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METALLURGY

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3 Claims. (Cl. 148—159)

This application is a continuation of application Serial No. 838,072, filed September 4, 1959, now abandoned.

This invention relates to treating aluminum to improve the strength thereof. More particularly, this invention relates to aging solution heated and quenched aluminum alloy 7079 to achieve high mechanical properties with a minimum amount of treatment time.

In the prior art production of wrought articles of solution heat treatable aluminum alloys, the stock after working e.g., rolling, forging, etc., is solution heated, quenched and subsequently aged. In the production of solution heat-treated articles of the aluminum base alloy designated by the Aluminum Association as 7079, it has been necessary to age the solution heat treated aluminum articles or bodies for a period of at least five days at room temperature (i.e., about 70° F.), followed by artificial aging in a furnace for 48 hours at 240° F. in order to achieve the desired high strength. The alloy designated by the Aluminum Association as 7079 and referred to herein as aluminum alloy 7079 consists essentially of not more than 0.30% silicon and 0.40% iron, from 0.40 to 0.8% copper, from 0.10 to 0.30% manganese, from 2.9 to 3.7% magnesium, from 0.10 to 0.25% chromium, from 3.8 to 4.8% zinc, and not more than 0.10% titanium, balance aluminum. The solution heat treatment of alloy 7079 generally comprises heating a body of the alloy to a temperature of from about 800 to 900° F. and maintaining the body at that temperature for a period of not substantially less than 15 minutes followed by quenching of the body preferably in water.

The above described prior art process of treating solution heated and quenched aluminum alloy 7079 possesses many inherent disadvantages, particularly with regard to the excessive period of time required for the aging treatment which necessitates large storage areas, excessive labor expense and difficulties with regard to providing the material when desired.

It has been found that such undue time consumption can be substantially reduced by applying the treatment of this invention. This invention comprises the steps of heating a solution heated and quenched body of aluminum alloy 7079 to a temperature of from about 100 to 140° F. and maintaining the body at that temperature for a period of not substantially less than 2 hours, followed by heating to a temperature of from about 225 to 275° F. and maintaining the body at that temperature for a period of not substantially less than 20 hours.

The duration of both the first heating step or pre-age and the second heating step or final age varies depending upon such factors as the mass of the material being treated, the internal structure, the composition of the alloy and the temperature. While period of time substantially greater than 2 hours for the pre-age and 20 hours for the second heating step may be employed, the minimum period of time consistent with obtaining the desired properties is the most economical and accordingly is preferred.

According to the preferred practice of this invention, the solution heated and quenched body of aluminum alloy 7079 is heated to a temperature of from about 115 to 125° F. and maintained at that temperature for a period of from about 4 to 8 hours, followed by heating to a temperature of from about 235 to 250° F. and maintaining the body at that temperature for a period of from about 35 to 60 hours.

The following examples illustrate the application of this invention to forged and to hot rolled aluminum bodies.

Example I

An aluminum alloy ingot of the type designated by the Aluminum Association as 7079, having an analysis of 0.13% silicon, 0.19% iron, 0.60% copper, 0.17% manganese, 3.60% magnesium, 0.19% chromium, 4.74 zinc, 0.03% titanium, balance aluminum, was hot rolled at a temperature of 600° F. to 0.375 inch. Specimens ½" wide by 8" long were then cut from the sheet and solution heated in a furnace by heating to and maintaining at 830° F. for one hour and quenching in water. The specimens were then pre-aged by heating in a furnace to the temperatures indicated in Table I below and maintaining at these temperatures for the periods of time indicated in Table I below, followed by heating in a furnace for 48 hours at 240° F. Specimens 1 through 5 were treated by the method of this invention while specimen 6 was treated according to prior practice, i.e., pre-aged for five days at room temperature and aged for 48 hours at 240° F. All specimens were subjected to conventional tensile tests, the results of which are given in Table I below.

TABLE I

Specimen No.	Preage Temp.° F.	Preage Time, Hours	Ultimate Strength, 1,000 p.s.i.	Yield Strength, 1,000 p.s.i.	Elongation in 2" Percent
1	100	8	78.3	68.5	11.5
2	100	16	78.1	69.5	10.7
3	120	4	78.4	69.8	10.7
4	120	8	78.6	69.6	10.8
5	120	16	78.4	68.9	10.7
6	(1)	(2)	78.2	69.1	11.2

[1] Room T. (70° F.).
[2] 5 days.

