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THERMAL TREATMENT FOR ALUMINUM BASE ALLOYS

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The invention relates to a thermal treatment for aluminum base alloys, and finds particular application in the treatment of the so-called spontaneously ageable aluminum base alloys. By aluminum base alloys we mean alloys containing more than 50 per cent of aluminum and a balance of one or more other alloying elements. The term spontaneously ageable will be hereinafter defined.

Certain physical properties of aluminum base alloys, and particularly alloys of that metal containing copper, may be improved by various thermal treatments. One of the most common of these treatments, often termed a solution heat treatment, consists in subjecting the metal to an elevated temperature slightly below the melting point of the most fusible constituent of the alloy. This procedure effects a solution of the soluble alloying elements in the alloy with the base metal at the high temperature which condition may be retained in the alloy at normal temperatures following rapid cooling or quenching thereto, and results in an immediate or eventual increase in the strength, hardness, and elasticity of the metal.

Although the solution heat treatment and quenching above described result in improved strength and hardness, the metal may nevertheless be mechanically deformed and subjected to the usual fabrication processes. However, if some alloys are allowed to stand or age for a few days, even at ordinary temperatures, their strength and hardness continue to increase even beyond the values existing immediately following solution heat treatment and quenching.

This gradual change in physical properties at ordinary or room temperatures is herein termed spontaneous or natural aging as distinguished from artificial aging. Artificial aging characterizes the effect on solution-treated alloys of a relatively low temperature but higher than room temperature. Spontaneously ageable alloys, therefore, are alloys which develop certain properties such as reduced ductility and increased hardness and strength at ordinary temperatures after a solution treatment as above defined.

Because of this hardening which takes place spontaneously in such alloys and which adversely affects their working characteristics, it is often necessary that an alloy which is to be fabricated following solution heat treatment be subjected to its forming steps immediately following cooling or quenching to normal temperatures and before natural aging increases its hardness to the point where it cannot be mechanically worked. No satisfactory method has been provided whereby an age-hardened alloy may be softened and rendered sufficiently plastic to permit ready application of all fabrication processes. The metal may be annealed prior to fabrication, but this is unsatisfactory because the metal does not age-harden and regain its former properties following the annealing step. The only remedy has been to repeat the solution heat treatment at an elevated temperature in order to produce resolution of its constituents and to overcome the effects of age-hardening, and then to cool the metal. Following this process, the metal may be immediately fabricated and then again permitted to age and to regain the properties taken from it by the additional solution heat treatment.

An object of this invention is to provide a method for improving the working characteristics of age-hardened alloys. The invention has for its further purpose the provision of an improved process whereby alloys may be rendered more plastic following solution heat treatment and age-hardening thereof, which method does not include a repetition of the solution heat treatment. More particularly, the object of the invention is to provide a method whereby the plasticity of such alloys may be increased without materially affecting the final hardness and strength of the alloy. The specific object of the invention is to provide such a method which is applicable to the working of aluminum base alloys which have been spontaneously age-hardened following solution heat treatment and rapid cooling thereof. In actual effect, the real purpose of the thermal treatment disclosed herein is to place an age-hardened article, made from spontaneously ageable aluminum base alloy, in a physical condition substantially equivalent to that existing immediately after the article was quenched from the solution temperature. Other objects will appear in the following description of the invention.

We have discovered that the working characteristics of spontaneously age-hardenable alloys may be greatly improved if the metal after age-hardening is subjected for a short time to an additional heat treatment, prior to fabrication, at a temperature slightly below the temperature at which the alloy is normally annealed, and is then rapidly cooled. The temperature and the time of treatment, of course, vary with the nature of the particular alloy being treated; but in the case of most aluminum base alloys, for example, the treatment should be at a temperature of from about 225° C. to about 300° C., and should last

for a period of from a few seconds to not more than 5 minutes. Following such a treatment, the metal may be worked with substantially the same ease as immediately following the quenching from the solution heat treatment temperature. Moreover, the alloy, upon re-aging subsequent to the treatment, regains substantially the same physical properties that it had prior to the practice of our process.

The invention may be more particularly described with reference to the following tests in which the values stated for tensile and yield strengths refer to pounds per square inch.

Specimens of aluminum alloy containing 3.95 per cent copper, 0.55 per cent manganese, 0.54 per cent magnesium, 0.51 per cent silicon, and 0.45 per cent iron were subjected to the usual solution heat treatment temperature and rapidly quenched in cold water. They then showed a yield strength of 18,150 lbs., a tensile strength of 48,585 lbs., and an elongation of 23.5 per cent. Following this treatment the specimens were permitted to stand for four days at room temperature. At the end of this time the specimens were found to have properties which made them practically unworkable when subjected to fabrication processes, their yield strength being 37,700 lbs., their tensile strength 64,630 lbs., and their elongation 21.0 per cent.

One of the specimens was then treated for a period of ½ minute in a salt bath having a temperature of 250° C. and was then rapidly quenched to normal temperature. By this treatment the yield strength was decreased to 21,050 lbs. and the tensile strength to 51,160 lbs. and the elongation was increased to 22.5 per cent. These properties approximated those of the specimens immediately following solution heat treatment, which made the alloy relatively easy to fabricate.

