Microhardness Analysis of as Rolled AZ61 magnesium alloy

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Abstract: Microhardness Analysis of as rolled AZ61 magnesium alloy was studied by isothermal annealing treatments .Samples of (AZ61) were subjected to annealing treatment at different temperatures of 373K, 423K, 473K, 523K, 573K, for the duration of the 2, 10, 30, 60, 120, minutes.Micro hardness analysis of as received, homogenized & rolled samples of the AZ61 Mg alloy has been done with the help of the Knoop hardness tester ,which is used for the indentation and 100 gm force is applied for the time of 13 sec and the hardness values are measured. The hardness values are evaluated for the as received, homogenized, and rolled condition. The comparison is made with the help of the various graphs of the Annealed samples of the AZ61 magnesium alloy.

Keywords: *Annealing treatment, Microhardness, Grain growth kinetics.*

1. Introduction

Grain size has very great influence on the magnesium alloys AZ61 on the basis of the hall-petch effect. If grain size increases due to the annealing process increases, the hardness value of the magnesium alloy decreases, which will also affect the strength of the magnesium alloy. SPD technique is most important technique for the grain refinement of the magnesium alloy.Ductility of UFG material produced by severe plastic deformation technique can further be improved by annealing process. Microstructure of most of the material produced by severe plastic deformation is in the non-equilibrium state and grain growth, occur during subsequent heating. When the specimen is subjected to intense load during the plastic deformation, high strain is used in the material. There is a tendency of formation of defects, dislocation and sub-grains due to high strain developed. Annealing is used for eliminating the above defects moreover the grain size of

the metallic materials hence in this paper the hardness values of the annealed samples were evaluated by exerting the 100 g force for the 13 sec and the analysis for the hardness with the help of various plots is analyzed in the present study.

2. ExperimentalProcedure

AZ61 magnesium alloy sheet was used as the initial material.The nominal composition of this material is given by table 1.

Table.1 Nominal composition of AZ61 alloy used for present study:

Alloy	NOMINAL COMPOSITION							
	Al	Zn	Mn	Si	Cu	Ni	Fe	Mg
AZ61	5.8-7.2	0.4-1.5	0.15	0.10	0.05	0.005	0.005	Balance

For the hardness Analysis of AZ61Mg alloy rolled sheets were divided into squares of 1x1 cm^2. Samples of (AZ61) were subjected to annealing treatment at different temperatures of 373K, 423K, 473K, 523K, 573K, for the duration of the 2, 10, 30, 60, 120, minutes. The annealing process was done in electrical resistance furnace in which the temperature of the furnace was controlled within ± 2^0C. After the annealing process the annealed samples were taken for the process of polishing and etching. The microstructure of the annealed samples were used for the hardness testing. The Knoop hardness tester which is used for testing is shown below.

Fig.1Photograph of micro hardness tester

3. Results and Discussion

3.1 Micro hardness analysis of as received, homogenized & rolled samples of AZ61 magnesium alloy:

Micro hardness analysis of as received, homogenized & rolled samples of the AZ61 Mg alloy has been done. The Knoop hardness tester is used for the indentation. 100 gm force is applied for the time of 13 sec and the hardness values are measured. The average of all readings will give the correct reading for the hardness.

Table.2 The hardness values of As Received AZ61 Mg alloy

	Hardness Values (HV)	Force	Time (sec)
1.	54	100	13
2.	56	100	13
3.	52	100	13
4.	54	100	13
5.	53	100	13
AVG	54	100	13

Table.3 The hardness values of homogenized AZ61 alloy

	Hardness Values (HV)	Force	Time (sec)
1.	68	100	13
2.	68	100	13
3.	65	100	13
4.	64	100	13
5.	68	100	13
AVG	67	100	13

Table.4 The hardness values of as rolled AZ61 Mg alloy

	Hardness Values (HV)	Force	Time (sec)
1.	72	100	13
2.	77	100	13
3.	72	100	13
4.	78	100	13
5.	76	100	13
AVG	75	100	13

It can be observed that the hardness values goes on increasing. Initially the hardness value is very much less in comparison to homogenized & as rolled samples this reduction in hardness value is due to the β phase present in the AZ61 sample. When the homogenization is done, Uniformity is obtained in the structure where in the case of as rolled samples grains are broken after the rolling by which their hardness values increases.

