As per UGC guidelines an electronic bar code is provided to seure your paper

International Journal for Modern Trends in Science and Technology, 8(06):01-05, 2022

ISSN: 2455-3778 online
DOI: https://doi.org/10.46501/IJMTST0806001
Available online at: http://www.ijmtst.com/vol8issue06.html

Check for updates

Fatigue behaviour of Al-Mg-Mn Alloy with minor additions of Scandium And Zirconium

Srinivasa Rao Mallipudi | B. Chandra Sekhar | B. Chandra Mouli | S. Madhu Sudhana Rao | Ch. K. Satya Sai Prasad | D. Srimanth

Department of Mechanical Engineering,Anil Neerukonda Institute of Technology and Sciences (A)
Corresponding Author Email ID: b.css.18.me@anits.edu.in

To Cite this Article
Srinivasa Rao Mallipudi, B. Chandra Sekhar, B. Chandra Mouli, S. Madhu Sudhana Rao, Ch. K. Satya Sai Prasad and D. Srimanth. Fatigue behaviour of Al-Mg-Mn Alloy with minor additions of Scandium And Zirconium. International Journal for Modern Trends in Science and Technology 2022, 8(06), pp. 01-05. https://doi.org/10.46501/IJMTST0806001

Article Info
Received: 22 April 2022; Accepted: 25 May 2022; Published: 27 May 2022.

ABSTRACT

The present project deals with study of fatigue life of Al-Mg-Mn alloy with and without minor additions of Sc and Zr. The investigated aluminium alloy which is cold rolled, tensile testing is done and then fatigue life of the investigated alloy is determined. Failure of the specimen at different stress applied is determined and number of cycles to failure is noted. Fatigue has become progressively more prevalent as technology has developed a greater amount of equipments subject to repeated loading and vibration. In our experiment the Al-Mg-Mn alloy with minor additions of Sc and Zr were produced by stir casting to form plates and treated with cold rolling. The tensile testing of the specimen was done in INSTRON 8801. The results obtained from this test says that yield strength of the Al-Mg-Mn-Sc-Zr alloy was found to be more than the Al-Mg-Mn alloy. The failure of the specimen here occurs at a very large number of cycles. This of the order of 10^5, this number of cycles decreases with an increase in the applied stress. As the load increases the failure of the specimen would occur at a less number of cycles. This alloy used fails at a large number of cycles. So for use of this alloy large number of cycles is required and also a lower yield stress. This aluminum alloy can be used for a large number of uses. Aircraft application, gas pipelines, oil tanks, pistons, etc.

KEYWORDS:fatigue, Al-Mg-Mn alloy, Al-Mg-Mn-Sc-Zr alloy, tensile testing.

1. INTRODUCTION

The development of lightweight metals in the field of engineering and technology is due to the demand for such high strength to weight ratio materials in aerospace, automotive and marine applications. Wrought Aluminum alloys were come under this category to fulfill the requirement for such applications.

In this work, a 5xxx series alloy is chosen for the investigation. This alloy usually contains aluminium (Al), magnesium (Mg), manganese (Mn) as principal alloying constituents and traces of other metals. This alloy attains medium strength and high corrosion resistance among all the non-heat treatable alloys, derives their strength primarily from solid solution strengthening by Mg and Mn. Increase in the Mg content in this series of alloys leads to increase in tensile strength, Mn increases corrosion resistant due to the presence of Al_3Mg_2, Mg_2Si, Al_6(Fe, Mn) intermetallics. These alloys are work-hardenable and can be easily drawn into any shape due to high formability, and exhibits high ductility, good weldability, durability, good finishing characteristics. Thus, these alloys were used in many chemical industries, ship buildings, naval and marine applications. Medium strength is the limitation for these alloys. Al-Mg-Mn alloys are often strengthened by work hardening/stain hardening strengthening, solid solution strengthening, grain refinement strengthening and precipitate strengthening mechanisms. Amongst different strengthening mechanisms for Al-Mg-Mn alloys, Minor-alloying strengthening is an alternative way, which involves the addition of alloying elements such as Ti, Fe, Er, Cr, Mn, Cu, Zn, Ni, Hf, Zr, and Sc as an alloying element. In the present study, Al-Mg-Mn alloy containing the traces of Sc and Zirconium is considered.

Failures occurring under conditions of dynamic loading are called fatigue failures, presumably because it is generally observed that these failures occur only after a considerable period of service. Fatigue has become progressively more prevalent as technology has developed a greater amount of equipment, such as automobiles,aircraft, compressors, pumps, turbines, etc., subject to repeated loading and vibration.

OBJECTIVES

This work aims to address the fatigue behavior of the investigated alloys.

2. RELATED WORK

There are numerous works that have been done related to fatigue behavior of Al-Mg-Mn alloys.

Bin Wang[1]studied that the high-cycle fatigue (HCF) and fatigue crack propagation (FCP) characteristic in relation to the microstructure in the 5083-O aluminum alloy. The HCF strengths of the 5083-O Al alloy in parallel to rolling direction (PD) and vertical to rolling direction (VD) specimens are 164 MPa and 165 MPa, respectively, However, the FCP resistance of the specimens reveals evident anisotropy.

