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ANALYSIS ON THE MECHANICAL PROPERTIES OF ANNEALED AL-5083

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In this investigation the mechanical properties of Aluminum alloy Al 5083 at different annealing temperature 350ºC, 400ºC and 450ºC and saw how it affects different mechanical properties such as hardness, tensile strength, ductility and toughness of Aluminum alloy Al 5083. The objective is to see the effect of these annealing temperatures on the mechanical properties of Aluminum alloy Al 5083. For this, first annealed Al 5083samples at different annealing temperatures and cooled to room temperature and then these samples of Al 5083 were tested for different kinds of mechanical properties like hardness test and tensile test. The test results obtained shows that with annealing there is a decrease in tensile strength, and hardness, but the ductility increases. And also with the results, it was concluded that with an increase in annealing temperature the properties like hardness, toughness and tensile strength decreases but the ductility increases.

1. Introduction

Aluminum Alloy Al-5083 comes in the category of wrought aluminum alloys. Normally, Aluminum alloy 5083 has 2.5% magnesium which is the major alloying element and 0.25% chromium. In general heat treatment basically modifies microstructures and thereby produces a variety of mechanical properties that are important in manufacturing, such as improved formability and machinability. Annealing is considered the most important heat treatment process as it helps to stabilize the microstructure. It helps to achieve the following main objectives:

a. To improve the grains and have a homogeneous structure
b. To relieve internal stresses set up due to cold working.
c. To improve machinability.
d. To effect changes in mechanical properties.

Annealing according to the requirement can be of following types:

1. Full Annealing
2. Process Annealing
3. Spheroids Annealing
4. Diffusion Annealing
5. Isothermal Annealing

Non-Ferrous Materials

The metals which do not have iron in their composition are known to be Non-ferrous metals. Also there melting points are relatively lower than those of ferrous ones. Alloys of these nonferrous metals are nowadays finding their use more as compared to their ferrous counterparts.

2. Past works

Studies on the mechanical properties of Aluminum alloy Al 5083 have been made by various scholars in the past. The majority of these studies were focused on the mechanical properties of Aluminum alloy Al 5083 but very less studied its mechanical properties in the annealed condition. Mhedhbiet. al. [1] performance of the homogenized AA1050 alloy, as well as after the different metallurgical conditions such as cold-rolling and cold-rolling annealed. For this reason, microstructures, microhardness, and tensile tests were studied. From the most important results, the optical micrographs show that with increasing cold-rolling reduction rate, the equiaxed grains are elongated along the rolling direction obviously. Bhowmiket. al. [3] review on development of new technologies in the field of manufacturing, there is a strong need of new and advanced materials to be analyzed and studied so as to get the most of the benefits of new technologies. In lieu of this if we talk about nonferrous materials which have some unique properties as compared to ferrous materials. In nonferrous materials, a very promising material is aluminum alloy Al 5052 which have good corrosion resistance, especially in the marine atmosphere. Shrivas& Kale [4] during his research aluminum alloys increases drastically in automobile and aerospace industries. The aluminum alloy takes the advantage of „strength to weight ratio" and corrosion properties over another structural element such as steel and its alloys. The altered mechanical properties are achieved in aluminum alloy by using different strengthening techniques such as age hardening etc.

Ertug & Kumruoglu [6] studied the corrosive behavior of 5083 and 1100 aluminum alloy in seawater under different conditions. During the investigation, the pit morphology on the polarized aluminum alloys showed hemispherical isolated deeper pits on the 5083 alloy. Samples of the 1100 alloy revealed a higher number of shallow pits (more close to patches of general dissolution). The results showed that the type of intermetallic particles in the aluminum alloy played a major role in passivity breakdown and pit morphology in seawater. Park et al [7] in their investigation of the mechanical behavior of 5000 and 6000 series aluminum alloy under cryogenic conditions. The material characteristics were investigated and summarized as a function of low temperature (110–293 K) and quasi-static strain rate (10^{-4} and 10^{-2} s^{-1}). It was found that with a decrease in temperature the strength and ductility was improved. It was also reported that these materials exhibit more ductility and also absorbs more energy to fracture at low temperatures. It was concluded that for large displacement involved structures 5000 series is more suited and for structures which are subjected to large loads 6000 series is more favorable.

