking a small piece of the metal die with it when the casting is ejected, or by electrolytic action since a bimetallic couple is formed. Furthermore, air and moisture in the graphite coating mixture may be released only later since the graphite has a microlamellar structure, and this contributes to casting porosity.

Attempts have been made to utilize various aluminum die casting lubricants for brass, but these have been largely unsuccessful. High-melting-point waxes, such as carnauba, while leaving very little residue to build up in the die, nevertheless give poor protection because of the very high temperatures involved. Such organic lubricants also tend to generate gases or become depolymerized or otherwise evaporated off of the die surface prior to casting so that no protective and lubricating barrier remains.

It may be mentioned that some lubricants which can be successfully used for casting iron and steel, which require considerably higher temperatures than brass, are likewise unsatisfactory when attempt is made to use them in the die-casting of brass. Such iron and steel lubricants may contain organic components such as starch, polyethylene oxide thickeners, and the like, which are completely decomposed and burned off at the high temperatures used for iron and steel, but which fail to become destroyed at the relatively lower temperatures necessary for brass casting. These additives may then build up on the mold and render it unuseable for further brass casting. Some such lubricants even include powdered charcoal, which has the disadvantages already noted for graphite.

Silicone fluids have been tried and to some extent used in die casting on the lower-melting-point alloys. The early dimethyl silicone fluids have been used with zinc die casting, but when used with aluminum, they are not satisfactory because the greater forces set up upon contraction, especially on the core, are too great to be eased by the feeble lubrication offered with the silicones generally. Indeed, the same chemical inertness that makes silicones in general heat resistant preclude them from chemisorbing onto metal surfaces after the fashion of a true lubricant. Also, they interfere with the subsequent surface treatment of the castings, such as painting, anodizing, or electroplating.

One prior art silicone fluid which has been used in die casting utilizes alkyl groups having more than one carbon atom to replace the methyl groups in company with other substitutions. Such alkyl groups as ethyl, amyl, and vinyl were used. These were successful with aluminum die casting and gave increased lubricity and better reception to paint on the finished casting. However, when these were tried on brass die casting, they decomposed and/or polymerized during the casting and not only created porosity, but also allowed a build-up of carbonaceous and/or resinous deposits on the dies. Any such gases of course contribute to porosity in the casting. This is illustrative of the difficulties faced in solving the problem involved.

An object of the present invention is to provide an improved silicone fluid lubricant for the die-casting of brass.

Another object of the invention is to provide easily applicable compositions containing the improved lubricant.

Another object of the invention is to provide a lubricant of the type noted and for the purposes noted which may be used indefinitely in the die-casting of brass without difficulty from build-up of solid deposits on the dies.

Other objects of the invention will appear as the description thereof proceeds.

Generally speaking and in accordance with illustrative embodiments of my invention, I carry out the die casting of brass by flowing molten brass under suitable pressure into a hollow partible metal mold or die, which may be of conventional construction, first having coated the interior walls of said mold or die with a film of a phenyl methyl silicone fluid which is a linear polymer having repeating units of the element

$$-\overset{\displaystyle R_1}{\underset{\displaystyle R_2}{\overset{|}{\underset{|}{Si}}}}-O-$$

wherein R_1 is methyl and wherein R_2 is chosen selectively to be either methyl or phenyl so that the resulting polymer has a phenyl-methyl ratio of between about 0.30:1.0 and about 0.85:1.0 and a viscosity at 77° F. of from about 50 to about 1,000 centistokes. After the molten brass is flowed into the so-coated mold, it is allowed to solidify therein in the usual fashion, after which the mold is parted and the casting ejected from the mold.

The method of coating the walls with the fluid may be adapted to the particular size and shape of the mold in use. For very primitive die-casting apparatus, especially with molds that are relatively large and have no re-entry portions of small dimensions, it would be possible to wipe the interior surfaces of the mold with a cloth moistened with the fluid. The thickness of the film is not critical in that a film of unduly great thickness is hardly attainable in the first place because of the Newtonian nature of the viscosity of the silicone fluids used in my invention. Again, because of the nature of the metal surface, once having wiped the fluid on, it is scarcely possible to rub the fluid off, as by rubbing with a dry cloth, to such an extent, lubrication in accordance with the invention is diminished or lost.

