

# Influence of RRA on Fatigue Behavior of Al 7075 Alloy

Dr. Sunil Kumar K<sup>1</sup>, Dr. Adil ahmed<sup>2</sup>, Dr. S Suhael ahemed<sup>3</sup>, Prashanth B<sup>4</sup>

<sup>1</sup>Associate Professor, Department of Mechanical Engineering, RLJIT, Doddaballapur, India

<sup>2</sup>Associate Professor, Department of Mechanical Engineering, KNSIT, Bangalore, India

<sup>3</sup>Assistant Professor, Department of Mechanical Engineering, Govt. Engg College, KR pate, India

<sup>4</sup>Associate Professor, Department of Mechanical Engineering, CIT, Bangalore, India

DOI: 10.47750/pnr.2023.14.03.253

## Abstract

In this exercise, I submitted an AL 7075 alloy to a two-step heat treatment procedure known as RRA to look at fatigue behaviour. This procedure combines annealing, high-temperature pre-precipitation, artificial ageing (T6), retrogression, and re-aging, among other heat treatments. The samples are heated to 473o first, then quenched in water medium. The samples are heated further to 18 hours, 22 hours, and 26 hours, respectively. After this, the specimens are heated to 230°, 250°, 270°, and 290° for various lengths of time—7 & 14 minutes, respectively—to increase the material's strength. This process is known as retrogression and re-aging. Following this trial discovered that the RRA approach allows us to maximise the material's strength.

## I. INTRODUCTION

M As can be seen from their qualities of low thickness, faultless quality, etc., high calibre 7xxx course of action aluminium amalgams are frequently utilised in the field of aeronautics. Beginning late, analyses completed to improve a few characteristics (for example, disintegration) of these amalgams including quality have expanded altogether [1-3]. The development of treatment is the most notable method utilised to raise the quality of Al-Zn-Mg-Cu amalgams. With alternative warmth treatment frames, the quality estimations of 7xxx course of action mixes might essentially be increased [4–9]. Under the fictitious developing (T6) conditions, 7xxx plan amalgams improve in quality, but they become remarkably resistant to stress disintegration. Henceforth, 7xxx course of action mixtures are treated with retrogression to equilibrate both mechanical characteristics and utilisation affectability under ideal conditions.

### 1.1 Material

In the trial contemplates, the AA7075 aluminum compound that is usually utilized in the part of room and aviation inferable from its particular weight, high quality, electrical and warm conductivities was utilized in the test thinks about. Concoction creation of the AA7075 amalgam utilized in the exploratory investigations is given in the Table

Table 1-Chemical Composition

Element	Weight %
Zn	5.690
Mg	2.074
Cu	1.507
Mn	0.069
Cr	0.244
Ti	0.080
Fe	0.222

Si	0.036
Al	Balance

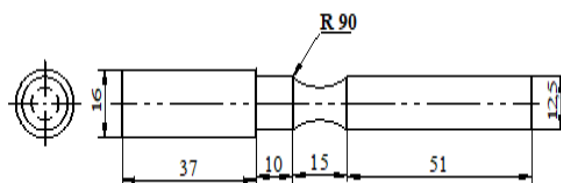
### 1.2 Retrogression and re-aging:

A two stage heat treatment procedure called retrogression and re-maturing is used. First, examples are warmed at 473 degrees for two hours before being put out in water. Examples are then heated to 135 degrees for 18 hours, 22 hours, and 26 hours, respectively. Once more, examples are warmed to 230°, 250°, 270°, 290° for 7 minutes, and 135° for 14 minutes.

This process will increase the material's strength to a more significant level. However, I used t-6 and RRA treated (4730C - 24h-2300C -7min) one retrogression condition for the current investigation.

