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Research Paper

HEAT TRANSFER EFFECT ON METAL HARDNESS

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The main purpose of this project is to reduce the hardness of a heat treatable alloy and to find a way to save the hardness in the minimum level. The procedure were not that complecated to reduce the hardness, that the first thing I had to do is to heat the test specimens to 493°C for 90 minutes in an accurate oven, then quench some samples in water at a room temperature, some of them in a boiling water and the rest of the samples were quenched in Oil. After that I measured their hardness by using ROCKWELL Hardness Machine. I found that the minimum hardness was of samples that have been quenched in Oil, but I put the safety factor in consideration, I would not use the oil as a quencher, because oil may reach the ignition point that may cause a fire. In the factories they prefer using water as a quencher rather than oil to be safe. I found during this investigation that the hardness went back to its original after four days of heat treating. When the temperatures increase, the hardness decrease and vice versa. I found that when storing the heat treated samples in a very low temperature refrigerator, the hardness was remaining too low. When I put samples that have been heat treated in refrigerator, and samples that have not been heat treated, I found that the hardness of the samples that have been treated were almost not changing, but the hardness of the samples that have not been heated treated was going up.

Keywords: Heat transfer, Hardness, Aluminum alloys, Rockwell hardness machine

INTRODUCTION

The purpose of this report is to determine the heat transfer on metal hardness. The material we used to run this experiment is Aluminum -2024, which is used in many of applications such as aircraft industry. Aluminum and its alloy are among the most readily formable of the commonly fabricated metals. There is a difference between aluminum alloys and other metals in the amount of permissible deformation, in some aspects of tool design, and in details of procedure. These differences stem primarily from the lower tensile and yield strengths of aluminum alloys, and from their comparatively slow rate of work hardening. The compositions and tempers of aluminum alloys also affect their formability.

Aluminum-2024 is a heat treatable alloy, and treatable alloys are used in applications for which a high strength- to- weight ratio is required. These included alloys 6061, 2014, 7075, 7178, and 2024,

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in approximate order of increasing strength. Material that has been solution heat tread at the mill, but not artificially aged, is generally suitable only for mild forming operations such as bending, mild drawing, or moderate stretch.

The chemical analysis limits for aluminum-2024 is as follower:

1) 0.50 % Silicon
2) 0.50 % Iron
3) 3.8-4.9 % Copper
4) 0.30-0.90 % Manganese
5) 1.2-1.8 % Manganese
6) 0.10 % Chromium
7) 0.25 % Zinc
8) 0.15 % Titanium
9) 0.15 % Others

The main idea of this project is to find a way reduce the hardness of a metals to its minimum level in order to from it and bend it, and also, to find a way to save the hardness of metals for a longer time .

This table shows the hardness of Aluminum 2024 samples after quenching in water at room temperature.

This table shows the hardness of Aluminum 2024 samples after quenching in oil.

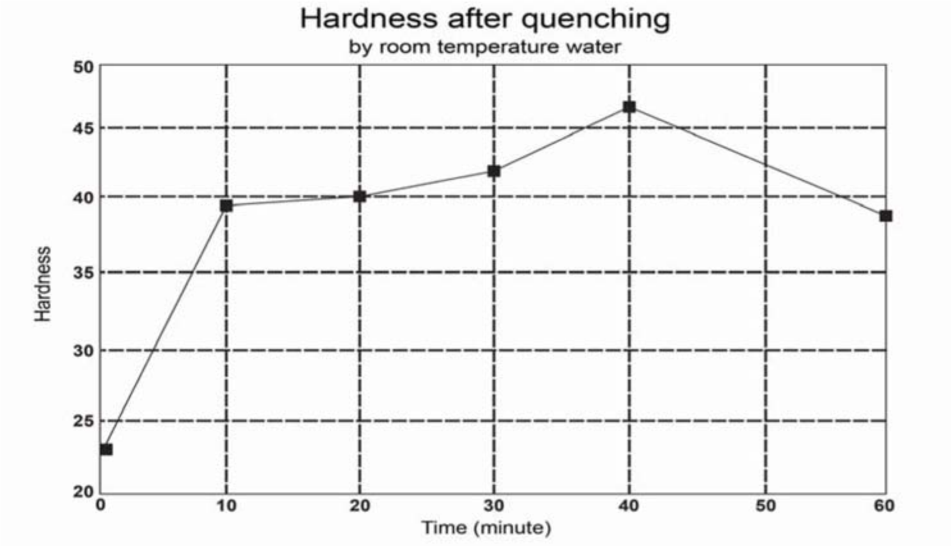
This table shows the hardness of Aluminum 2024 samples after quenching in water at 90 Degrees Centigrade.

