CHARACTERIZATION OF T6 HEAT TREATED AL-ALLOY BY ULTRASONIC WAVE TECHNIQUES

[1]Pravin kalal, [2]Neel shah, [3]Denish Panchal, [4]Deepak Pathak, [5]Dhruv Patel
[1]Student, [2]Student, [3]Student, [4]Student, [5]Assistant Proffessor
Department of Mechanical Engineering
Aditya Silver Oak Institute of Technology, Ahmedabad, Gujarat, India

Abstract: In this study, criteria for automotive Al-Mg-Si alloys are investigated in the context of commercial alloys with T6 heat treatment. The artificial aging of 6XXX [Al-Mg-Si] alloy at temperature 150, 180 and 200°C, is investigated through the use of ultrasonic velocity measurement. Development of the Mg_2Si precipitates was understood by carrying out optical microscopy and energy dispersive X-ray [EDX] spectroscopy measurement. The present study is to explore the possibility of using ultrasonic velocity measurements and Micro hardness [HV] for investigating and correlating them for a complete characterization of the precipitation behavior in an aluminum alloy. The present study can be used for monitoring the strengthening process, phase distribution and as a result of the precipitation on aging at various time and temperature.

I. INTRODUCTION

6xxx series has widely used of application in automobile area. We are studying effect of addition for Al/Si/Mg elements obtaining of better mechanical properties.[1] This material is very sensible of precipitation hardening. In the case of solution treatment all the silicon atoms will set up in cluster formation. The gradually increase in the hardness in ageing heat treatment causes the formation of precipitates with higher density. Ultrasonic testing non-destructive testing(NDT) basically determines the property of material and detect the flaw and check the surface irregularities.[2] Ultrasonic velocity would be helping us in finding the porosity of the material higher the value of the ultrasonic velocity, higher would be the porosity of the material. Ultrasonic testing is slightly affected by the changes in microstructure and also by its mechanical properties. T6 heat treatment undergoes solutionizing and artificial ageing for better result in hardness of material.[3] As it can be observed from the graph for the aging time at 150°C the hardness of the alloy is the strongest as compared to the other aging time. Testing of the alloy after heat treatment would help to know the changes in the properties of the alloy and the major property whose change would make an abrupt change in the hardness so the HV5 hardness testing is done on the material so as to better known the changes in the hardness.

II. EXPERIMENTAL PROCEDURES:

The aluminum alloy of the 6xxx series was bought from the market of the desired dimensions as cast so we did not have to melt the alloy and cast it in the desired dimensions. The analysis of the chemical composition of the alloy was obtained from the CRM spectrometer analysis and following are the results:

Table-1[Result of Chemical composition]

Elements	Si	Cu	Mg	Mn	Fe	Zn	Ti	Ni	Al
Wt%	0.36	0.03	0.54	0.036	0.36	0.023	0.020	0.002	98.5

Solution heat treatment was conducted at 420°C for 8 hr. Further the alloy was treated for the ageing purpose at 150°C,180°C and 210°C for 2hr,4hr and 6hr for each following temperature for soaking time processed by water quenching at room temperature. This temperature for the solutionizing and the artificial ageing was decided by observing the TTT and CCT diagrams for the chemical composition of the alloy.

