70(10A): 318-323; 2022. DOI: 10.18311/jmmf/2022/32774

Print ISSN : 0022-2755
Journal of Mines, Metals and Fuels
Contents available at: www.informaticsjournals.com/index.php/jmmf

Design and Analysis of Wing Root Fitting of a Medium Fighter Aircraft Made of B4C Reinforced Al7075 Alloy

Rakesh C M[a*] and Pavan D[b]

[a]*School of Mechanical Engineering, REVA University, Bangalore 560064,Karnataka, India. *Email: rakeshcm1998@gmail.com*
[b]*Assistant Professor, School of Mechanical Engineering, REVA University, Bangalore*

Abstract

In the present work, an attempt has been made to synthesize metal matrix composite using Al7075 as matrix material with B4C particles as reinforcement using liquid metallurgy technique in particular stir casting process. Microstructural characterization was carried out for the above prepared composites by taking specimens from central portion of the casting by microstructural studies and SEM analysis. Tensile, shear, compression and bending properties of the prepared composite were studied before and after addition of Al7075 particulates to note the extent of improvement. Microstructural characterization of the composites has revealed fairly uniform distribution of B4C particulates and some amount of grain refinement in the specimens.

The design and analysis of wing root fitting of on medium fighter aircraft carried out using CATIA V5 and ANSYS workbench software. Finite element method is used for the stress analysis. Calculation of equivalent stress, shear stress and total deformation will be considered under this study.

Keywords: *A17075, SEM, B4C, CATIA V5, ANSYS workbench software, reinforced, wing root fitting, aircraft etc.*

1.0 Introduction

An aircraft is a machine that is able to fly by gaining the support from the air. It is used to transport the passengers from one place to the other. Since from the mythology many attempted to fly a machine in the sky and many were unsuccessful in flying their machines, and have lost the lives during the experiment. But eventually in 1910 Wright Brothers were able to build a machine which was able to fly for 59 seconds that is a short duration of time; it was a first milestone for development of the aviation. Later many researches were made for transporting the goods and passengers. Then it was brought to business for the purpose of transportation. And also used in military for air support, hence forth many fighter planes are developed. Although the airplanes are designed for different purposes, most of the components will be similar. Most of the airplane structures include fuselage, wings, empennage, landing gears and power plant and the control surfaces.

Wing is connected to fuselage through lug attachment so wing load transferred through lug joint hence lug joint high stress and bending moment. Failure of lug attachment may separates wing-fuselage so it is required to establish design criteria and analysis methods to ensure the damage tolerance of aircraft attachment lugs.

Materials that are created by two or more materials combined such that the added materials are having different

*Corresponding Author

properties and also they are insoluble with one another. These materials which are having properties are clubbed to form a unique property which is superior than the individual property [1] and this type of materials are known as composite materials. Constituents continue to have their identity, also performs in such a manner that a new result in properties are going to better than sum of their constituents.

The application of modern higher properties materials in the aerospace sector and automobile companies have progressed to the gradual improvement of MMCs. In a MMCs consists of meta or alloy as a matrix material and reinforcements such as ceramics. Composites are heterogeneous at microscopic level and homogenous at macroscopic level. The key is the evaluation of macroscopic property of a material wherein the parts made by these composites can be recognized through naked eyes. Various types of materials are combined at a macroscopic level like alloy of metals and corresponding material is for all practical applications macroscopically homogeneous, that is the parts cannot be differentiated through the naked eyes and a definitely act together. By combining more than two materials to make a composite are more work than using traditional monolithic steel and aluminium materials. Basically these metals and their alloys they always don't meet the requirements of today's advanced technologies. Required performance is met only when we for various combinations of materials. At present, advanced materials have boosted its acceptance in the aircraft industries.

