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Analysis of Tensile and Fatigue Strength of Annealed Aluminium Alloy for Building Construction Applications

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Abstract—*Aluminium is the second most widely specified metal in buildings after steel, and is used in all construction sectors, from commercial buildings to domestic dwellings. Fatigue has become progressively more prevalent as technology has developed a greater amount of equipment, such as bridges, office building structures, automobiles, aircrafts etc., subject to repeated loading and vibration. In this research work the tensile strength and fatigue life of Aluminium alloy; annealed at two different temperatures as above and below its recrystallisation temperature in the recovery range is calculated. Failure of the specimen at different stresses applied is determined and number of cycles to failure is noted.*

It is found on the basis of obtained results that yield strength of the aluminum alloy was found to be more below recrystallisation temperature then that above recrystallisation temperature. The failure of the specimen here occurs at a very large number of cycles as order of 105. This number of cycles decreases with an increase in the applied stress. There is also no endurance limit is obtained 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 such as bridges, office building structures aircraft application, gas pipelines etc.

Keywords*: Aluminium alloy, heat treatment, annealing, tensile strength, fatigue strength.*

1. INTRODUCTION

Aluminium is a product with unique properties, making it a natural partner for the building industry. Thanks to its strength, durability, corrosion resistance and recyclability, it has become an essential product for the building industry and over the past 50 years its use in building applications has shown continuous and consistent growth.

Aluminium extruded, rolled, and cast products are commonly used for window frames and other glazed structures ranging from shop fronts to large roof superstructures for shopping centers and stadiums; for roofing, siding, and curtain walling, as well as for cast door handles, catches for windows, staircases, heating and air-conditioning systems. Most recently, aluminium has played a significant role in the renovation of historic buildings. The characteristics and properties of aluminium as a material have lead to revolutionary and innovative changes in building techniques and architectural and engineering projects. Aluminium is leading the way into the future of the construction industry having various advantages listed below:

- Aluminium is one of the lightest available commercial metals with a density approximately one third that of steel or copper.
- Aluminium has excellent resistance to corrosion due to the thin layer of aluminium oxide that forms on the surface of aluminium when it is exposed to air
- Whereas steel becomes brittle at low temperatures, aluminium increases in tensile strength and retains excellent toughness.
- Aluminium can be easily fabricated into various forms such as foil, sheets, geometric shapes, rod, tube and wire.
- For many applications, aluminium requires no protective or decorative coating; the surface supplied is entirely adequate without further finishing.

2. FATIGUE FAILURE OF ALUMINUM ALLOYS

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. A fatigue failure is particularly insidious because it occurs without any obvious warning. Fatigue results in a brittle-appearing fracture, with no gross deformation at the fracture. On a macroscopic scale the fracture surface is usually normal to the direction of the principal tensile stress. A fatigue failure can usually be recognized from the appearance of the fracture surface, which shows a smooth region, due to the rubbing action as the crack propagated through the section, and a rough region, where the member has failed in a ductile manner when the cross section was no longer able to carry the load. Frequently the progress of the fracture is indicated by a series of rings, or "beach marks", progressing inward from the point of initiation of the failure.

One can determine that a material failed by fatigue by examining the fracture sight.

Three basic factors are necessary to cause fatigue failure such as Maximum tensile stress of sufficiently high value, Large enough variation or fluctuation in the applied stress and sufficiently large number of cycles of the applied stress. In addition, there are a lot of other variables, such as stress concentration, corrosion, temperature, overload, metallurgical structure, residual stresses, and combined stresses, which tend to alter the conditions for fatigue. Since we have not yet gained a complete understanding of what causes fatigue in metals, it will be necessary to discuss each of these factors from an essentially empirical standpoint.

Aluminum alloys are alloys of aluminum often with copper, zinc, manganese, silicon, or magnesium. They are much lighter and more corrosion resistant than plain carbon steel but not quite as corrosion resistant as pure aluminum. Bare aluminum alloy surfaces will keep their apparent shine in a dry environment, but light amounts of corrosion products rub off easily onto skin when touched. Galvanic corrosion can be rapid when aluminum alloy is placed in proximity to stainless steel in a wet environment. Aluminum alloy and stainless steel parts should not be mixed in water containing systems or outdoor installations. When these alloys are subjected to thermal treatment failure on its surface will be there, which would lead to failure of the material. The fatigue crack growth of metallic materials is widely considered to be affected by both intrinsic and extrinsic contributions to propagation resistance Extrinsic resistance to propagation is identifiable with a variety of micromechanical effects which can reduce the crack tip driving force, with crack closure (and associated compressive load transfer in the crack wake) being identified as a major influence on crack growth resistance in various material/load condition.

3. HEAT TREATMENT OF ALUMINIUM ALLOY

In this research work authors are studying the fatigue behavior of aluminum alloy which occurs when the alloy is subjected to heat treatment. Due to the application of temperature failure of the alloy will occur at a stress much lower than its yield stress. In this process first the specimens will be heated to their recrystallisation temperature and then annealing is done at temperature at and below this temperature. This treatment will thus lead to failure of the material. This failure resulting from heat treatment can be by any of the processes. There are various types of heat treatment processes that can be employed such as normalizing, tempering, annealing, quench tempering and cold working.