3.2 Micro hardness analysis of as annealed samples of AZ61 magnesium alloy:

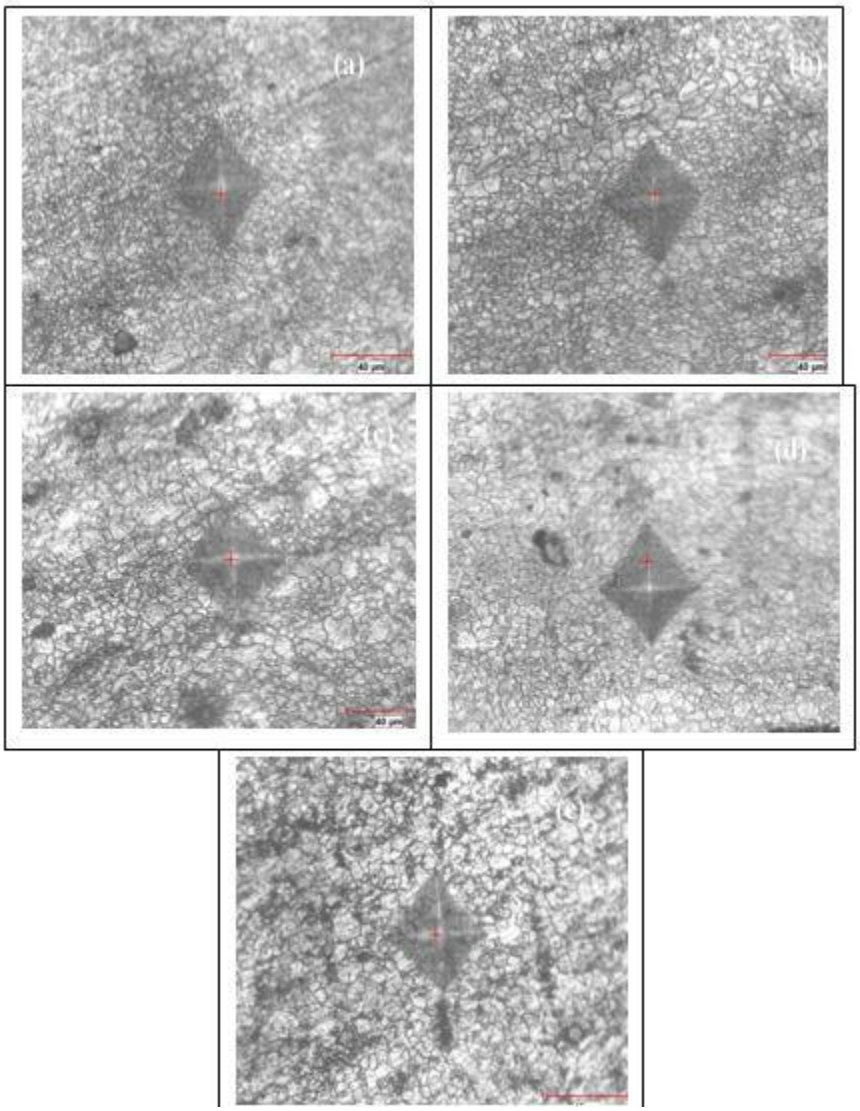

Fig. 2 Micro hardness indentations of annealed samples of rolled AZ61 alloy at 473 K for (a) 2, (b) 10, (c) 30, (d) 60, (e) 120 minutes

Table.5 Comparison of AZ61 Alloy in different processes:

Process used on AZ61 Magnesium alloy	Hardness Value (HV)
As Received	54
Homogenized	67
As -Rolled	75

Table.6 Micro hardness values at different Annealing temperature and time

Annealing Time in (min)	Hardness values at different Annealing Temperatures In (HV)				
	100^0 C	150^0 C	200^0 C	250^0 C	300^0 C
2	68	66	65	63	61
10	65	64	63	61	59
30	63	61	60	58	55
60	60	59	57	56	53
120	58	57	55	53	51

From the above micro hardness table it can be seen that theas the temperature increases the value of the micro hardness decreases (Su et al., 2008). This mechanical property can be understood by the hall petch effect [Dieter, G. E., (1988)].