3. Objective

From recent past, Aluminum alloy Al 5083 showed its presence more rapidly and there's an urgent need for enhancement and investigation of its mechanical properties. Attempts have been made by various scholars in this area. The present study is focused on how the mechanical properties such as strength, ductility, toughness, and hardness behave or change when Aluminum alloy Al 5083 is annealed to different temperatures. This not only helps to study the behavior of the material but also makes it more effective in utilization in various sectors.

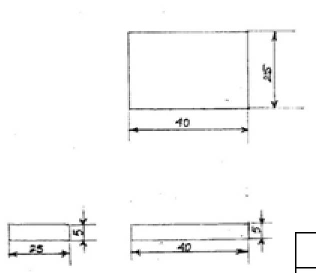
The objective of this investigation is to study the behavior of mechanical properties due to change in the annealing temperature of Aluminum alloy Al 5083. In this context, the following activities are aimed to carry out.

1) Preparation of samples for the respective test according to ASTM Standards.
2) Annealing of samples of Aluminum alloy Al 5083 under controlled conditions to different temperatures.
3) Determination of Mechanical properties viz. strength and hardness of these samples.
4) Analysis and interpretation of the outcome.

4. Methodology

The samples of aluminum alloy Al 5083 were prepared as per the sample drawing as shown in Fig 1 & 2 which were based on ASTM Standards. These were used in the investigation for various properties such as hardness, tensile strength, toughness, and ductility or percentage elongation. The detail descriptions for various samples are discussed in subsequent sections.

All dimension are in mm

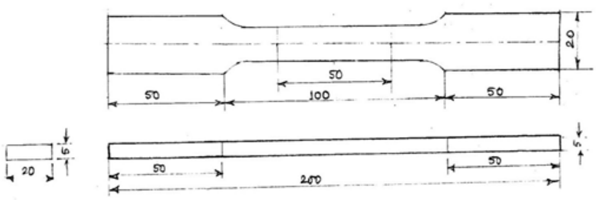


MATERIAL OF CONSTRUCTION	
ALLOY NO.	AL5083
ANNEAL TEMP.	350, 400, 450 C
QUANTITY	04

TEST CONDITION	
ROCKWELL	1.588mm BALL 60KGF
SURFACE FINISH	SMOOTH AND EVEN

Fig. 1 Sample Drawing for Hardness Test for Aluminum alloy Al 5083 as per ASTM Standards

ALL DIMENSION ARE IN MM



TEST CONDITION	
TENSILE TEST	UTM
LOAD	UP TO FAILURE
QUANTITY	04

MATERIAL CONSTRUCTION	
ALLOY NO.	AL5083
ANNEAL TEMP.	350, 400, 450^{0}C
QUANTITY	04

Fig. 2 Sample Drawing for Tensile Test for Aluminum alloy Al 5083 as per ASTM Standards

The sample for Impact Toughness test

The sample for Tensile test

The test samples for tensile strength and percentage elongation were prepared and in total four numbers of samples were obtained. The ASTM standards were used to prepare these samples. The dimensions used are as follows:

Tensile Test Sample

i. Gage length of the sample: 50 mm
ii. The width of the sample: 12.4 mm
iii. The thickness of the sample: 05 mm
iv. overall length of the sample: 200 mm
v. Length of the grip section: 50 mm
vi. The width of the grip section: 20 mm

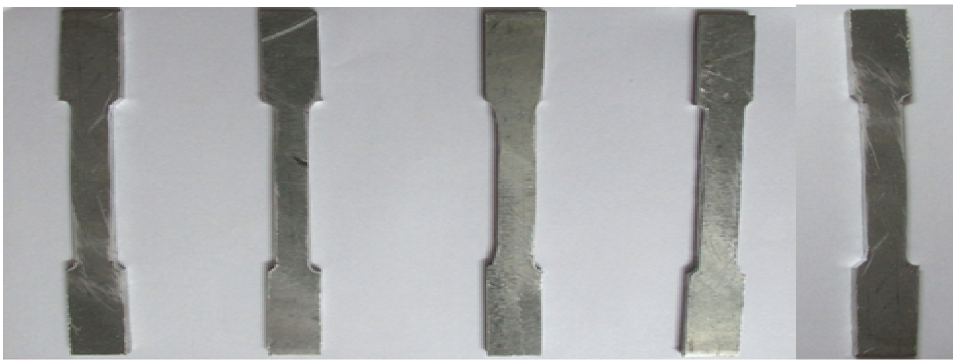


Fig. 3 Tensile Test Samples

The sample for Hardness test

The test samples for hardness test were prepared and in total four numbers of samples were obtained. The ASTM standards were used to prepare these samples. The dimensions used are as follows:

