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HEAT TREATED ALUMINUM BASE ALLOY

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This invention relates to the thermal treatment of aluminum base alloys, and it is more particularly concerned with accelerating the solution heat treatment of aluminum-copper alloys.

Aluminum-copper alloys have been extensively used in the manufacture of cast articles because of their good casting qualities. While the alloy has favorable casting qualities it does not possess a sufficiently high strength for many purposes. In order to develop the maximum strength in cast aluminum-copper alloys it has therefore been found necessary to subject the castings to a prolonged treatment at an elevated temperature followed by rapid cooling to room temperature. Wrought alloys are also improved by treatment at high temperatures but they generally attain the desired internal structural condition in a shorter time than do cast products. The heat treatment referred to consists essentially in elevating the temperature to increase the solubility of alloy constituents which are virtually insoluble at ordinary temperatures, thus to obtain an alloy in which substantially all of the copper-rich constituent is in solid solution. The heated article is rapidly cooled to room temperature to retain the solid solution. In the commercial production of heat treated cast articles it is desirable to effect the thermal treatment in as short a time as possible and this may be partially accomplished through holding the casting as close to the temperature of incipient fusion as possible since an increase in temperature generally accelerates the rate of solution of undissolved constituents. Such practice, however, necessitates very accurate temperature control, and the danger of overheating the metal is always present. A need has therefore been felt for a method of heat treatment which would permit greater latitude in heat treating temperature and at the same time shorten the time of treatment.

My invention is designed to fulfill the foregoing need, and in particular, to accelerate the rate at which undissolved alloy ingredients in aluminum-copper alloys may be dissolved. A further object is to produce a higher strength in alloys which may be heat treated for the same length of time normally given to cast aluminum-copper alloys. Another object is to make it possible to shorten the heat treatment without disadvantageously affecting the casting quality or other desired characteristics of the herein described type of alloy.

I have discovered that the addition of from about 0.05 to 0.5 per cent vanadium to aluminum-copper alloys containing from about 3 to 6 per cent of copper markedly improves the strength of said alloys when heat treated and thereafter aged at room temperature. It has also been unexpectedly found that the presence of vanadium in the alloy permits it to be cast at higher temperatures without producing a coarse-grained structure. This feature is of particular importance where the molten alloy must be heated to a high temperature to obtain the desired degree of fluidity. The vanadium may be added to the molten alloy in any suitable manner such as in the form of a rich alloy or in the form of a salt which will be reduced by molten aluminum.

In the practice of my invention the aluminum-copper alloy is first melted within the normal range of melting temperatures or superheated if a higher degree of fluidity is desired. The vanadium is then incorporated in the molten alloy by any suitable means, and the molten charge finally poured into molds in the usual manner. The casting is removed from the mold, cooled to room temperature, trimmed or partly finished, then heated to a temperature of between about 475° C. and the point at which incipient fusion occurs, for a period of from about 5 to 60 hours depending upon the character and thickness of the casting. When the desired solution of the soluble alloy constituents has been attained, the casting is rapidly cooled to room temperature and allowed to age for several days in order to reach its maximum strength.

In heat treating the alloy the temperature used may vary over a considerable range depending upon the copper content, the nature of the casting and the strength desired. It is obvious that the rate of heat treatment increases with a rise in temperature but practical considerations prevent use of the highest possible temperature for fear of overheating. It is my preferred practice to heat the castings between about 500 and 530° C. The length of time necessary to treat the castings depends upon the alloy composition, the character of the product and the temperature of treatment. Under ordinary conditions from about 5 to 20 hours is sufficient to bring about the desired solution.

While my invention is effective over a range of from 3 to 6 per cent copper, I have found that alloys containing from 4 to 5.5 per cent of copper are especially benefited by the addition of vanadium. From about 0.1 to 0.3 per cent vanadium produces satisfactory results in alloys of such a copper content. Other elements than copper and vanadium may also be present for the purpose of enhancing some property of the basic alloy. Such elements as silicon, iron, manganese, chromium and nickel may serve as alloy constituents without substantially interfering with the action of vanadium in hastening the heat treatment of the alloy. From about 0.75 to 3 per cent of silicon may be advantageously used in certain instances where fluidity of the molten metal is of particular importance. In order to increase the strength of the casting from about 0.1 to 0.5 per cent of magnesium may be used in combination with the silicon. The elements manganese, iron, chromium, nickel and the like may be added in amounts of from 0.1 to 1.5 per cent, the total quantity in case more than one of these elements is added should not exceed 1.5 per cent. The foregoing alloys are usually poured at temperatures between about 700 and 740° C., but if desired, temperatures as high as 775° C. may be employed when an extremely fluid melt is required.

The improvement obtained through the use of vanadium in an aluminum-copper alloy may be more readily seen by comparison with a similar alloy containing no vanadium. An alloy composed of about 4.3 per cent copper, 0.7 per cent iron, 0.7 per cent silicon, and balance aluminum was melted and cast in a sand mold. The casting was then heat treated at about 515° C. for 16 hours, quenched in water and aged 3 days at room temperature before testing. This alloy had a tensile strength of 25,300 lbs. per sq. in., a yield strength of 14,000 lbs. per sq. in. and an elongation of 4.8 per cent in two inches. A similar alloy containing 0.2 per cent vanadium made up, cast, heat treated and aged under the same conditions had a tensile strength of 27,900 lbs. per sq. in., a yield strength of 17,200 lbs. per sq. in. and an elongation of 4.2 per cent. From this and other data on the effect of heat treating for various periods of time it becomes apparent that the vanadium serves to increase the strength of an alloy when treated under the same conditions as a normal alloy containing no vanadium. It is also apparent that the strength obtained in the normal alloy might have been attained in the alloy containing vanadium if it had been heated for a shorter time. In other words, the vanadium acts as an accelerator of heat treatment of aluminum-copper alloys.

The term aluminum as used herein refers to the metal of commercial purity containing the usual impurities. The term aluminum-copper alloy as here employed designates an aluminum base alloy containing more than 75 per cent aluminum with copper as the predominant alloying constituent.

I claim:

1. A heat treated cast aluminum base alloy containing from about 3 to 6 per cent copper and 0.05 to 0.5 per cent vanadium, and characterized by a higher strength than the same alloy devoid of vanadium when heat treated under the same conditions.

2. A heat treated cast aluminum base alloy containing from about 3 to 6 per cent copper, 0.05 to 0.5 per cent vanadium, 0.75 to 3 per cent silicon, the balance being aluminum.

3. A heat treated cast aluminum base alloy containing from about 3 to 6 per cent copper, 0.05 to 0.5 per cent vanadium, 0.75 to 3 per cent silicon and 0.1 to 0.5 per cent magnesium, the balance being aluminum.

4. A heat treated cast aluminum base alloy containing from about 4 to 5.5 per cent copper and 0.1 to 0.3 per cent vanadium, the balance being aluminum.

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