The concept of materials has increased drastically from less than 4.5% in the late eighties to greater than 55% at the beginning at this decade [1]. The materials provide high strength for the weight ratio, corrosion resistance, high fatigue resistance etc. These advantages are transformed the aviation world traveling to better fuel consumption, reliable and more passengers. However, by making use of composites set a new requirement. Actual structures are going to be examined before tested from small scale to the actual scale in a controlled atmosphere either at lab or test cell. However, the attributes occurred during the operation sometimes showing different behavior when the actual work is conducted due to environment factors, human factors and support availability.

2.0 Methodology

2.1 Designing and Modeling of Wing Root Fitting

Wing Root Fittings are connector type components widely used basically as a support structure which connects the aircraft wing with fuselage. Failure of this wing root fitting may end up in catastrophic failure of the whole aircraft. Finite element study and experimental analysis helps designer for safeguarding the aircraft from failure. The selection of materials for this application is important. Here basically industries go with AL-7075 alloy and an attempt is made by applying hybrid composite for increasing its load carrying capacity and also reducing its weight. In aerospace domain always preference is given to strength to weight ratio that is having more strength with considerably low weight. It is why we use composites in most of the aerospace applications offering better strength by reducing weight.

2.2 Geometric Modeling of Wing Root Fitting

The Figure 1 below shows the 2-dimensional view of wing root fitting attachment used for this particular application, the dimensions are in mm and we can see all the views clearly from the figure.

From the above draft copy we can see different views of wing root fitting with all dimensions than this same model is converted into a three dimensional model using CATIA software and the converted model looks as indicated in Fig.2.

2.3 Meshing of Wing Root Fitting

As we all know that meshing is most important process in any of computer simulation. Meshing is the method creating mesh of grid points known as nodes. Here in this work we are gone with mesh size of 15 as we go with finer mesh it is taking more time to calculate the analysis solutions. The meshed model of wing root fitting shown in Fig.3.

