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METHOD OF TREATING ALUMINUM-MAGNESIUM ALLOYS

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This invention relates to aluminum-magnesium alloys, particularly those alloys containing 9.5%-10.5% magnesium, and has for its object the provision of an improved method of conditioning the alloy for casting and of heat-treating the cast alloy to improve the physical properties of the casting.

Another object is to provide castings, consisting of an aluminum-magnesium alloy containing from 9.5%-10.5% magnesium, having consistently high average values of tensile strength, yield point and elongation.

Other objects will be apparent as the invention is more fully hereinafter disclosed.

Heretofore in the art, the aluminum-magnesium alloy containing from about 9.5%-10.5% magnesium has been recognized as being an excellent casting alloy which is responsive to a treating process including the steps of solution-annealing, precipitation-hardening and aging, to develop higher and better physical properties. The main difficulty with this alloy, however, and the main reason why the alloy has not achieved wide utility is that the improvement in the physical properties obtained by such treating is inconsistent and widely variable such that the general average of values obtained is low.

The main object of the present invention is to eliminate such wide variations in attained values and to obtain a high average value of such physical properties consistently, thereby to greatly enlarge the field of utility of said alloys.

We have discovered that by refining the grain structure of the alloy by thoroughly degasifying and scouring the alloy while in its molten state and incorporating therein between .001%-.05% boron, casting the alloy and then subjecting the cast product to a heat-treating process including a relatively short time solution-anneal at 820° F., a retarded cooling from the solution-anneal temperature down to about 680°-730° F., quenching in cold water, extraordinary high average physical values are consistently obtainable in the alloy, said average values being well above the best physical values heretofore inconsistently obtainable in the alloy. Furthermore, we have discovered that the time period for aging to obtain still higher physical properties is materially reduced to a period approximating 90 days.

In the practice of the present invention, we prefer to degasify and scour the molten aluminum-magnesium alloy with boron trichloride in accordance with the invention of Cooper Patent No. 2,369,213 issued February 13, 1945, which patent is assigned to the same assignee as the present application, using a sufficient excess of the boron trichloride over that required to completely degasify and scour the molten alloy providing approximately .01% boron in the cast alloy product. Usually, we find that under the best melting

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practice this desired result and boron content can be obtained by limiting the time interval of a strong free flow of the boron trichloride to that approximating 2 seconds per pound of molten metal being treated.

Following this treatment the treated bath is permitted to stand quiescent for a short time interval to permit the last traces of chlorine to escape therefrom before skimming and casting. The cast product then is ready for heat-treatment in accordance with the process of the present invention.

We have found that the major advantage of the fine grain structure, obtained by the boron addition to the alloy, is that a materially shortened time interval of heating is required to redissolve the precipitated phases of the alloy at the solution-anneal temperature, shortening this time interval from the previously required time of 10 to 20 hours to from 3 to 4 hours.

We have also found that the fine grain structure, obtained by the boron addition to the alloy, is particularly favorable to relatively rapid reprecipitation of the redissolved precipitated phases at temperatures approximating 680°-730° F., and that by slow cooling the alloy from the solution-anneal temperature to a temperature approximating the lowest temperature in this range (680° F.), as by cooling down in the furnace, the major portion of the precipitating phase is ejected from solid solution.

Thereafter, we find that upon under-cooling, as by quenching in cold water from said temperature of 680° F., the remaining precipitating phase is ejected from solid solution at room temperatures substantially completely on aging at room temperatures within a period of about 90 days instead of from 8 to 12 months, as heretofore experienced with these alloys.

The time intervals saved on solution-annealing and aging the cast alloy by the practice of the present invention represent economic advantages. The higher average physical values consistently obtained by the practice of the present invention greatly enlarge the field of utility of the alloy and also present economic advantages.

As one specific embodiment of the present invention we will describe the same as it has been adapted to the treating of an aluminum-magnesium alloy containing 10% magnesium. The Metals Handbook (1939 edition) gives the following average values of tensile strength, yield strength and elongation, respectively, for this alloy: 45,000 p. s. i., 25,000 p. s. i., and 12%-14%.

By the practice of the present invention we obtain a tensile strength average of 52,000-53,000 p. s. i.; a yield strength averaging 28,000 p. s. i.; and an elongation averaging about 18%.