## II. TEST CONDUCTED

### 2.1 Fatigue Test



Fatigue Test Specimen

Fig -1 Test Specimen



Fig-2 fatigue testing machine



Fig-3 Heating Furnace

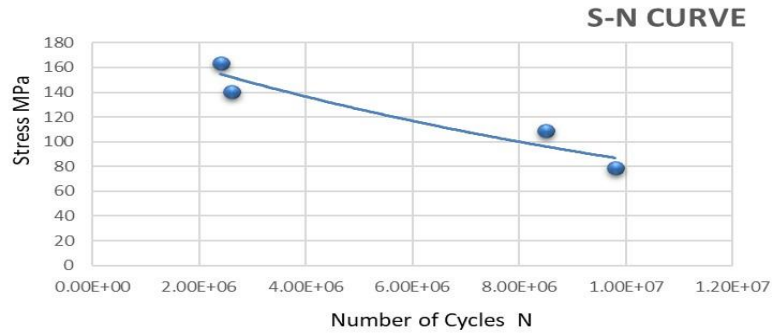
### 2.2 Results and Discussion:

Table-2 S-N values of as-cast alloy

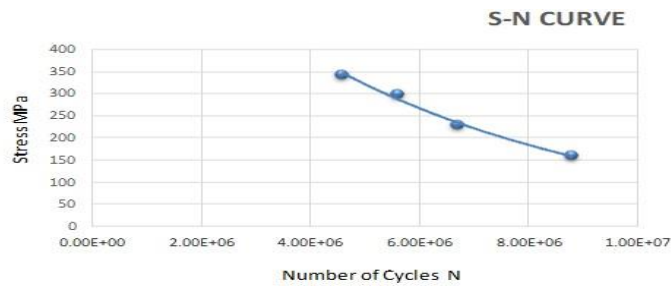
As-cast Condition UTS 220 MPa

%UTS	Stress MPa	No. of cycles for failure
39	80.5	9.8E6
59	113	8.5E6

73	146.5	2.6E6
86	166.5	2.4E6



Graph-1 S-N curve of as-cast alloy



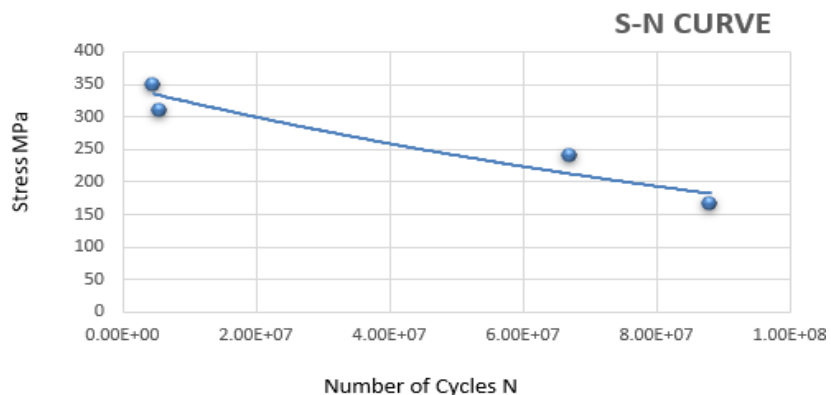
Graph-2 S-N curve of solution treated (18h) alloy

Table-3 S-N values of solution treated (18h) alloy

<b>Solution Heat treated at 473°C-18h UTS 450 MPa</b>		
<b>%UTS</b>	<b>Stress MPa</b>	<b>No. of cycles for failure</b>
38	160.5	8.8E7
56	230	6.7E7
70	298.5	5.6E6
81	343.5	4.6E6