Srinivasa Rao[2]studied the effect of minor additions of scandium and zirconium to Al-Mg-Mn alloys. They observed that Scandium (0.2 – 0.6 wt. %) and zirconium (0.1wt. %) addition introduce an appreciable improvement in the mechanical properties to mechanical properties of Al-Mg-Mn alloys.

Zhang Zhijun[3]The room temperature high-cycle fatigue performance of Al-4.7Mg-0.7Mn-0.4Er-0.1Zr alloy sheet is studied, and the fatigue performance of the alloy is calculated by the lifting method. The strength is 293.6MPa. Scanning electron microscopy was used to observe the morphological characteristics of the fracture surface of the fatigue specimen, and the cause of fatigue cracks and the process of fatigue fracture were analyzed. The results show that after the addition of erbium and zirconium, nano-sized spherical Al3Er particles are formed inside the alloy, and the fatigue strength of the alloy at room temperature is significantly improved.

Zhemchuzhnikova[4]The tensile strength and fatigue properties of alloy 1575 of the Al – Mg – Sc system are studied after hot deformation (at 360°C) and subsequent cold rolling with different reduction ratios. The effect of the deformed structure on the properties and mechanisms of fracture of the alloy under cyclic tests is determined and studied that cold rolling increases the fatigue and tensile strength of the alloy.

.However there has been little to no work put into the viability of minor additions of scandium and zirconium to Al-Mg-Mn alloys to achieve fatigue strength.

3. EXPERIMENTATION

The machining is carried out on water jet machine with a cutting speed of 2 meter/minute and cutting pressure of 250MPa on the 5 mm thick plate which is obtained by cold rolling in multiple passes. The final dimensions of plate before cutting is 150 mm x 150 mm x 5 mm. This has to be converted as ASTM E8 standard specimen with water jet machining as shown if figure 1. Post machining the Specimen is tested for Tensile strength and Fatigue failure.

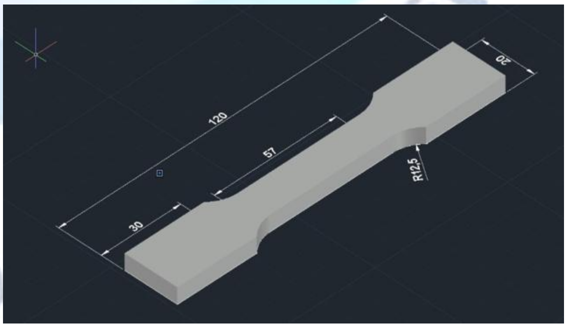


Figure 1 ASTM E8 Standard Specimen

The tensile testing and fatigue failure is tested on THE INSITRON 8801 computerized universal testing machine for which after concluding the tensile test for specimens the yield strength is noted and the fatigue cycle load is applied at 40% of Yeild Strength which is Standard testing method for aluminum 5 series 5083 alloys. The machine and its specifications are shown below.

Figure 2 Universal testing machine

After the calculation of yield stress is done, the specimen then would be treated in INSTRON 8801. In this fatigue life of the material is known. In this machine number of cycles leading to failure of the material is known which gives the fatigue strength. This is a Electro-magnetic resonance machine capable of 50kN dynamic and 100kN static loading. Fitted with a DCPD system with PC based data acquisition. In this test the fatigue life of the specimen was determined for Al-Mg-Mn alloy and Al-Mg-Mn-Sc-Zr alloy.

In this machine the fatigue life of the specimen is calculated. The load applied here is 90% of the yield stress of the material.

Figure 3 Before fatigue test : (a) Al-Mg-Mn alloy and (b) Al-Mg-Mn-Sc-Zr

Figure 4 After fatigue test Al-Mg-Mn alloy

Figure 5 After fatigue test Al-Mg-Mn-Sc-Zr alloy

4. RESULTS AND DISCUSSION

The fabricated aluminum alloys was Al-Mg-Mn and Al-Mg-Mn-Sc-Zr alloys. The tensile testing of this specimen is done in INSTRON 8801. Findings of tensile test are shown in table 1. Findings of fatigue test is shown in table 2. This is done at a stress value of about yield stress (YS). The specimen taken were applied a load of about this high stress value

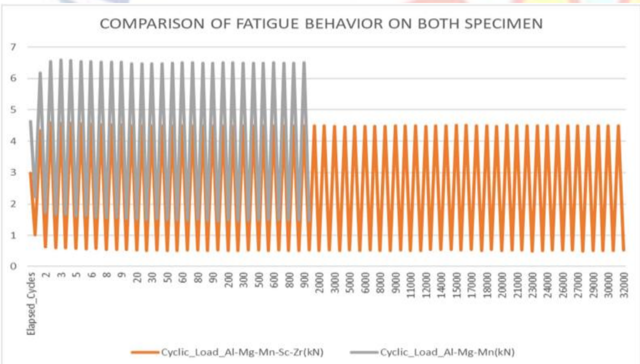
Table 1 Mechanical Properties of the fabricated alloys