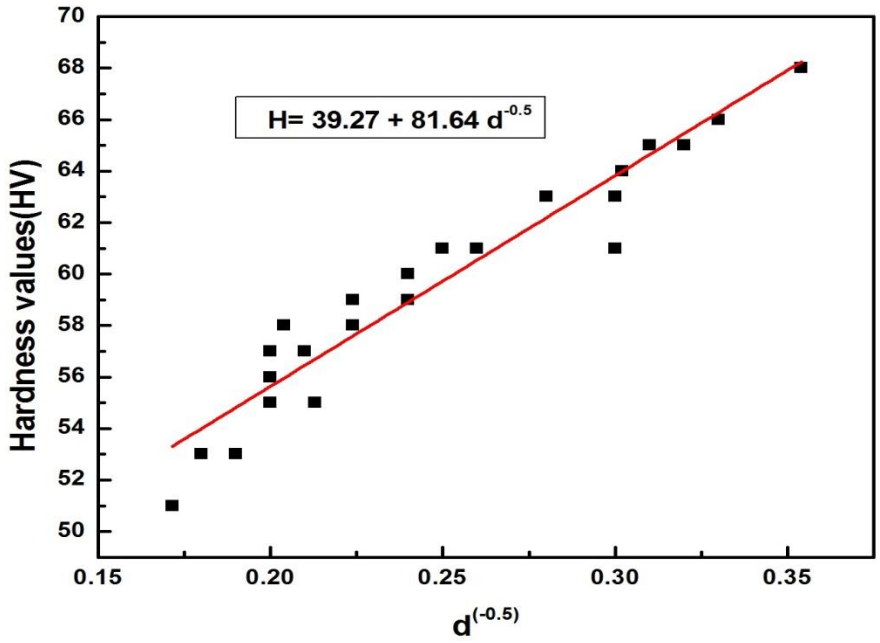

Fig .3 Hardness variation using the hall-petch equation

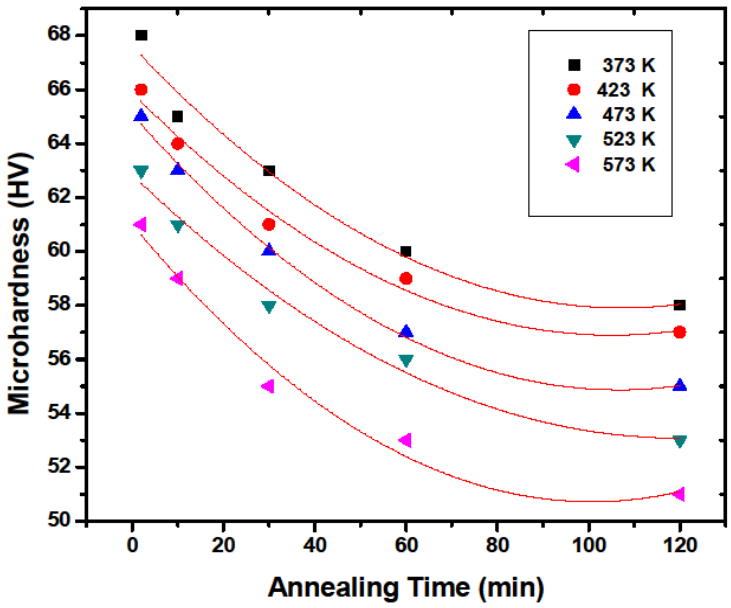

Fig .4 Relation between micro hardness & annealing time of rolled AZ61 alloy

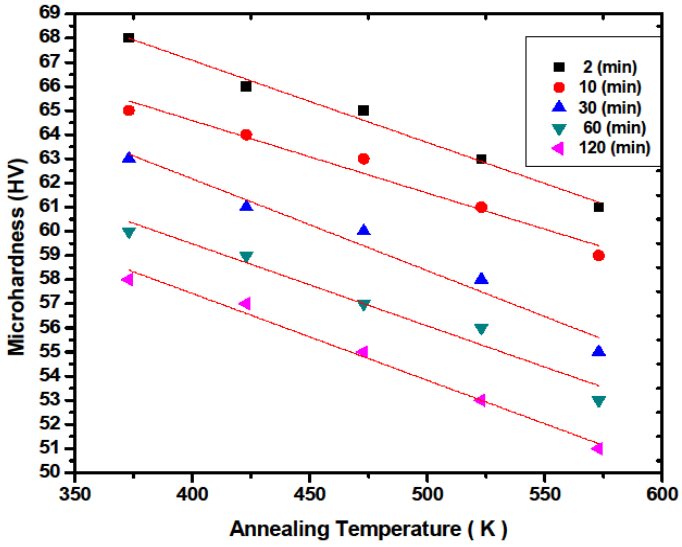

Fig.5 Relation between micro hardness (HV) and annealing temperature (K)

From the above hardness table, we can observe that increase in temperature decreases the hardness of that sample and similarly in isothermal condition, hardness decreases with time. It can be seen that hardness decreases rapidly in the first 60 min of annealing and reaches a steady level after 120 min. Hence temperature and the annealing both have the significant effect on the hardness value.

Conclusions

As the temperature increases the grain refinement is observed. AZ61 magnesium alloy when processed at 523 K and 573 K dynamic recrystallization is the main mechanism for the grain refinement. The value of the microhardness increases as the result of the grain refinement & decreases with the increase of temperature.The size of the ultra-fine grains increased as we increase the annealing duration and the temperature. Annealing temperature has significant role in the grain growth in comparison to annealing time.

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