Hardness Test Sample

i. Length of the sample: 40 mm
ii. The width of the sample: 25 mm
iii. The thickness of the sample: 05 mm

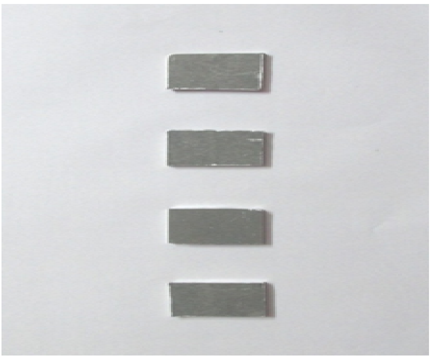


Fig. 4 Hardness Test Samples

Annealing of Aluminum Alloy Al 5083

The test samples for various tests made from aluminum alloy Al 5083 were annealed. In this, the test samples were placed inside the muffle furnace and heated to the set temperatures 350°C, 400°C and 450°C with a holding time of 30 minutes respectively and then air cooled.

Hardness Test

In our investigation for determination of hardness, we used Rockwell hardness testing method. This method is generally used due to this speed and error-free measurement. The hardness of this method is determined by the indentation caused by the static load.

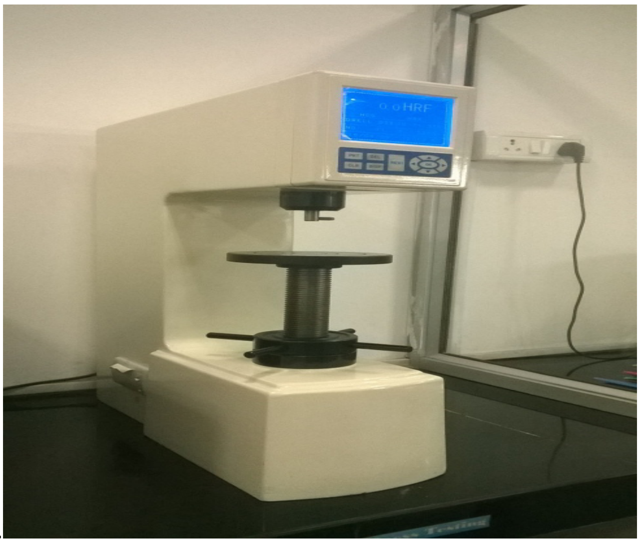


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Fig. 5 Rockwell Hardness Tester

Tensile Test

Formulas used in the calculation of tensile strength and percentage elongation:

i. Tensile Strength = $\frac{\text{Load at Break}}{\text{Original Cross sectional Area}}$

ii. Percentage Elongation = $\frac{\text{Elongationatbreak}}{\text{Original Gage Length}}$

In our present investigation, we tested the samples of Aluminum alloy Al 5083 under different annealing condition for 300°C, 325°C and 350°C and also at the unannealed condition.

The sample specifications are as follows:

i. Gage length of the sample: 50 mm
ii. The width of the sample: 12.4 mm
iii. The thickness of the sample: 05 mm
iv. overall length of the sample: 200 mm
v. Length of the grip section: 50 mm
vi. The width of the grip section: 20 mm

Fig. 6 Tensile Testing Machine

5. Results and Discussions

The aluminum alloy Al 5083 samples were annealed at different temperatures in a muffle furnace and they were subjected to various tests like a tensile test for tensile strength and percentage elongation and the observed values obtained were recorded in Table 2 and Table 3 respectively. The results of different mechanical properties like hardness, tensile strength, percentage elongation, and toughness under different annealing temperatures like 350°C, 400°C and 450°C were observed and recorded in Table 1 to 3. Following points can be asserted from the results received.

i. With annealing and increase in annealing temperature, the tensile strength is varied from 486.87 MPa to 342.86 MPa which is recorded in Table 2 and is highest for unannealed Al 5083 alloy and lowest for Al 5083 annealed at 450°C

ii. With the results of the tensile test for percentage elongation, it indicates that it increases with annealing and varies from 22% to 38% which is reported in Table 3 and is highest when annealed at 350°C and lowest when no annealing is done.

iii. From the results of hardness test conducted in Rockwell with a load of 60 kg and in HRF scale which is recorded in Table 1 shows it varies from 57.63 to 73.26 and is lowest when annealed at 450°C and highest when no annealing is done.

iv. The overall result is that to improve ductility annealing is needed but the annealing temperature should be such that the other properties have optimal value in corresponding to ductility.