From the results shown in Table I above it can be seen that specimens 1 through 5 which were treated by the method of this invention exhibited tensile strengths, yield strengths and percent elongations substantially the same as specimen 6, which was treated according to prior art practice requiring the undesirable five day pre-age at room temperature.

Example II

Eight hand forgings of 7079 aluminum alloy were heated to and maintained at a temperature of 865° F. for 6 hours. The dimensions and amounts of elements other than aluminum for all forgings are provided in Table II below.

TABLE II

Hand Forging No.	Si	Fe	Cu	Mn	Mg	Cr	Zn	Ti	Size
1	.13	.19	.57	.17	3.45	.17	4.58	.06	6"x11½"x56".
2	.13	.19	.66	.19	3.36	.16	4.39	.06	5"x17"x50".
3	.14	.19	.69	.17	3.41	.16	4.35	.05	5"x17"x50".
4	.13	.18	.67	.19	3.25	.16	4.37	.06	5"x17"x50".
5	.12	.16	.66	.18	3.36	.16	4.56	.06	6"x11½"x30".
6	.14	.20	.65	.17	3.18	.17	4.30	.06	6"x11½"x30".
7	.13	.18	.65	.19	3.37	.15	4.40	.06	5"x17"x55".
8	.08	.15	.69	.22	3.40	.15	4.65	.05	5r"x17"x55".

All forgings were sawed in half and were separated into two groups each group containing one-half of each forging. The sections in the first group were processed in accordance with the prior art practice, i.e., were aged at room temperature (70° F.) for five days followed by artificial aging in a furnace for 48 hours at 240° F. The sections in the second group were pre-aged at 120° F. for five hours in a steam heated, thermally controlled tank of water, immediately followed by heating in a furnace to a temperature of 240° F. and maintaining at that temperature for 48 hours. Corresponding test specimens were taken from both groups. Three specimens from the long transverse direction and three specimens from the short transverse direction were cut from each half of each forging, subjected to conventional tensile tests and the averages from each set of three specimens of the ultimate strengths, yield strengths and percent elongations are indicated in Table III below. These specimens were standard size in accordance with ASTM designation E8–54T.

In Table III the forgings are numbered from 1 to 8 and the two halves of each forging are directly compared with regard to ultimate strength, yield strength and elongation. The expression "Elongation in 4D Percent" means the percent a gauge length of the specimen equal to four times the diameter of the specimen stretched during the test.

Example III

A contour hand forging of aluminum alloy 7079 approximately 31" long and 3⅜" thick having an analysis of .14% silicon, .20% iron, .65% copper, .17% manganese, 3.18% magnesium, .17% chromium, 4.30% zinc, .06% titanium, balance aluminum, was heated to and maintained at a temperature of 865° F. for 6 hours and quenched in water. The forging was cut into two identical halves and equivalent sets of samples were taken from each half. Three specimens from the longitudinal direction, ten specimens from the long transverse direction, and six specimens from the short transverse direction were obtained from each half of the forging. These were standard size specimens in accordance with ASTM designation E8–54T. The specimens from one-half of the forging were processed according to the prior art, i.e., pre-aged for five days at room temperature, followed by a nartificial furnace age for 48 hours at 240° F. The duplicate specimens from the other half of the forging were pre-aged five hours at 120° F. in a steam heated, thermally controlled tank of water and immediately furnace-aged for 48 hours at 240° F. The specimens were all subjected to conventional tensile tests. The ultimate strengths, yield strength and elongations for the specimens treated by the method of this invention are compared directly in Table IV below with equivalent