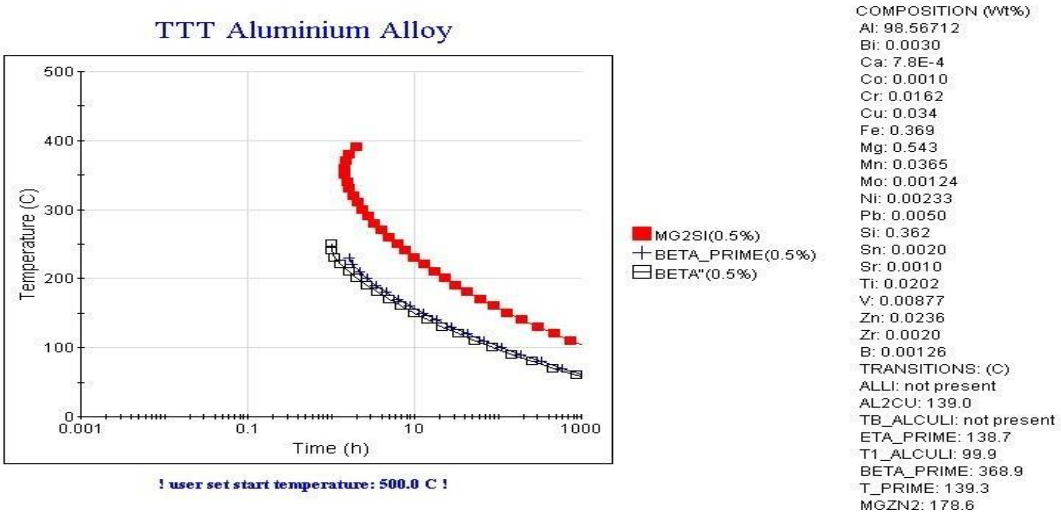

Fig. 1:TTT for Al-Alloy

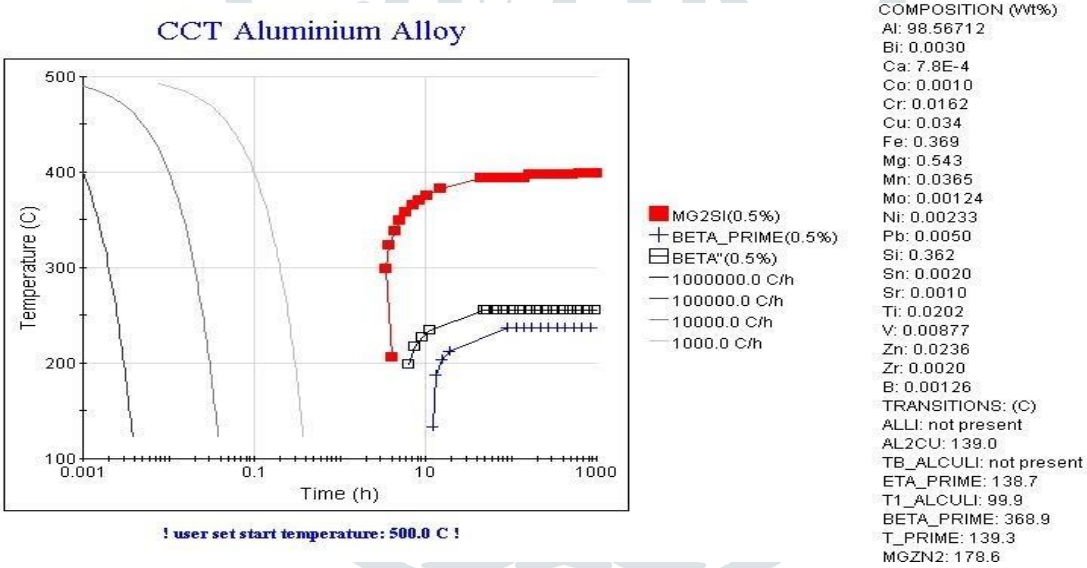

Fig.2: CCT Al-Alloy.

Testing of the alloy after the T6 heat treatment would help us to know the changes in the properties of the alloy and the major property whose change would make an abrupt change in the value of the material is hardness. So, the HV5 hardness testing is done on the material so as to better know the changes in the hardness. This testing is done on the Vickers Hardness Testing device under the load of 5 KN. Ultrasonic velocity of the sample was measured by NDT thickness gauge (38DLPlus). To measure the ultrasonic velocity, the formula used is:

$$V=2h/t$$

Where,

V = ultrasonic velocity
h = thickness of material
t = time travelled by wave

Table: 2[Co-relationship between Hardness and Ultrasonic velocity]

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Serial number	Aging temp. [°C]	Aging time [hr.]	Hardness [HRC]	UT Velocity [m/s]
As Cast	**-**	**-**	79.8	**6310**
Solutionized	**420**	**8**	37.6	**6129**
1	150	2	46	6304
2		4	46.8	6307
3		6	52.8	6313
4	180	2	49	6325
5		4	43.4	6297
6		6	44.2	6303
7	210	2	61.4	6329
8		4	55.7	6310
9		6	58.8	6329

III. Result and Discussion:

- ***Microstructure***

The microstructure gives the better idea about the structure and arrangement of the alloy. The microstructure of the alloy is obtained on Olympus GX-51 metallurgical microscope. The microstructures were obtained under 200X.