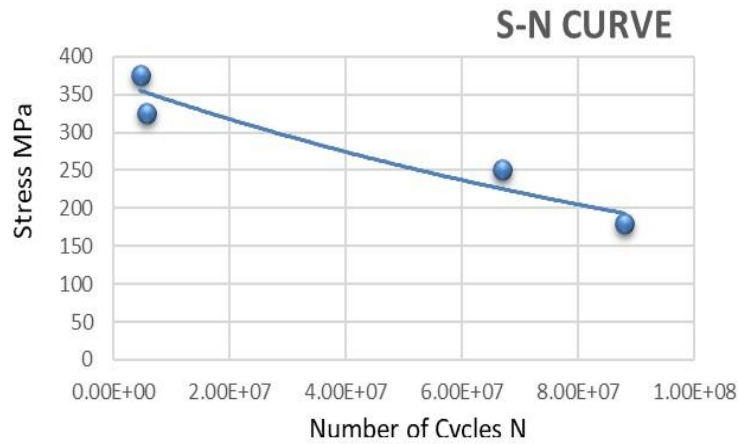
Table-4 S-N values of solution treated (22h) alloy

<b>Solution Heat treated at 473°C-22h</b>		
<b>%UTS</b>	<b>Stress MPa</b>	<b>No. of cycles for failure</b>
39	175.5	8.8E7
59	249	6.7E7
73	311.5	5.6E6
86	354.5	4.6E6



Graph-3 S-N curve of solution treated (22h) alloy

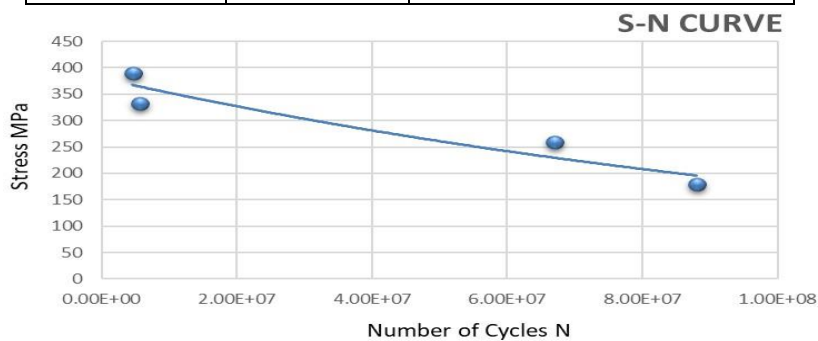
<b>Solution Heat treated at 473°C-26h UTS 500 MPa</b>		
<b>%UTS</b>	<b>Stress MPa</b>	<b>No. of cycles for failure</b>
<b>38</b>	<b>189</b>	<b>8.8E7</b>
<b>58</b>	<b>259</b>	<b>6.7E7</b>
<b>72</b>	<b>375</b>	<b>5.6E6</b>
<b>85</b>	<b>3902</b>	<b>4.6E6</b>



Graph-4 S-N curve of solution treated (26h) alloy

Table-6 S-N values of RRA treated alloy

<b>RRA treated (473<sup>0</sup>C -24h-230<sup>0</sup>C -7min) UTS 506 MPa</b>		
<b>%UTS</b>	<b>Stress MPa</b>	<b>No. of cycles for failure</b>
38	183.1	8.8E7
58	263	6.7E7
72	345.9	5.6E6
85	392.5	4.6E6



Graph-5 S-N curve of RRA treated alloy

#### Discussion of the findings

The age-hardened and RRA-treated alloys have demonstrated strengths of roughly 109 and 119MPa, respectively, whereas the as-cast 7075 alloy demonstrated 100 MPa fatigue strength during  $5 \times 10^6$  cycles and 24 hours. The specimen that underwent a 7-minute retrogression at 2300C after being aged for 24 hours showed the highest fatigue strength. This shows that at lower retrogression temperatures and times, fatigue strength increases with age hardening time. When compared to the as-cast specimen, the increase in fatigue strength is almost twice as great. This can be because the as-cast specimen has casting flaws.