Table 1 Rockwell hardness of annealed aluminum alloy Al 5083, at load 60 kg

Sample: Aluminum Alloy Al 5083		
Annealing Condition		Hardness (HRF)
Temperature (°C)	Holding Time (min)	
Unannealed	-	73.26
350°C	30 min	61.83
400°C	30 min	69.73
450°C	30 min	57.63

Table 2 Tensile Strength of annealed aluminum alloy Al 5083

Sample: Aluminum Alloy Al 5083		
Annealing Condition		Tensile Strength (MPa)
Temperature (°C)	Holding Time (min)	
Unannealed	-	486.75
350°C	30 min	397.57
400°C	30 min	362.42
450°C	30 min	342.86

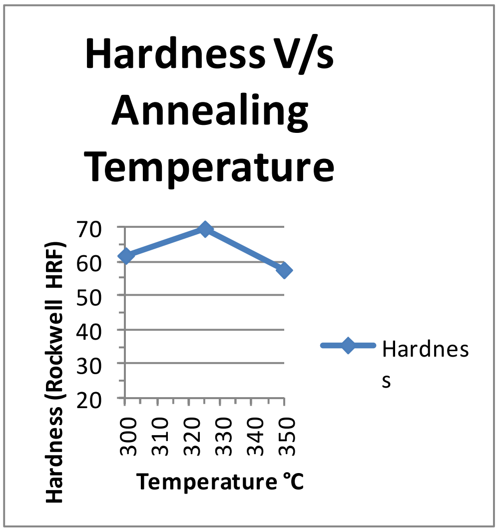

Fig. 7 Hardness Variation with Annealing Temperature

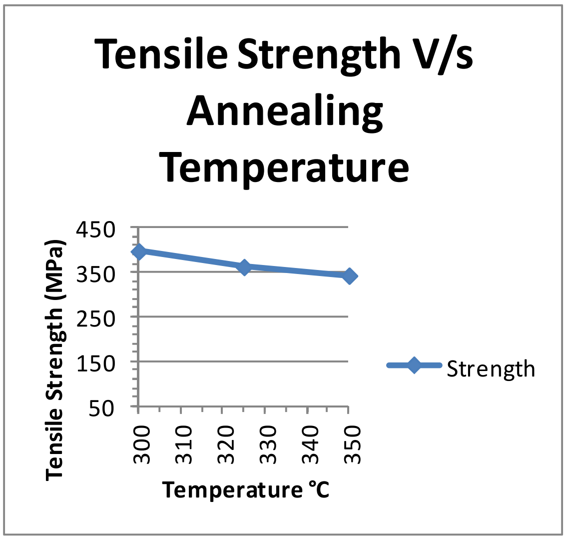

Fig.8 Tensile Strength Variation with Annealing Temperature

Table 3 Percentage Elongation of annealed aluminum alloy Al 5083

Sample: Aluminum Alloy Al 5083		
Annealing Condition		Percentage Elongation (%)
Temperature (°C)	Holding Time (min)	
Unannealed	-	22
350°C	30 min	25
400°C	30 min	30
450°C	30 min	38