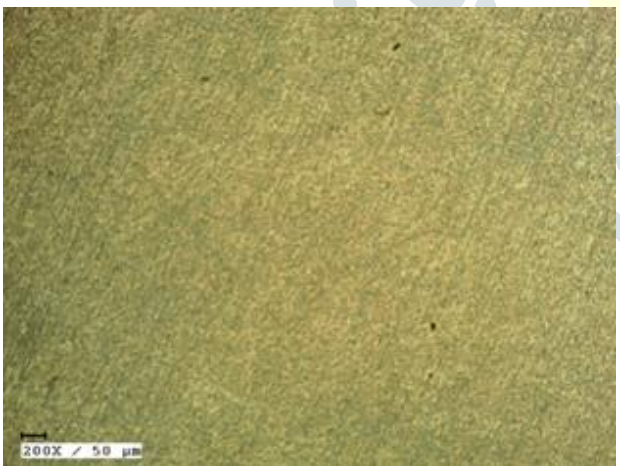

Fig.3: Aging 180°C 4 hrs

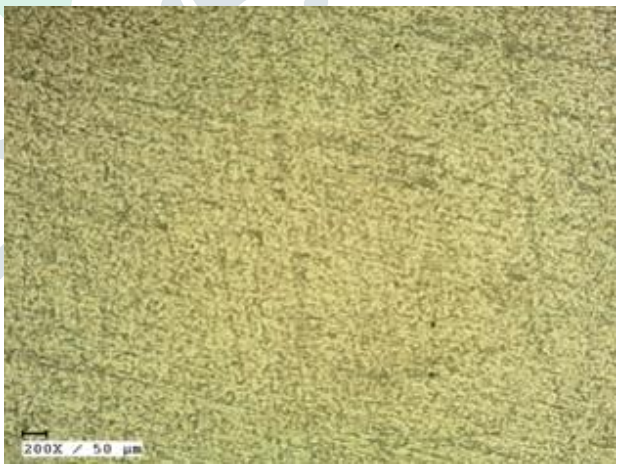

Fig.4: Aging 210°C 4 hrs

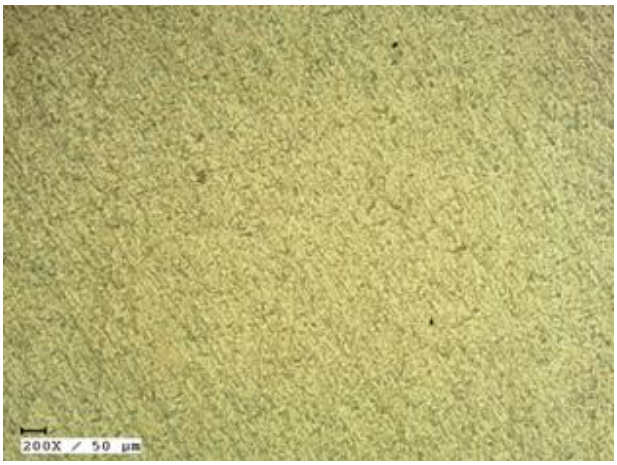

Fig.5: Aging 210°C 2 hrs

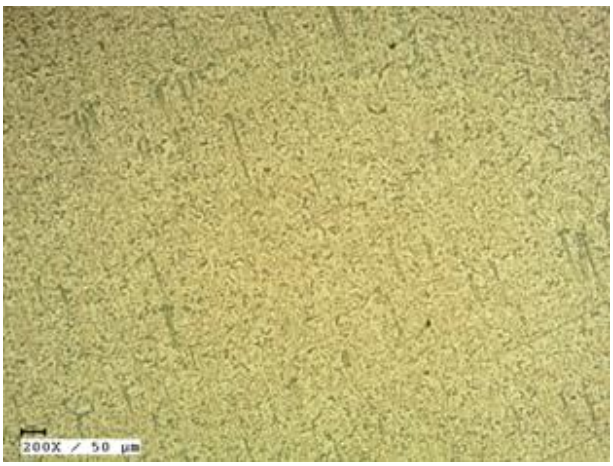

Fig.6: Solutionizing 420°C-8 hrs

For solutionizing microstructure, the alloy reaches recrystallization temperature due to which the chemical composition becomes uniform throughout the alloy. Due to this process, grains in the microstructure of the solutionized alloy are very less. Further during the ageing process, the precipitates of Mg_2Si are formed in the alloy. Due to this there are lots of gains observed the microstructure of the artificially.