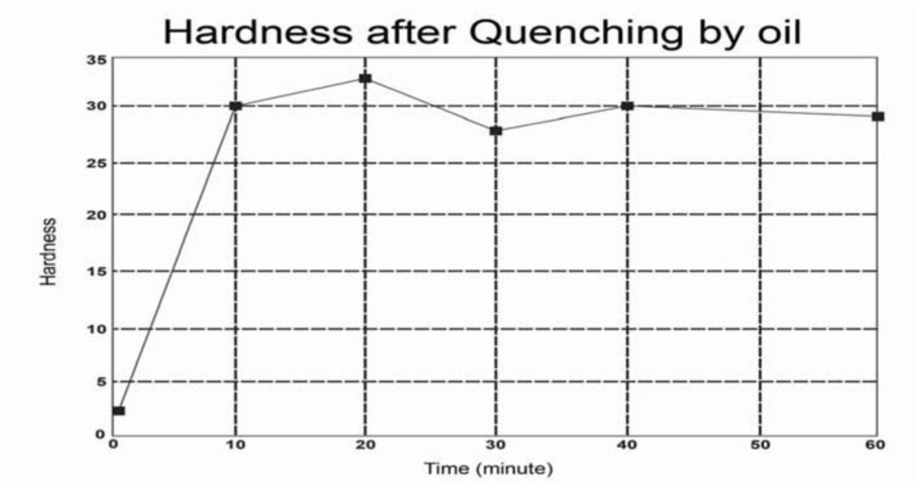
Table A: After Quenching in Water at Room Temperature

ROCKWELL										
Specimen Number	After 0.5 Min	After 10 Min	After 20 Min	After 30 Min	After 40 Min	After 1 Hour	After 1 Days	After 2 Days	After 3 Days	After 4 Days
1	22.9	39.9	39.9	41.5	46.9	38.8	40.5	43.4	45.8	47.8
2	25.6	36.4	37.0	43.6	47.7	40.1	41.8	44.2	46.0	47.8
3	21.6	37.9	40.0	39.2	46.2	40.9	41.2	43.0	45.6	47.8
4	25.1	38.3	36.4	39.2	41.1	39.5	42.0	43.9	45.9	47.8
5	22.2	38.9	39.4	41.0	47.2	39.0	40.9	42.8	45.2	47.8

Table B: After Quenching in Oil

ROCKWELL HARDNESS										
Specimen Number	After 0.5 Min	After 10 Min	After 20 Min	After 30 Min	After 40 Min	After 1 Hour	After 1 Days	After 2 Days	After 3 Days	After 4 Days
1	1.9	29.8	32.9	28.1	30.0	28.9	38.8	45.2	46.1	47.8
2	0.4	27.2	33.5	26.9	31.3	27.9	38.9	44.9	45.9	47.8
3	1.0	26.8	35.4	30.2	32.0	28.5	37.8	44.9	46.7	47.8
4	2.5	32.2	33.0	31.2	29.9	28.3	37.9	45.3	47.0	47.8
5	1.5	30.2	32.7	28.5	30.5	28.7	37.8	46.4	47.0	47.8


Hardness after quenching
by room temperature water
Hardness
Time (minute)
50
45
40
35
30
25
20
0
10
20
30
40
50
60


Hardness after Quenching by oil
Hardness
Time (minute)
35
30
25
20
15
10
5
0
0
10
20
30
40
50
60