### III. FATIGUE FRACTURE STUDIES

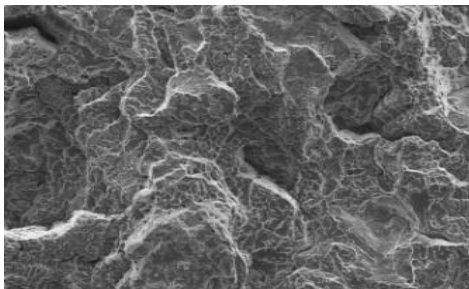


fig .4 fatigue fractured surface of as cast specimen

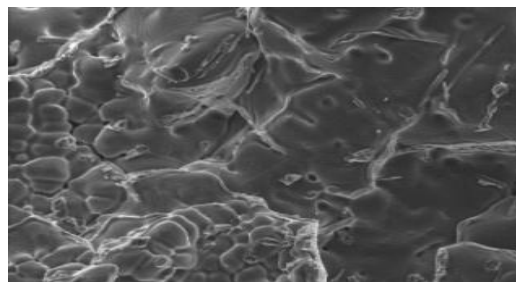


fig .5 fatigue fractured surface of 473oc-18hrs

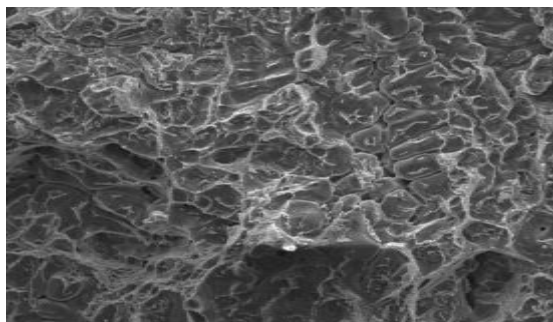


fig .6 fatigue fractured surface of 473oc-22hrs

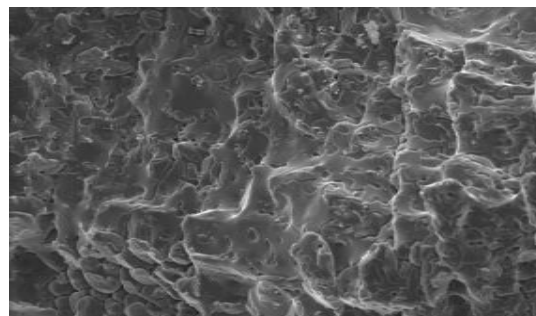


fig .7 fatigue fractured surface of 473oc-26hrs

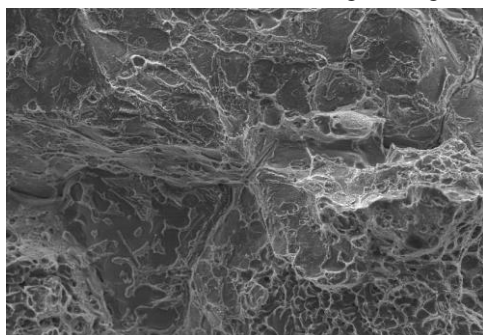


fig 8: fatigue fracture surface of (4650C -24h-2200C – 5min) treated alloy

#### Discussion of the findings

As-cast, Solutionization-treated, and RRA-treated alloys' fatigue fractured surfaces are depicted in PLATEs from. Photos of as-cast alloys have revealed badly broken grains, voids, and coarse silicon particles, which may be the cause of the alloy's shorter fatigue life. Heat treatment extended the fatigue life of heat-treated alloys by precipitation strengthening the alloy. As-cast alloys have a fatigue strength of around 90 MPa at  $5 \times 10^6$  cycles, while alloys that have been RRA-treated at 4730C-26 hours have a fatigue strength of up to 170 MPa. The precipitation strengthening of the alloying element may be the cause of the increased fatigue strength of heat-treated alloys, while casting flaws may be to blame for the decreased strength of unheated specimens.