Due to cold working hardness tensile strength, electrical resistance increases while a decrease in the ductility is there. Also a large increase in the number of dislocation is there. The cold worked material is at higher internal energy than the undeformed metal. Although it is mechanically stable, but not thermodynamically. With increasing temperature it will become more unstable. Hence annealing is done by which the distorted cold worked lattice structure is changed back to one which is strain free by application of heat In this process heating to and holding of the specimen at a temperature and then cooling at a suitable rate is done which thus decreases the hardness, improves machinability, and other properties producing a desired microstructure. This annealing treatment can be divided into three processes as Recovery, Recrystallisation and Grain growth. During this process various structural and physical property changes occur in the specimen. The various changes occurring in aluminum alloys during this annealing for subsequent processes are given below

4. EXPERIMENTAL PROCEDURE

A specimen sheet was taken of the size 1 feet X 170 mm. It was cut into the size so as to make 5 tensile specimens and 5 fatigue specimen of size. For tensile specimen has the size of 100mm × 10mm×6mm having gauge length of 25 mm. While Fatigue specimen was made of the size 170mm×52mm×6mm and having notch size of 13 mm. The specimens were properly finished by the milling machine and smoothening by the belt grinder. These specimens were then annealed in the furnace at a temperature below recrystallisation temperature of 150^0C and the other above recrystallisation temperature at 200^0C. To determine the tensile strength of specimens test was performed and from this obtained data the fatigue test was conducted. After the calculation of yield stress is done, the specimens then would be treated in INSTRON 8502 for obtain fatigue life of the material. In this machine number of cycles leading to failure of the material is known which gives the fatigue strength. In this test the fatigue life of the specimens was determined at two different temperatures one above the recrystallisation range other below this temperature in recovery range.

5. RESULT AND DISCUSSION

The results of tensile test and fatigue test are listed in table 1 and 2 respectively. The fatigue test is performed at a stress value of about 90% of the yield stress. The specimen taken were applied a load of about this high stress value. As seen in table the difference between numbers of cycles to failure of the specimen is less at an applied stress of 70% of the yield stress. This difference in the number of cycles is near about same for 70% Y.S and 80% Y.S. But this difference increases for 90% Y.S. The failure of the specimen here occurs at a very large number of cycles.

Table 1: Results of Tensile Test

Specimen Temperature	Above Recrystallisation Temp. (2000C)	Below Recrystallisation Temp. (1500C)
Young's Modulus (MPa)	5446	1238
Stress At 0.2 % Yield (MPa)	1.187	8.998
Stress At Break (MPa)	60.500	42.550
Energy To Yield Point (J)	0.612	4.840
Energy To Break Point (J)	51.670	53.320

Table 2: Results of Fatigue Test

MAXIMUM LOAD	FATIGUE LIFE	
	Above Recrystallisation Temp. (2000C)	Below Recrystallisation Temp. (1500C)
70 % of Yield Strength	5.67 × 106	5.32×106
80 % of Yield Strength	6.98×105	7.4×105
90 % of Yield Strength	8.45×104	9.98×104

6. CONCLUSION

It is found on the basis of obtained results that yield strength of the aluminum alloy was found to be more below recrystallisation temperature then that above recrystallisation temperature. The failure of the specimen here occurs at a very large number of cycles as order of 105. This number of cycles decreases with an increase in the applied stress. There is also no endurance limit is obtained 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 such as bridges, office building structures aircraft application, gas pipelines etc.

REFRENCES

[1] Xiaodan Wei, Xiangrong He, "The Application of Steel Structure in Civil Engineering", International Conference on Education, Management and Computing Technology (ICEMCT 2014)

[2] www.aluminium.org, "factsheet aluminium in building and construction".

[3] Minakshi Vaghani, " Stainless Steel As A Structural Material: State Of Review", Int. Journal of Engineering Research and Applications, ISSN : 2248-9622, Vol. 4, Issue 3(Version 1), March 2014, pp.657-662.

[4] L. Gardner, A. Insausti, K.T.Ng, M.Ashraf, "Elevated temperature material properties of stainless steel alloys", Journal of Constructional Steel Research 66 (2010) 634-647.

[5] L. Gardner, M. Theofanous, "Discrete and continuous treatment of local buckling in stainless steel elements", Journal of Constructional Steel Research 64 (2008) 1207-1216.

[6] Mahmud Ashraf, Leroy Gardner, David Nethercot, "Finite element modelling of structural stainless steel cross-sections", Thin-walled Structures 44(2006)1048-1062.

[7] S.M. Zahurul Islama, Ben Young, "Strengthening of ferritic stainless steel tubular structural members using FRP subjected to Two-Flange-Loading", Thin-Walled Structures 62 (2013) 179–190.

[8] Standard Test Methods for Tension Testing of Metallic Materials.