I find it more convenient, and indeed more generally applicable to molds of intricate configuration, to apply the silicone fluid in a volatile carrier liquid. My silicone fluid is soluble in many organic solvents, such as hydrocarbon solvents, for example, petroleum naphtha and the like. These are advantageous because they are nontoxic. A solution preferably within the range of from one part of the silicone fluid to from six to 10 parts by weight of the organic solvent is suitable. This forms a liquid which can readily be sprayed into the interior portions of the die or mold; and since during an actual run the mold is quite hot, the solvent promptly evaporates and leaves a film of the silicone fluid behind, thereby coating the mold. As exemplified hereinbelow, a solution consisting of one part by weight of the silicone fluid in from six to 10 parts by weight (and optimally about eight parts by weight) of a petroleum naphtha of the dry cleaning grade known as Stoddard solvent is especially suitable. THe book by George S. Brady "Materials Handbook," Ed. 9, New York 1963, page 501 states: "Stoddard solvent is a standardized fraction of petroleum, or naphtha, used in dry cleaning or as a solvent. It is water-white in color, flash point above 100° F., and consists of the distillation fraction not over 410° F. with 50 percent below 350° F."

Also, water may be used as the volatile carrier liquid. WHile the silicone fluid is not soluble in water, it can be readily dispersed in water in the form of an emulsion using a minor amount of any suitable dispersing agent. A particularly suitable dispersing agent is a polyethyleneoxy ester of nonyl phenol, that is, a poly(ethylene oxide) condensate of nonyl phenol. The latter is commercially available under various names from several manufacturers. Many emulsifying agents are commercially available which are adapted for producing aqueous silicone fluid emulsions, and in general, these may be used. In order to make a suitable emulsion, the water is added to the silicone fluid containing the emulsifying agent under conditions of agitation as by a propeller or homogenizer. A suitable range of concentration is one part of silicone fluid to from six to 60 parts of the water, optimally about eight parts of water. The emulsifying agent can comprise about one-tenth by weight of the silicone fluid. The ethylene oxide condensate of nonyl phenol in which the polyoxy chain is about 12 carbon atoms long is suitable. Here again, when the emulsion so formed is sprayed into the hot die, the water evaporates and leaves behind a film of the silicone fluid in accordance with the invention. The quite minor proportion of emulsifying agent has no effect one way or another upon the lubricating action in accordance with the invention.

The aqueous emulsion is advantageous, as compared to the hydrocarbon solvent liquid, where air pollution control regulations limit the use of hydrocarbon solvents. A further difference is that the aqueous emulsion causes more chilling of the die than does the hydrocarbon solvent liquid, because of the greater latent heat of evaporation of water. This can be put to good use by employing the hydrocarbon solvent liquid for lubricating the core portion of the mold while using the aqueous emulsion for the other side of the die.

Of course, where small castings are involved which do not require much heat dissipation, the aqueous emulsion can be dispensed with altogether. Either form of carrier liquid can be used, both as already described or none at all, the silicone fluid being wiped on as previously described, although the last-named method is not always practical.

It has been found that in producing brass die castings in accordance with the invention, astonishing die life is obtained. In one test run, where the die was made of steel of the type known as H–13, the composition of which is described on page 254 of the book by Doehler already mentioned, more than 125,000 castings were made with a particular die, the last castings being as satisfactory as the first. Astonishingly, the castings were free of any residuum of silicone on the surface, so that they could be readily painted or electroplated without further treatment.

It may be observed that the silicone fluid which I use in my invention is completely characterized by the structural formula set forth hereinabove taken together with the recitation of the phenyl-methyl ratio and with the stated viscosity at the standard temperature. (The ratio is molar, not by weight, throughout this specification and claims.) It is unnecessary to specify the average molecular weight since this follows from the foregoing specifications of phenyl-methyl ratio and viscosity. It may be stated, however, although not in a limiting sense, that the molecular weights will be of the order of 5,000–20,000, this, however, being dependent upon the method selected for inferring the molecular weight. The end groups are unimportant because of the relatively high molecular weight; they may be methyl or phenyl, and are generally methyl in the commercially available fluids of the type described. Commercial silicone fluids useable in the invention are available in the United States under the trade designations "DC 710," "DC 550," and "SI 1154;" and in West Germany under the trade designation of "Bayer PH."

The production of silicones having the requisite specifications for use in accordance with the invention is fully set forth in the literature. Reference may be made to the following books, which, together with the citations therein, are hereby included herein by reference:

Stone and Graham: *Inorganic Polymers*, New York, 1962.
Eaborn: *Organosilicon Compounds*, New York, 1960.
Petrov et al.: *Synthesis of Organosilicon Monomers*, New York, 1964.
Fordham: *Silicones*, London, 1960.
Meals and Lewis: *Silicones*, New York, 1959.
McGregor: *Silicones and Their Uses*, New York, 1954.
Gunderson et al.: *Synthetic Lubricants*, New York, 1962.
Ullmann: *Encyklopaedie der Technischen Chemie*, Ed. 3, Vol. 15, chapter entitled "Silikone," Munich, 1964.