The specimen then was permitted to stand at room temperature for four days, and tests showed that its yield strength had again arisen to 38,300 lbs., its tensile strength to 64,405 lbs. and its elongation had decreased to 20.8 per cent, indicating that the specimen had age-hardened following its ½ minute treatment at 250° C. and that it had substantially the same properties as the specimens after age-hardening subsequent to solution heat treatment.

Other specimens were similarly treated at the same temperature for various periods and the results of the tests may be tabulated as follows:

Properties of specimens following solution heat treatment and quenching

Yield strength	Tensile strength	Elongation
Pounds	*Pounds*	*Percent*
18,150	48,585	23.5

Properties of specimens following solution heat treatment, quenching, and four day aging at room temperature

Yield strength	Tensile strength	Elongation
Pounds	*Pounds*	*Percent*
37,700	64,630	21.0

Properties of above heat treated and aged specimens following treatment at 250° C.

Time of treatment at 250° C.	Yield strength	Tensile strength	Elongation
Minutes	*Pounds*	*Pounds*	*Percent*
½	21,050	51,160	22.5
1	22,100	50,835	22.3
2	25,350	51,140	20.3
4	29,550	50,450	15.5

Properties of heat treated and aged specimens following treatment at 250° C. and additional four day aging

Time of treatment at 250° C.	Yield strength	Tensile strength	Elongation
Minutes	*Pounds*	*Pounds*	*Percent*
½	38,300	64,405	20.8
1	38,100	64,110	20.0
2	39,400	63,525	19.5
4	39,750	60,210	15.5

The tests indicate that for the particular alloy described reduction may be effected in the yield and tensile strengths of the age-hardened alloy if it is heated to a temperature of between about 225° C. and about 300° C., and they further show that the treatment may continue for periods up to 5 minutes. However, elongation is decreased by the treatment if the alloy is heated for the longer periods, and, for that reason, the alloy may best be fabricated following treatment between those temperatures continuing from about 15 seconds to about 2 minutes, preferably for a minute or less. Moreover, the alloy, if heated for a period of over 4 minutes, appears to lose its capacity to age-harden following the treatment and therefore does not recover the strength and hardness which it had as an age-hardened alloy prior to the treatment.

Other spontaneously age-hardenable aluminum base alloys are familiar to those skilled in the aluminum base alloy art. For instance, without intending to limit the scope of the invention, we may mention aluminum base alloys containing appreciable amounts of magnesium and silicon; we have successfully used our invention on a specific aluminum base alloy of this nature containing approximately 0.7 per cent silicon, 1.25 per cent magnesium, and 0.25 per cent chromium, the balance being aluminum containing the usual impurities. As hereinabove described, it is apparent that the method is applicable to any spontaneously ageable aluminum base alloy, regardless of the extent or diversity of its added alloying constituents. It will be understood that the various modifications in time and temperature of treatment which may be needed in order to treat other alloys according to our method are within the purview of our invention.

We claim:

1. A method for improving the working characteristics of spontaneously ageable aluminum base alloys following age-hardening thereof, which comprises subjecting said alloys to a temperature between about 225° C. and about 300° C. for a period of from a few seconds to about 5 minutes, and rapidly cooling said alloys.

2. A method for improving the working characteristics of spontaneously ageable aluminum base alloys containing copper following age-

hardening thereof, which comprises subjecting said alloys to a temperature between about 225° C. and about 300° C. for a period of from a few seconds to about 5 minutes, and rapidly cooling said alloys.

3. A method of working spontaneously age-hardened aluminum base alloys, which comprises treating said alloys for a period of from a few seconds to about 5 minutes from a temperature of from about 225° C. to about 300° C., subjecting said alloys to fabrication steps, and then age-hardening said alloys.

4. A method for restoring to an article of spontaneously aged aluminum base alloy substantially the same properties prior to its fabrication which it possessed immediately after solution heat treatment and quenching, which comprises subjecting said article to a temperature between about 225° C. and about 300° C. for a period of between a few seconds and about 5 minutes, and rapidly cooling said article.

5. A method for restoring to an article of spontaneously aged aluminum base alloy containing copper substantially the same properties prior to its fabrication which it possessed immediately after solution heat treatment and quenching which comprises subjecting said article to a temperature between about 225° C. and about 300° C. for a period of from a few seconds to about 5 minutes, and rapidly cooling said article.

6. A method for restoring to an article of spontaneously aged aluminum base alloy containing magnesium and silicon substantially the same properties prior to its fabrication which it possessed immediately after solution heat treatment and quenching which comprises subjecting said article to a temperature between about 225° C. and about 300° C. for a period of from a few seconds to about 5 minutes, and rapidly cooling said article.

7. A method for restoring to an article of spontaneously aged aluminum base alloy containing copper and magnesium substantially the same properties prior to its fabrication which it possessed immediately after solution heat treatment and quenching, which comprises subjecting said article to a temperature between about 225° C. and about 300° C. for a period of from a few seconds to about 5 minutes and rapidly cooling said article.

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