Alloytype	**UTS (MPa)**	**YS (MPa)**	**%E**
Al-Mg-Mn alloy	188.8	69.6	8.7
Al-Mg-Mn-Sc-Zr alloy	260.4	208.0	7.4

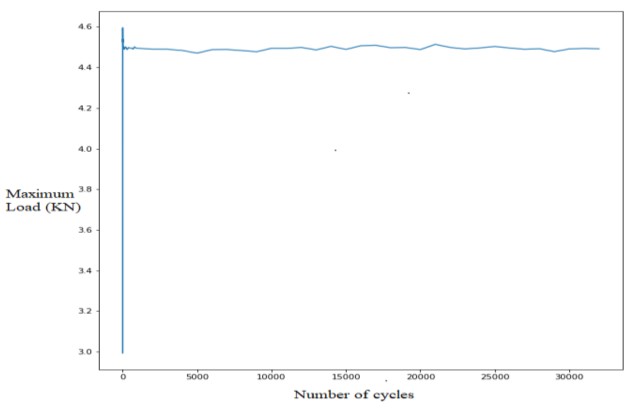
Table 2 Life of the fabricated alloys

Maximum load	**Life (cycles)**	
	Al-Mg-Mn alloy	Al-Mg-Mn-Sc-Zr alloy
40% of YS	1247	32188

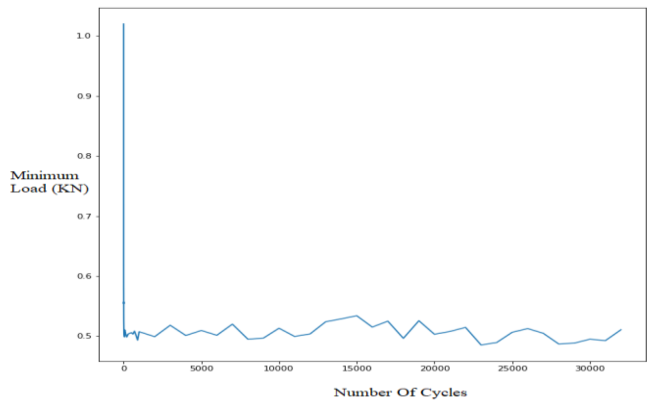
From the adjacent graphs and tables, it is evident that the tensile fatigue load is always fluctuating. In the graph we can observe that alloyed specimen could withstand till 32188 cycles, whereas the base alloy could only will 1247 cycles.



From the below graph it is evident that the tensile fatigue load is always fluctuating. So, it is organized to visualize the variation of maximum load applied in every cycle to the corresponding number of cycles.



The load applied rises from 3 KN to 4.6 KN in the first cycle and then it fluctuates in range of 4.4 KN to 4.6 KN throughout the testing phase. Initially a gradual tensile load of 3 KN is applied over the specimen. This initial load is applied carefully in order to prevent sudden impact.



In this Minimum Load vs Number of Cycles graph, it is observed that the load varies from 0.4 KN to 1.1 KN over the entire process from 0th cycle to 32188th cycle the load fluctuates over a small range with respect to number of cycles. The highest minimum load applied is found to be applied during the initial stage of testing. This is due to the initialization parameters set to the testing machine.

5. CONCLUSIONS

- The addition of scandium and zirconium eventually increased the Fatigue life of the investigated alloy compared to base alloy.
- The alloy with added scandium and zirconium is able to withstand the applied cyclic loads for 10^2order of cycles more than the base alloy.
- This indicates the grain refinement property of scandium worked on the alloy and made the alloy more reliable and withstand fatigue load for longer period of time.
- The added zirconium's fatigue corrosion cracking rate reduction property made an impact on the investigated alloy's Fatigue life by slowing down the possible corrosion cracking due to fatigue loading condition.

6. FUTURE SCOPE

- The tensile properties can be determined for the fabricated alloys at different temperatures.

The fatigue properties can be determined for the fabricated alloys at different temperatures

Conflict of interest statement

Authors declare that they do not have any conflict of interest.

REFERENCES

[1] BinWang (2021) Investigation of high-cycle fatigue and fatigue crack propagation characteristic in 5083-O aluminiumalloyMay 2019International Journal of Fatigue 126(7), DOI:10.1016/j.ijfatigue.2019.05.020

[2] Srinivasa Rao Mallipudi, 2019/1, Effect of Scandium and Zirconium Additions on Mechanical Properties of Al–Mg–Mn Alloy, Transactions of the Indian Institute of Metals, Volume72, Issue1, PublisherSpringer India

[3] Zhang Zhijun Influence of Erbium on Fatigue Behavior of Al-4.7Mg-0.7Mn-0.4Er-0.1Zr Alloy, College of Material Science and Engineering,Beijing University of Technology,Beijing 100124,China.

[4] Daria Zhemchuzhnikova, Effect of Rolling on High-Cycle Fatigue and Fracture of an Al – Mg – Sc Alloy:July 2016, Metal Science and Heat Treatment, DOI:10.1007/s11041-016-9978-7.