Among the many advantages of the silicone fluid which I use is that they do not polymerize further if they get into the working parts of the die and its accessory parts. This is a disadvantage found with many other silicones, which does not come to light at once, but which gives trouble upon long-continued use. It may be further noted that, as already stated, my silicone fluid is a fluid both at room temperature and under the working conditions encountered in the practice of the invention. It is by no means a resin, which would defeat many of the objects of the invention, particularly those having to do with continued, trouble-free use on a given die without build-up of solid, gummy coatings and inclusions which would be the case if a resin were used.

EXAMPLE 1

A phenyl-methyl silicone fluid of the type described was used, which had a molar ratio of phenyl:methyl of 0.75:1, and a viscosity at 77° F. of 500 centistokes. A portion was made into a solution by adding 1 pound of this silicone fluid to 8 pounds of a petroleum naphtha of the dry cleaning grade known as Stoddard solvent. Simple stirring brought about complete solution to produce a readily applicable form of the silicone fluid in a carrier liquid. This was successfully used in lubricating a hardened steel die producing brass castings.

EXAMPLE 2

To another portion of the same silicone fluid there was added polyoxyethylated nonyl phenol having six ethylene oxide groups per nonyl phenol moiety, and thus 12 carbon atoms in the attached polyoxyethyl chain. This nonyl phenol compound was a pale yellow liquid having a density of 1.04 and a viscosity of about 200 centipoises at 77° F. It was added in the proportion of 1 pound per 10 pounds of the silicone fluid. Simple stirring effected a complete solution. The mixture was placed in a laboratory mixer, and water was gradually added until 50 parts of water were present for each part by weight of silicone fluid. A stable emulsion was formed which differed little from water in either viscosity or density. It was used in accordance with the invention, together with the hydrocarbon solvent mixture, in lubricating a hardened steel die producing brass castings.

EXAMPLE 3

Example 2 was repeated, using eight parts of water instead of 50 parts of water.

EXAMPLE 4

Example 1 was repeated, except that a phenyl-methyl silicone fluid of the type described and having a viscosity of 175 centistokes at 77° F. was used. This silicone fluid had a specific gravity of 1.05 at the same temperature. Its trade designation was SF 1154. The solvent was petroleum naphtha as before. It performed very well in lubricating a hardened steel die producing brass castings.

EXAMPLE 5

Example 4 was repeated using another silicone fluid within the invention which had a viscosity of 115 centistokes at 77° F. This had a density of 1.068, and was sold under the trade designation DC 550. It performed excellently when used in the same class of service as Example 1.

As mentioned, the die is usually made of a high-grade steel alloy, selected for its durability and mechanical properties at high temperatures. Occasionally, the metal of the die may be tungsten, molybdenum, or various alloys of these and even of cobalt, in order to give still greater durability. My invention is applicable to all of these metals and metallic alloys, which are all necessarily characterized by great hardness and durability and high melting point.

It should be mentioned that the terms "die" and "mold" have been used interchangeably in this specification and in the claims since these are synonymous in the art. Also, it should be noted that what is referred to as "die casting" in the United States is generally known as "pressure casting" in Great Britain, the latter being in contrast to "gravity molding" as the older, non-die casting process of producing metal castings in mold.

It will be appreciated that while I have illustrated my invention by the aid of numerous specific ingredients, concentrations, working conditions, and the like, many variations in these variables are possible within the broad scope of the invention as set forth in the claims which follow.

Having described my invention, I claim:

1. In the process of producing brass castings by the method of die casting wherein molten brass is caused to flow under pressure into a hollow partible metal mold and allowed to solidify therein so as to form a casting, after which said mold is parted and said casting is thereupon ejected from said mold, the improvement therein which comprises the step of coating the interior walls of said mold prior to flowing said molten brass therein with a film of a phenyl-methyl silicone fluid which is a linear polymer having repeating units of the element

$$\begin{array}{c} R_1 \\ | \\ -Si-O- \\ | \\ R_2 \end{array}$$

wherein R_1 is methyl and wherein R_2 is chosen selectively to be either methyl or phenyl so that the resulting polymer has a phenyl-methyl ratio of between about 0.30:1.0 and about 0.85:1.0 and a viscosity at 77° F. of from about 50 to 1,000 centistokes.

2. The process in accordance with claim **1** wherein said metal is steel.

3. The process in accordance with claim 1 wherein said silicone fluid has a phenyl-methyl ratio of about 0.75.

4. The process of claim 1 wherein said silicone fluid is brought to said walls of said mold in a water carrier in the form of an emulsion of said silicone fluid and said water.

5. The process in accordance with claim 4 wherein the weight ratio of said silicone fluid to said water in said emulsion is within the range of from about 1:6 and about 1:60.

6. The process in accordance with claim 1 wherein said silicone fluid is brought to the walls of said mold in a liquid hydrocarbon solvent carrier.

7. The process in accordance with claim 6 wherein the ratio of said silicone fluid to said solvent is within the range of from about 1:6 to about 1:10.

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