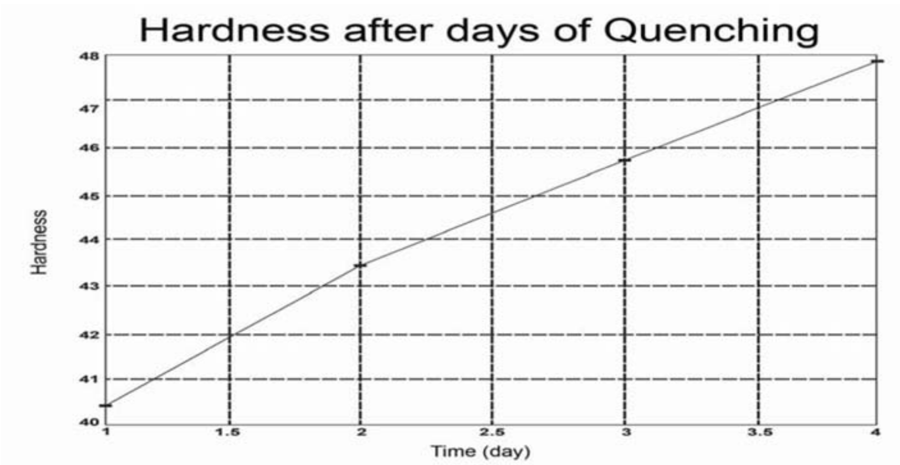
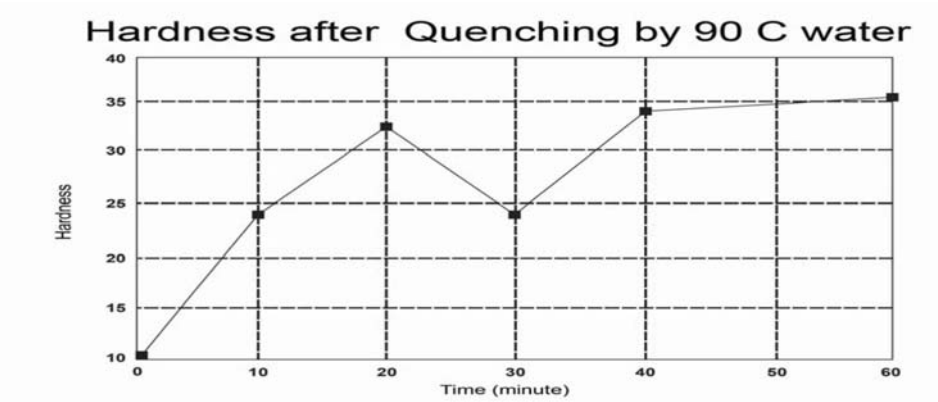
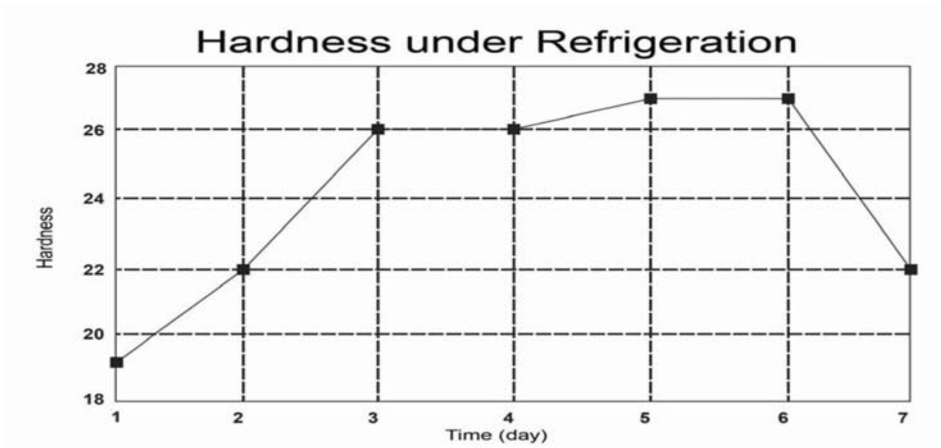