This improved result is obtained by degasifying and scouring the alloy while in its molten state

with boron trichloride, using a strong free flow of the boron trichloride for a time interval approximating 2 seconds per pound of molten alloy. Under the best metallurgical melting practices this should give a boron content in the molten alloy approximating .01%. This percent of boron appears to produce the best grain size and uniformity of grain size for best results from the heat-treatment process of the present invention. A lower boron content gives a somewhat larger grain structure and a higher boron content produces a somewhat finer grain structure.

The treated alloy is then cast in accordance with standard best practice and the cast product is treated as follows:

The casting is placed in the usual type muffle furnace and is heated slowly to a temperature approximately 820° F. and is maintained at this temperature for a period of time at least approximating 3 hours, but not exceeding 4 hours. The furnace heating is then interrupted and the casting is permitted to cool slowly in the furnace to a temperature within the range 680°-730° F., but preferably to 680° F. Then the casting is quenched in cold water and is allowed to stand at room temperatures for a period of time approximating 90 days.

Various tests have indicated that after a period of about 90 days aging at room temperatures, no further change or improvement in the physical properties of the treated casting occurs.

Various tests also have indicated that quenching the alloy at any temperature above about 730° F. in cold water results in lower physical values and a longer aging time interval with a wide variation in such physical values resulting in a low average value. Quenching at temperatures below about 680° F. also results in lower and inconsistent average values.

One of the significant advantages resulting from the present invention is that the magnesium content of the alloys may be increased to 11%-12% to obtain consistently still higher average physical values without increasing the time interval of solution-annealing or extending the aging time interval. Thus, with alloys containing 10.5%-11.5% magnesium, a tensile strength approximating 55,000 p. s. i. is consistently obtainable together with a yield point of about 30,000 p. s. i., and an elongation approximating 20%.

It is believed apparent from the above disclosure that the invention may be widely varied without essential departure therefrom and all such modifications and departures therefrom are contemplated as may fall within the scope of the following claims:

What we claim is:

1. The method of treating an aluminum-magnesium alloy containing 9.5-12% magnesium balance aluminum to impart thereto a fine grain structure and relatively high average values of physical properties which comprises treating the metal while in its molten condition with boron trichloride to degasify and scour the molten metal, using an excess of the boron trichloride sufficient to provide a boron content within the range .001%-.05%, casting the alloy and heat-treating the casting at a solution-anneal temperature approximating 820° C. for from 3 to 4 hours, slow cooling the casting from the solution-anneal temperature to a temperature within the range 680°-730° F., and quenching the slow cooled casting in cold water to room temperatures.

2. The method of treating an aluminum-magnesium alloy containing 9.5-12% magnesium balance aluminum to impart thereto a fine grain structure and relatively high average values of physical properties which comprises treating the metal while in its molten condition with boron trichloride to degasify and scour the molten metal, using an excess of the boron trichloride sufficient to provide a boron content within the range .001%-.05%, casting the alloy and heat-treating the casting at a solution-anneal temperature approximating 820° F. for from 3 to 4 hours, slow cooling the casting from the solution-anneal temperature to a temperature within the range 680°-730° F., quenching the slow cooled casting in cold water to room temperatures and aging the quenched casting at room temperatures for a period of time approximating 90 days.

3. A product of manufacture comprising a cast article consisting of an aluminum-magnesium alloy containing 9.5%-10.5% magnesium and .001%-.05% boron, balance aluminum, said article being characterized by a fine grain structure and by a tensile strength, yield point and elongation materially higher than obtainable in the alloy of the same composition without the boron, said physical properties having been imparted thereto by the practice of the heat-treating process of claim 1.

4. A product of manufacture comprising a cast article consisting of an aluminum-magnesium alloy containing about 10% magnesium and about .01% boron, balance aluminum, said article being characterized by a fine grain structure and by a tensile strength, yield point and elongation materially higher than obtainable in the alloy of the same composition without the boron, said physical properties having been imparted thereto by the practice of the heat-treating process of claim 1.

5. A product of manufacture comprising a cast article consisting of an aluminum-magnesium alloy containing about 10% magnesium and about .01% boron, balance aluminum, said article being characterized by a fine grain structure and by a tensile strength within the range 50,000-55,000 p. s. i., yield point within the range 28,000-30,000 p. s. i., and an elongation about 18%, said physical properties having been imparted thereto by the practice of the heat-treating process of claim 1.

6. The method of claim 1, wherein the boron trichloride is passed in a strong free flow through the molten metal for a period of time approximating 2 seconds for each pound of molten metal to degasify and scour the molten metal and to obtain therein a boron content approximating .01%.

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