- ***Correlation between hardness/ultrasonic velocity and ageing time***

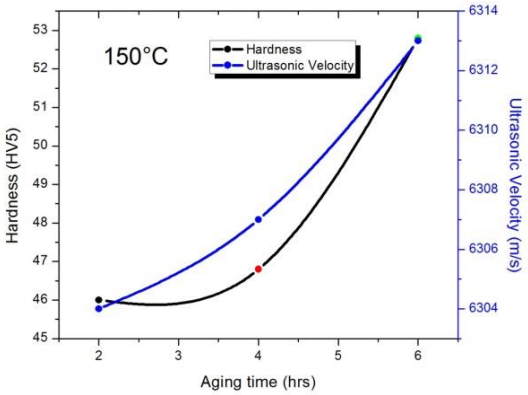

Fig.7: 2Y Plot for AT-Hardness-UT at 150°C

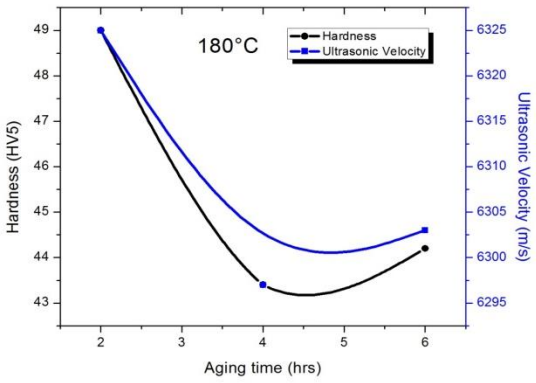

Fig.8: 2Y Plot for AT-Hardness-UT at 180°C

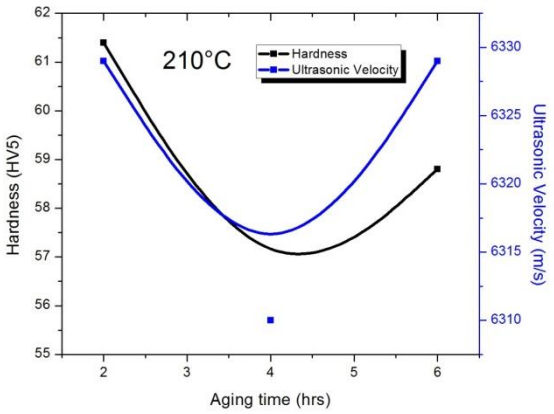

Fig.9: 2Y Plot for AT-Hardness-UT at 210°C

From the above graph as observed for 150°C there is gradually increase in hardness ultrasonic velocity and ageing time respectively. For 180°C as the hardness decreases gradually ultrasonic velocity also decreases with aging time untill 4.5 hours then it gradually increases for aging time more than 5 hours corresponding to ultrasonic velocity and hardness also increases. Further for 210°C the hardness is higher as compare to ultrasonic velocity as gradually ageing time increases hardness and ultrasonic velocity decreases up to 4 hrs then starts to gradually increasing after it gets to more than 4.5 hours, but ultrasonic velocity can be increases drastically as compared to hardness and can be observed in the above graphs.

IV. CONCLUSION:

- So it can be concluded that lower aging time at 150ºC which is more convenient and can greatly increases the hardness as compare to another aging time i.e 180 and 210ºC and can be seen clearly in the graphs given above.
- Ultrasonic velocity is the type of non-destructive testing and can detect the flaw in the material and in its properties, so we are correlating the hardness properties of the alloy material with the ultrasonic velocity of the material. As the ultrasonic velocity testing falls under category of the non-destructive testing so it is better to test the alloy under this test and we can finally get the hardness by the correlation without destructing the material.

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