Hardness after days of Quenching
Hardness
Time (day)
48
47
46
45
44
43
42
41
40
1
1.5
2
2.5
3
3.5
4

Table C: After Quenching in Water at 90°C										
ROCKWELL										
Specimen Number	After 0.5 Min	After 10 Min	After 20 Min	After 30 Min	After 40 Min	After 1 Hour	After 1 Days	After 2 Days	After 3 Days	After 4 Days
1	10.0	20.9	33.1	24.0	33.9	35.3	41.8	45.5	46.6	47.8
2	9.0	21.7	24.5	18.0	30.2	32.2	40.3	46.8	47.0	47.8
3	12.3	26.7	31.9	22.9	30.2	33.4	43.8	46.8	47.1	47.8
4	12.9	22.8	31.4	23.7	32.8	35.0	43.0	47.0	47.3	47.8
5	9.8	22.6	27.8	25.5	32.8	35.0	42.1	46.6	47.2	47.8

Table D: Stored in (-10°C) After Heating to 493°C							
ROCKWELL							
Specimen Number	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
1	22	23	24	24	26	26	23
2	19	22	26	26	27	27	22





This table shows the hardness of Aluminum 2024 samples that have been stored in the refrigerator ta – 10 degrees Centigrade immediately after heating them at 493 degrees Centigrade.

Heat treatment is to increase of aluminum alloys is a three process:

1) Solution heat treatment.

2) Quenching.

3) Age hardening

Each of these steps and the use of quench factor analysis are described in the following four factors. Typical solution and precipitin heat treatment for mill products are given in some references.

SOLUTION HEAT TREATMENT

To take advantage of the precipitin hardening reaction, it is necessary first to produce a solid solution. The process by which this is accomplish is called solution heat treating, and its objective is to take into solid solution the maximum practical amounts of the soluble hardening elements in the alloy. The processes consist of soaking the alloy at a temperature sufficiently high and for a time long enough to achieve a nearly homogeneous solid solution.

Nominal commercial solution Heat: Treating temperature is determined by the composition limits of the alloy and an allowance for unintentional temperature variations.

Solution-treating Time

The time nominal heat-treating temperature required to effect a satisfactory degree of solution of the dissolved or precipitated soluble constituents and to achieve good homogeneity of the solid solution is a function of microstructure before heat treatment. This time requirement can vary from less than a minute for thin sheet to as much as 20 h for large sand or plaster-mold casting.

QUENCHING

Quenching is in many ways the most critical step in the sequence of heat-treating operations. The objective of quenching is very preserve the solid solution formed at the solution heat-treating temperature, by rapidly cooling to some lower temperature usually near room temperature from the preceding general discussion, this statement applies not only to retaining solute atoms in solute, but also maintaining a certain minimum number of vacant lattice sites to assist in promoting the low temperature diffusion required for zone formation

FORMING AND STRAIGHTENING AFTER QUENCHING

Immediately after being quenched most aluminum alloys as ductile as they are in the annealed condition. Consequently, it is often advantageous to from or strengthen parts in this temper.

AGE HARDENING

Aging characteristics vary from alloy to alloy with respect to both time to initial change, but aging can effects always are lessened by reduction in aging temperature. With some alloys aging can be suppressed or delayed for several days by holding at a temperature of (-18C) or lower.

CONCLUSION

In alloy Aluminum – 2024, most of the strengthening occurs within a day at room temperature, the mechanical properties are essentially stable after four days. This alloy is widely used in naturally aged tempers.

Since the alloy are softer and more ductile immediately after quenching that after aging, straightening or forming operation may be performed more readily in the freshly quenched condition. Production schedules must permit these operations before appreciable natural aging occurs. As an alternative, the parts may be stored under refrigeration to retard again. The introduction of localized strain hardening and residual stresses in parts by forming after quenching may have an adverse effect on fatigue or on resistance to stress corrosion. In critical application, forming prior to heat treatment is the procedure preferred to avoid these effects. The electrical and Thermal conductivity is of most heat treatable alloys decrease with the progress of natural aging. This is in sharp contrast to the changes that occurs during elevated – temperature aging.

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