

UNITED STATES PATENT OFFICE.

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METHOD OF MAKING ALUMINUM-SILICON-ALLOY CASTINGS.

No Drawing.

Application filed April 29, 1925. Serial No. 28,808.

To all whom it may concern:

Be it known that I, DOUGLAS B. HOBBS, a citizen of the United States, and a resident of Cleveland, in the county of Cuyahoga and State of Ohio, have invented a new and useful Improvement in Methods of Making Aluminum-Silicon-Alloy Castings, of which the following is a specification.

This invention relates to aluminum alloys containing substantial amounts of silicon, and its object is to provide a simple method of making aluminum-silicon alloy castings with improved physical properties, such as tensile strength, yield point and hardness.

The invention is based upon my discovery that the physical properties of cast aluminum-silicon alloys, especially those which have been "modified" by treatment with alkali metals or with alkali metal fluorides, are greatly dependent upon the time which elapses between the solidification of the castings in non-chilling molds and their attainment of room temperatures, or, more accurately, temperatures below about 250° C.

It is well known that sand cast aluminum-silicon alloys, containing silicon in amounts from about 3 to 15 per cent do not ordinarily possess properties much different from other sand cast aluminum alloys, for example, from an 8 per cent copper alloy. However, by a suitable procedure, commonly termed "modifying", it is possible to greatly enhance their physical properties, so that such alloys at once become better adapted for commercial use. The modifying procedure may, for example, be that disclosed by A. Pacz in U. S. Patent No. 1,387,900 or that disclosed by J. D. Edwards, F. C. Frary and H. V. Churchill in U. S. Patent No. 1,410,461. Aluminum-silicon alloys untreated by any such method will hereinafter be termed "normal" to distinguish them from the treated, or "modified" alloys. As is already well known, such processes act to refine the grain of the alloy and to disperse highly the silicon particles.

In carrying out my invention, I make use of an alloy of aluminum containing from about 3 to 15 per cent silicon, which may be made by stirring silicon into molten aluminum at 750° to 850° C. until solution is complete. In making castings, the alloy is

preferably modified by treating it while molten with a suitable refining agent, say 0.1 per cent by weight of metallic sodium at a temperature of about 800° C., or 2 per cent of sodium fluoride at a temperature of about 940° C., and allowed to cool to a suitable pouring temperature, whereupon it is cast into a non-chilling mold, by which is meant a mold whose walls do not rapidly chill the molten alloy. A suitable pouring temperature for an aluminum-silicon alloy containing 12 per cent silicon is approximately 650° C., although with alloys of higher freezing points, somewhat higher pouring temperatures may be required. As soon as practicable after the mold is filled, the casting is removed and quenched in a suitable liquid, preferably water, in order to cool it as quickly as possible to room temperature or to a temperature below about 250° C. The physical properties are greatly improved by this treatment and are materially better than those of like alloys similarly treated with an alkali metal or an alkali metal fluoride flux, but which are cooled normally to room temperature in sand molds.

As an example of the improvement effected merely by the modifying treatment, a normal aluminum alloy containing approximately 13 per cent silicon and approximately 0.5 per cent iron, showed an average tensile strength for two bars of 19,530 pounds per square inch and an elongation of 3.5 per cent in two inches, when cast and permitted to cool in sand in the form of a test bar 0.5 inch in diameter, the alloy being poured at 650° C. The same alloy, after being treated at 940° C., with 2 per cent of a refining flux (sodium fluoride) and cast similarly at 650° C., had an average tensile strength for two bars of 28,100 pounds per square inch and an elongation of 7.5 per cent in two inches.

The physical properties of such a modified alloy are further substantially improved if the casting is promptly removed from a non-chilling mold and suitably chilled. For example, by removing the bars from the molds shortly after pouring, i. e., while they are still relatively hot, and quenching them in cold water, the tensile strength and hard-

ness may be substantially increased. Thus by pouring consecutive test bars in sand holes as rapidly as possible, in order to obviate variations in casting conditions, from the same 20-pound melt of modified aluminum-silicon alloy cited above, and quenching bars at various times, I found the properties to vary as follows:—

Time before quenching of casting	Yield point	Tensile strength	Elongation	Hardness Brinell
	Lbs./sq. in.	Lbs./sq. in.	%	
74 seconds.....	13, 133	36, 775	6.5	72
120 seconds.....	16, 133	33, 450	5.5	66
163 seconds.....	16, 125	31, 915	5.0	62
15 Cooled in mold to room temperature.....	13, 150	28, 100	7.5	54

Thus it is seen that the tensile strength and hardness have been greatly improved as the result of the rapid cooling of the casting. Temperature measurements made by inserting an 18 gauge chromel-alumel thermocouple in the mold before pouring showed that the temperature varied as follows, the metal being at 650° C. when poured:

Time after pouring	Temperature
Minutes	° C.
1	565
2	535
3	510
4	485
5	470
10	350

I have found further that if the iron content of these alloys is reduced, the physical properties are still further improved by my process. For example, a 20-pound melt of aluminum alloy containing approximately 13 per cent silicon and approximately 0.1 per cent iron, was treated with 2 per cent of the sodium fluoride modifying flux at 930° C. and allowed to cool to 650° C., whereupon it was poured into sand molds, as before. Bars cooled to room temperature in the molds showed an average tensile strength for two bars of 24,890 pounds per square inch, a yield point of 11,830 pounds per square inch and 18.3 per cent elongation in two inches. Bars removed from the molds and quenched in cold water within 90 seconds after pouring showed for two bars an average tensile strength of 34,150 pounds per square inch, yield point 15,090 pounds per square inch, and 8.3 per cent elongation. Bars quenched at intermediate periods showed properties varying between these.