TABLE III

Hand Forging No.	Direction of Test Specimen	Ultimate Strength, p.s.i.		Yield Strength, p.s.i.		Elongation in 4D, percent	
		5 Day 70° F. Preage	5 Hr. 120° F. Preage	5 Day 70° F. Preage	5 Hr. 120° F. Preage	5 Day 70° F. Preage	5 Hr. 120° F. Preage
1	Long Trans.	72,000	74,700	61,700	66,900	7.3	6.8
	Short Trans.	72,100	73,600	62,500	65,300	4.7	4.8
2	Long Trans.	74,100	74,100	63,400	64,000	7.8	7.8
	Short Trans.	73,300	74,000	62,600	65,700	4.8	4.8
3	Long Trans.	72,700	73,700	63,400	63,200	8.8	9.2
	Short Trans.	70,700	71,800	58,700	61,700	5.9	5.7
4	Long Trans.	74,900	74,500	62,300	65,200	9.3	9.0
	Short Trans.	73,400	74,400	61,700	65,700	5.5	5.2
5	Long Trans.	73,400	72,400	62,600	61,400	8.8	8.3
	Short Trans.	70,800	71,700	62,400	63,100	4.2	4.5
6	Long Trans.	73,900	74,000	62,300	63,200	9.0	9.0
	Short Trans.	73,600	73,500	62,600	63,300	5.2	4.8
7	Long Trans.	75,000	75,200	64,200	65,700	8.7	8.7
	Short Trans.	74,300	73,700	64,000	64,500	5.2	4.7
8	Long Trans.	75,800	75,100	63,500	65,100	9.3	9.5
	Short Trans.	74,300	74,000	61,600	64,500	6.2	5.5

specimens treated by the prior art method as described above. Equivalent specimens from each half of the hand forging were given identical numbers and accordingly only one number appears for each pair of equivalent specimens in Table IV.

TABLE IV

Test Specimen No.	Direction of Test Specimen	Ultimate Strength, p.s.i.		Yield Strength, p.s.i.		Elongation in 4D, percent	
		5 Day 70° F. Preage	5 Hr. 120° F. Preage	5 Day 70° F. Preage	5 Hr. 120° F. Preage	5 Day 70° F. Preage	5 Hr. 120° F. Preage
1	Longitudinal	74,600	75,700	67,900	65,300	8.0	8.0
2	do	74,600	75,900	65,100	65,600	9.5	9.5
3	do	75,500	72,300	65,500	64,000	7.0	10.0
1	Long Trans		75,000		63,000		9.5
2	do		75,000		63,500		8.0
3	do	69,100	70,800	57,100	57,000	4.6	7.5
4	do	68,800	70,400	54,100	56,100	6.3	5.7
5	do	69,300	70,500	54,200	57,100	5.7	6.3
6	do	69,800	70,400	55,100	56,000	5.7	7.5
7	do	68,800	69,800	53,100	55,400	6.9	6.3
8	do	69,500	69,500	55,400	55,800	6.9	6.3
9	do	75,000	76,500	63,600	59,000	8.0	8.6
10	do	75,200	77,300	69,900	60,000	8.6	8.6
1	Short Trans	68,700	68,600	56,700	57,500	6.5	6.0
2	do	68,800	68,700	57,300	57,000	5.0	6.0
3	do	71,200	69,400	60,000	58,000	5.5	6.5
4	do	68,300	69,500	56,400	58,000	6.5	5.5
5	do	68,500	69,800	57,200	58,000	6.0	6.0
6	do	71,400	69,100	60,000	57,500	6.0	6.5

Example IV

A 40" x 20" x 43" hand forging of aluminum alloy 7079 having an analysis of .08% silicon, .15% iron, .69% copper, .22% manganese, 3.40% magnesium, .15% chromium, 4.65% zinc, .05% titanium, balance aluminum was heated to and maintained at a temperature of 865° F. for 6 hours and quenched in water. Two sets of long transverse specimens, three specimens per set, were taken from each edge, and the center of the hand forging and the same number of short transverse specimens from each edge and the center of the hand forging. A second group of specimens similar to the above specimens were taken from locations adjacent thereto. All specimens were standard size in accordance with ASTM designation E8–54T. One group of specimens was treated according to the prior art, i.e., pre-aged for 5 days at room temperature (70° F.) and furnace aged for 48 hours at 240° F. The other group was pre-aged for 5 hours at 120° F. in a steam heated thermally controlled tank of water and furnace aged for 48 hours at 240° F. The specimens were all subjected to conventional tensile tests. The ultimate strengths, yield strengths and elongations of the specimens treated according to this invention are compared directly in Table V below with the equivalent specimens in the group treated according to the prior art.