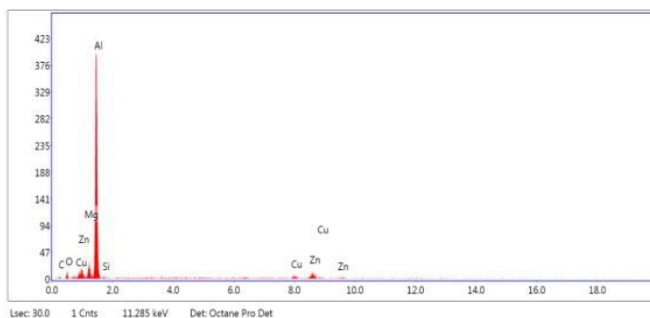


Fig-9 EDS Analysis for as –cast specimen

Table-7 EDS Data collected for as – cast specimen

Element	Weight %	Atomic %
C	13.64	25.69
O	9.9	14.03
MgK	4.8	4.4
Al	62.05	52.03
SiK	0.9	0.7
Cu	2.5	0.9
Zn	6.0	2.1

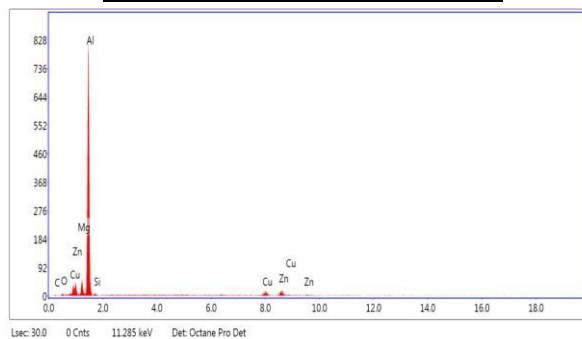


Fig-10 EDS Analysis for as –18hr aged specimen

Table -8 EDS Data collected for 18hr aged specimen

Element	Weight %	Atomic %
C	6.2	13.4
O	3.1	5.1
Mg	4.7	5.0
Al	74.0	70.8
SiK	1.8	1.6
Cu	4.4	1.8
Zn	5.5	2.2

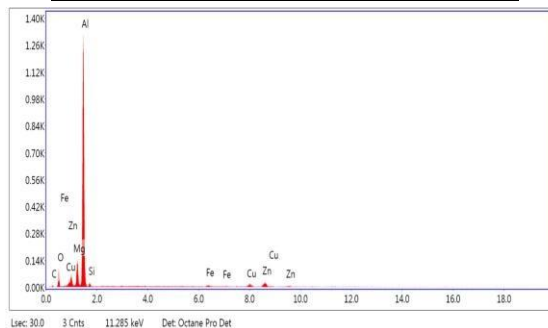


Fig -11 EDS Analysis for 22hr aged specimen

Table-9 EDS Data collected for 22hr aged specimen

Element	Weight %	Atomic %
C K	7.1	13.69
O	17.97	25.70
MgK	6.7	6.3
Al	59.40	50.37
SiK	1.7	1.4
Fe	0.8	0.3

Cu	2.2	0.8
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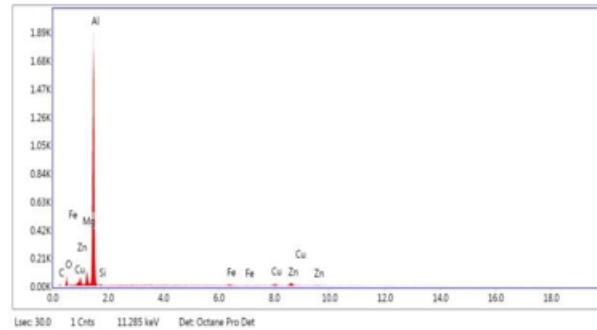


Fig-12 EDS Analysis for 26hr aged specimen

Element	Weight	Atomic
C K	7.0	13.70
O	13.72	20.10
MgK	4.3	4.2
Al	67.72	58.84
SiK	1.0	0.8
Fe	0.9	0.3
CuK	1.8	0.6

Figure 10 EDS Data for a 26-hour-old specimen was collected Likewise, the presence of Fe was observed during the EDS test. The fact that Fe is present supports the development of the Fe particles from the plate to the example surface. Fe particle growth from the plate to the example is attributable to the example's increased hardness.

following RRA handling. It may be observed that with subsequent RRA passes, the growth of the Fe particles from the plate to the example increases. The placement of oxide layer increments and the subsequent RRA passes is also included. In contrast to one pass and two pass testing, the oxidation wear system performs better in four pass tests.