The casting temperature and time elapsing before quenching will naturally vary somewhat with the nature and size of the casting, but I have found that in order to obtain improvement in properties of the test bars referred to above the bars should generally be quenched in less than five

minutes after pouring, and to obtain optimal properties, in less than 3 minutes, or as soon as solidification makes quenching practical. The approximate temperatures of the bars, corresponding to these limits of time, were 470° and 510° C., respectively. Quenching ten minutes after pouring castings of the size of test bars does not alter appreciably the properties obtained by slow cooling to room temperature, but it will be understood that in the case of large castings greater periods of time must elapse between casting and removal from molds than in the case of small castings.

I have also found that by applying this quenching process to normal, or unmodified, aluminum-silicon alloys, an improvement is effected, but it is not so large as that obtained by applying it to the modified alloys. As stated above, the silicon content of the alloy is preferably from about 3 to 15 per cent. In the case of normal alloys the silicon content is ordinarily not greater than 5 to 10 per cent, while in the case of modified alloys it is preferably from about 8 to 13 per cent. The invention is not limited to alloys containing only aluminum and silicon, but is applicable to aluminum-silicon alloys containing other elements, such as copper, zinc and nickel.

In a copending application of R. S. Archer and J. D. Edwards, Serial No. 426,839, there is described the production of aluminum-silicon alloys of similar composition with improved physical properties, which comprises causing the alloy to solidify rapidly, as for example, by casting in a chill mold. As a result of this rapid solidification of the molten alloy, a very high dispersion of the silicon particles is secured. My process is not concerned, however, with the rapid solidification of the molten metal, but with an improvement in the properties of the casting which can be effected by a rapid cooling of the casting immediately after it has solidified in a non-chilling mold, and is largely predicated on my discovery that the physical properties of the casting may be improved by rapid cooling after the casting has solidified sufficiently to remove it from a mold. My invention is particularly applicable to castings made in sand molds which normally permit a relatively slow rate of cooling of the casting as long as it stays in the mold. It may also be applied effectively in the case of castings made in metal molds as described in the above-mentioned application, but where the mold temperature was maintained too high to permit the obtaining of the improved physical properties resulting from chilling of the casting. Such a heated metal mold is a non-chilling mold in the sense in which the term is herein used. In some cases a casting may

be removed from a mold and quenched before it has completely solidified internally, and in these cases an additional improvement may be secured by the rapid solidification of the interior sections of the casting produced by quenching.

The modification treatments used to improve the properties of aluminum-silicon alloys have for their ultimate effect the high dispersion of the silicon particles, the normally relatively large plates and needles of silicon being thereby dispersed as fine particles, even appearing globular in character. It is the maintaining of this high dispersion of the silicon particles which symbolizes my process in its preferred form. By removing the castings from the mold as soon as they are rigid enough to handle, and then quenching in a suitable fluid, such as water, it appears that the silicon particles are cooled rapidly through a temperature range in which they normally grow to some extent, and this growth, which lowers the hardness, yield point and strength, is thereby inhibited. It is also probable that my process retains in solid solution a greater proportion of silicon than normally obtains on slow cooling of a casting of similar composition and the strength of the casting is thereby improved.

According to the provisions of the patent statutes, I have explained the principle and mode of operation of my invention, and have specifically described the preferred manner of practicing it as to temperature, compositions and cooling periods. However, I desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as explained in the specific examples given.

I claim:

1. The method of making aluminum-silicon alloy castings, comprising filling a non-chilling mold with molten aluminum-silicon alloy, promptly removing the casting from

the mold after initial solidification, and rapidly chilling the casting.

2. The method of making aluminum-silicon alloy castings, comprising filling a sand mold with molten aluminum-silicon alloy, promptly removing the casting from the mold after initial solidification, and rapidly chilling the casting.

3. The method of making castings of aluminum-silicon alloy, comprising filling a non-chilling mold with molten aluminum-silicon alloy which has been treated with a reagent capable of refining the grain and dispersing the silicon particles, removing the casting from the mold after initial solidification, and rapidly chilling the casting.

4. The method of making castings of aluminum-silicon alloy, comprising filling a sand mold with molten aluminum-silicon alloy which has been treated with a reagent capable of refining the grain and dispersing the silicon particles, removing the casting from the mold after initial solidification, and rapidly chilling the casting.

5. The method of making castings from an aluminum-silicon alloy containing from about 3 to 15 per cent silicon, comprising filling a non-chilling mold with said alloy in a molten condition, promptly removing the casting from the mold after initial solidification, and rapidly chilling the casting by quenching it in a quenching liquid.

6. The method of making castings from an aluminum-silicon alloy containing from about 8 to 13 per cent silicon, comprising filling a non-chilling mold with said alloy in a molten condition and after being treated with a reagent capable of refining the grain and dispersing the silicon particles, removing the casting from the mold after initial solidification, and rapidly chilling the casting by quenching it in a quenching liquid.

In testimony whereof I sign my name.

DOUGLAS B. HOBBS.