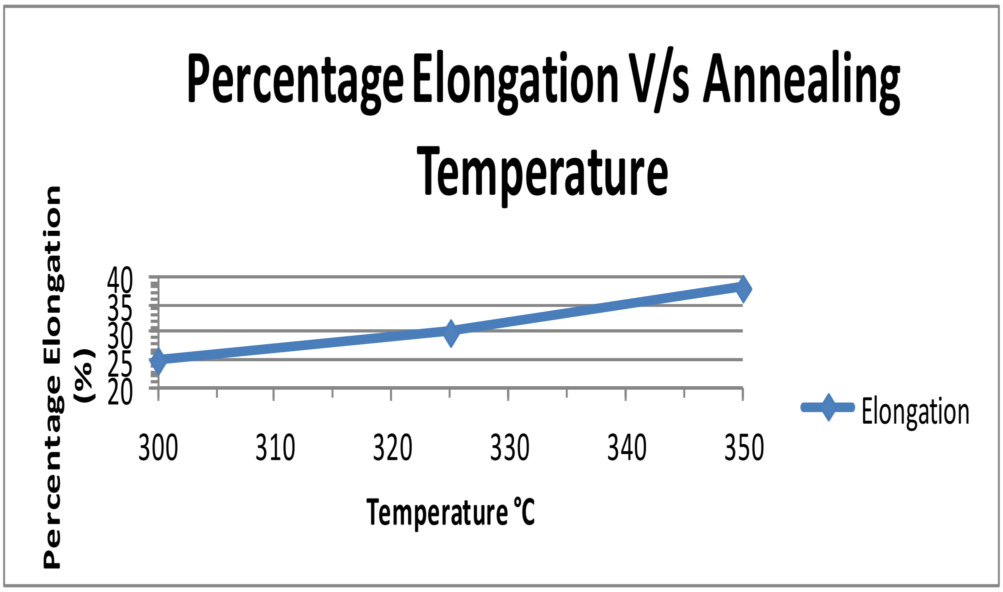

Fig. 9 Percentage Elongation Variation with Annealing Temperature

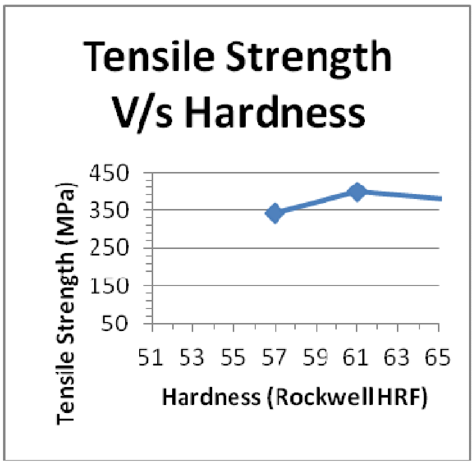

Fig. 10 Tensile Strength Variation with Hardness for the same Annealing Temperatures

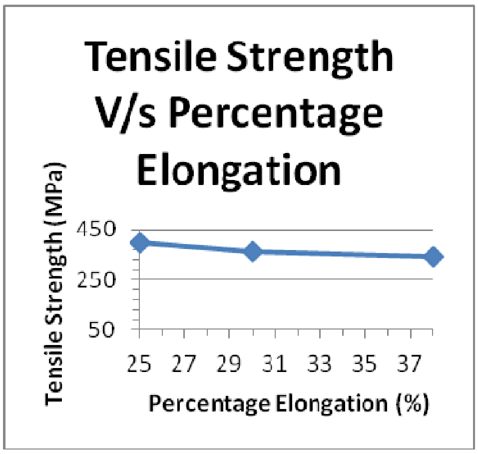

Fig.11 Tensile Strength Variation with Percentage Elongation for same Annealing Temperatures

6. CONCLUSIONS

The following conclusion can be drawn from the present investigation on mechanical properties of annealed aluminum alloy Al 5083.

- There is a strong influence of annealing on the mechanical properties of aluminum alloy 5083.
- The annealing process decreases the tensile strength & hardness.
- The annealing process improves the ductility or percentage elongation. The ductility goes on increasing with the increase of annealing temperature.
- With the increase in annealing temperature, there is a decrease in hardness & tensile strength.
- Aluminum alloy Al 5083 shows an increase in ductility with an increase in annealing temperature which is a strong requirement in metalworking or fabrication but as there is a decrease in other mechanical properties with increase in annealing temperature the choice of selecting the best annealing temperature rest on the design consideration.

The scope of Future Work

With the investigation on the properties of annealed aluminum alloy Al 5083 and also with varying the annealing temperature of 300°C, 325°C, and 350°C. This investigation opens scope for further investigation, some of the suggested work can be:

- The investigation can be made for the wear properties of the aluminum alloy Al 5083 annealed and unannealed condition.
- The present study can be performed by changing the annealing temperatures.
- The present study can be performed by changing the holding time for each annealing temperature.
- The present study can be performed by heating to the desired annealing temperature through incremental heating.
- The present study can be performed by cooling the sample slowly in the furnace.
- Microstructure analysis can be made for the unannealed and annealed aluminum alloy Al 5083.

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