TABLE V

Test Specimen Location	Direction of Test	Ultimate Strength, p.s.i.		Yield Strength, p.s.i.		Elongation in 4D, percent	
		5 Day 70° F. Preage	5 Hr. 120° F. Preage	5 Day 70° F. Preage	5 Hr. 120° F. Preage	5 Day 70° F. Preage	5 Hr. 120° F. Preage
Edge	Long Trans	75,000	75,400	63,000	65,300	10.0	10.0
Center	do	75,900	73,000	63,900	63,400	11.7	12.8
Edge	do	75,800	75,400	63,200	65,300	11.2	10.0
Do	do	76,800	73,700	64,200	62,800	11.7	10.3
Center	do	75,000	73,400	62,500	62,800	11.0	11.8
Edge	do	75,900	74,400	63,800	63,400	11.3	11.0
Edge	Short Trans		76,700		66,300		6.5
Center	do	75,300	74,300	64,500	62,800	5.3	7.6
Edge	do	74,800	77,000	60,100	66,500	6.1	6.4
Do	do	74,300	73,400	60,100	63,900	5.5	5.5
Center	do	73,800	71,800	60,100	61,500	5.7	5.1
Edge	do	73,500	72,900	60,500	62,700	5.5	5.3

As in the case of Example I, it can be seen that in Examples II–IV the specimens treated according to the method of this invention had strength properties substantially equal to the specimens treated according to the prior art practice and yet a substantial saving in time, i.e., reduction in the pretreatment time from five days to five hours is achieved by applying the method of this invention. This is a reduction in time required for the first or pre-aging step of over 95%.

It will be understood that various changes, omissions and additions may be made to the invention without departing from the spirit and scope thereof as set forth in the appended claims.

What is claimed is:

1. In a method of treating an aluminum alloy consisting essentially of not more than 0.30% silicon and 0.40% iron, from 0.40 to 0.8% copper, from 0.10 to 0.30% manganese, from 2.9 to 3.7% magnesium, from 0.10 to 0.25% chromium, from 3.8 to 4.8% zinc, and not more than 0.10% titanium, balance aluminum, wherein said method comprises the steps of solution heat treating and quenching a body of said aluminum alloy, pre-aging said body and finally aging said body by heating to a temperature of from about 225 to 275° F. and maintaining said body at said temperature for a period of not substantially less than 20 hours, the improvement wherein said pre-aging is accomplished by heating said body to a temperature of from about 115 to 140° F. and maintaining said body at said temperature for a period of from about 2 to about 8 hours.

2. In a method of treating an aluminum alloy consisting essentially of not more than 0.30% silicon and 0.40% iron, from 0.40 to 0.8% copper, from 0.10 to 0.30% manganese, from 2.9 to 3.7% magnesium, from 0.10 to 0.25% chromium, from 3.8 to 4.8% zinc, and not more than 0.10% titanium, balance aluminum, wherein said method comprises the steps of solution heat treating and quenching a body of said aluminum alloy, pre-aging said body and finally aging said body by heating to a temperature of from about 235 to 250° F. and maintaining said body at said temperature for a period of from about 35 to 60 hours, the improvement wherein said pre-aging

is accomplished by heating said body to a temperature of from about 115 to 125° F. and maintaining said body at said temperature for a period of from about 4 to 8 hours.

3. In a method of treating an aluminum alloy consisting essentially of not more than 0.30% silicon and 0.40% iron, from 0.40 to 0.8% copper, from 0.10 to 0.30% manganese, from 2.9 to 3.7% magnesium, from 0.10 to 0.25% chromium, from 3.8 to 4.8% zinc, and not more than 0.10% titanium, balance aluminum, wherein said method comprises the steps of heating a body of said aluminum alloy at a temperature of from about 800 to 900° F. and maintaining said body at said temperature for a period of not substantially less than 15 minutes, quenching said body in water, pre-aging said body and finally aging said body by heating to a temperature of from about 235 to 250° F. and maintaining said body at said temperature for a period of from about 35 to 60

hours, the improvement wherein said pre-aging is accomplished by heating said body to a temperature of from about 115 to 125° F. and maintaining said body at said temperature for a period of from about 4 to 8 hours.

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