From the circle to the example, the growth of the Fe particles is consistent with earlier conceptions of

Figure 6a–c shows the region of split development in the high K system and highlights the related information. Aside from the absence of some characteristics, the T6 condition exhibits comparative highlights to the low-K system, but their undeniable nature is more obvious due to the high-K. This system also displayed similar highlights to those observed in the low K system for the T6 and RRA circumstances. In Fig. 6b–c, it is possible to see how the direction of the striation arrangement varies from fix to fix. This suggests that the split front is not maintained as a straight line, suggesting that the split development bearing and the break front are altering across the spread. It is remarkable that the dispersion between adjacent striations correlates with the typical break development rate each cycle for cyclic burdens, according to the results described in the article. As a result, Table II's data for the three circumstances' purposeful striation splitting at the broken surface suggests a connection with weakness.

#### IV. CONCLUSION

This study can be used to infer the following conclusions from the experimental studies: It was observed that the sample's fatigue strength varied according to the heat treatment used to finish the fatigue testing. The samples treated with the artificial ageing (T6) technique showed the maximum fatigue strength, while the samples that had been annealed showed the lowest fatigue strength. required. Although a conclusion could summarise the paper's main ideas, avoid using the abstract as the conclusion. The relevance of the work may be further discussed in the conclusion, and applications and extensions may be offered.

#### REFERENCES

1. Giménez, S.; Vleugels, J.; Van der Biest, O. In situ investigation of dewaxing and sintering of stainless-steel powder compacts by impulse excitation. *Scr. Mater.* 2008, 58, 985–988. [CrossRef]
2. Heinz, S.; Eifler, D. Crack initiation mechanisms of Ti6Al4V in the very high cycle fatigue regime. *Int J. Fatigue* 2016, 93, 301–308. [CrossRef]
3. Hansen, N. The effect of grain size and strain on the tensile flow stress of aluminium at room temperature. *Acta Metall.* 1977, 25, 863–869. [CrossRef]
4. Hansen, N. Hall–Petch relation and boundary strengthening. *Scr.*

- Mater. 2004, 51, 801–806. [CrossRef]
5. Kouzeli, M.; Mortensen, A. Size dependent strengthening in particle reinforced aluminium. *Acta Mater.* 2002, 50, 39–51. [CrossRef]
  6. Yonenaga, I.; Motoki, K. Yield strength and dislocation mobility in plastically deformed bulk single-crystal GaN. *J. Appl. Phys.* 2001, 90, 6539–6541. [CrossRef]
  7. Fleischer, R.L. Rapid solution hardening, dislocation mobility, and the flow stress of crystals. *J. Appl. Phys.* 1962, 33, 3504–3508. [CrossRef]
  8. Chai, G.; Zhou, N. Study of crack initiation or damage in very high cycle fatigue using ultrasonic fatigue test and microstructure analysis. *Ultrasonics* 2013, 53, 1406–1411. [CrossRef] [PubMed]
  9. Zuo, J.H.; Wang, Z.G.; Han, E.H. Effect of microstructure on ultra-high cycle fatigue behavior of Ti–6Al–4V. *Mater. Sci. Eng. A* 2008, 473, 147–152. [CrossRef]
  10. Ahn, D.G.; Amanov, A.; Cho, I.S.; Shin, K.S.; Pyoun, Y.S.; Lee, C.S.; Park, I.G. Gigacycle fatigue behavior by ultrasonic nanocrystalline surface modification. *J. Nanosci. Nanotechnol.* 2012, 12, 5902–5906. [CrossRef] [PubMed] © 2018