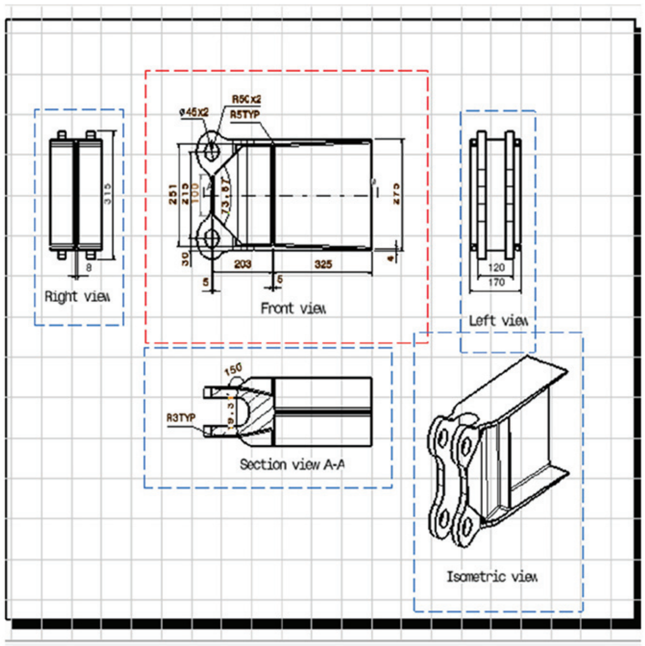

Figure 1: Two-Dimensional view of wing root fitting

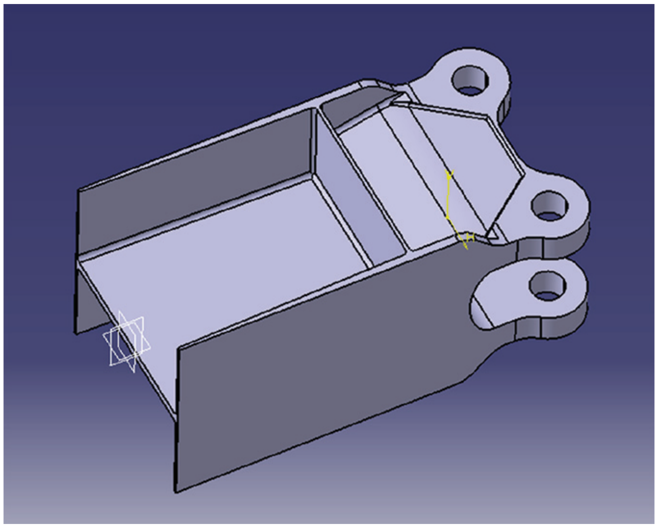

Figure 2: Three-dimensional model of wing root fitting

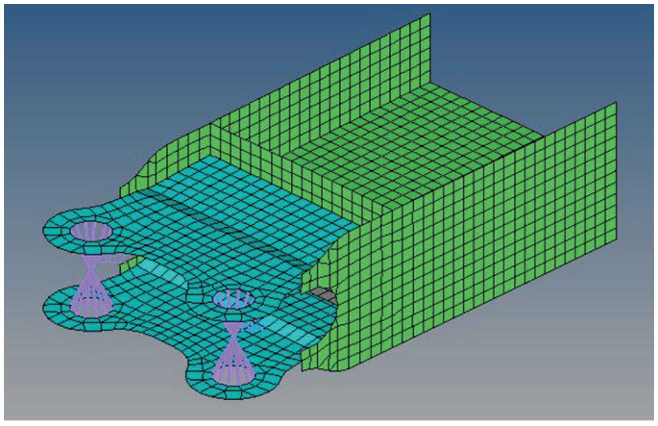

Figure 3: FEA model of wing root fitting

3.0 Results and Discussion

Various tests are performed to check effect of adding the B_4C into the matrix alloy of aluminium-7075. The results are showing an increase in magnitude values for reinforced material composite when compared to unreinforced material. Here the hard ceramic particle resists the applied load there by increasing its strength.

3.1 Evaluation of Mechanical Properties of Composite

3.1.1 Tensile strength of composites

As seen in Fig.4 that as we reinforce the boron carbide particulates increase in ultimate tensile strength as indicated in the graphs. This is due to presence of strong interfacial bonds along the interface. This interfacial bond strength is increased by adding the reinforcements with potassium titanium fluoride, also upon adding the B_4C it acts as resistance for moment of dislocations here there is an increase in strength.

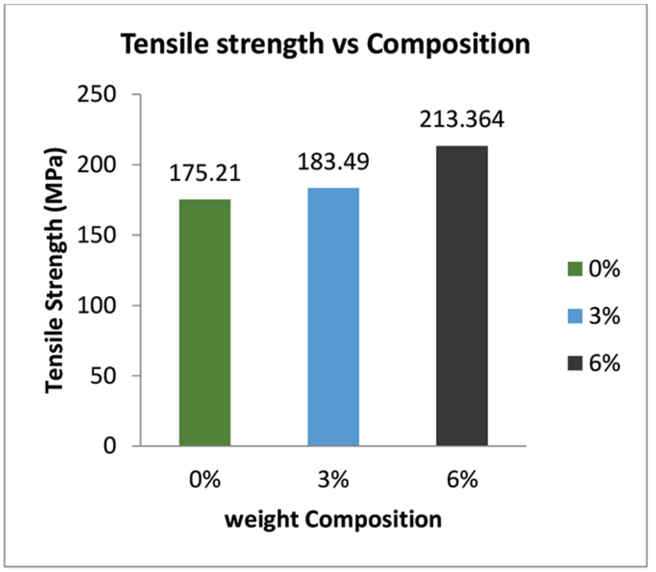

Figure 4: Ultimate tensile strength of composites

3.1.2 Compression strength of composites

It's a major mechanism for improving the dislocation density of the Al alloy, hence strengthening the metal matrix and improves the composite strength. In compression property composites exhibits more than monolithic materials. Plastic deformation of soft metal (matrix) is more difficult than non-deformable metals the base metal.

3.1.3 Shear strength of composite

Results are plotted for both single shear and double shear as shown in Fig.5 also from the graph we can see that there

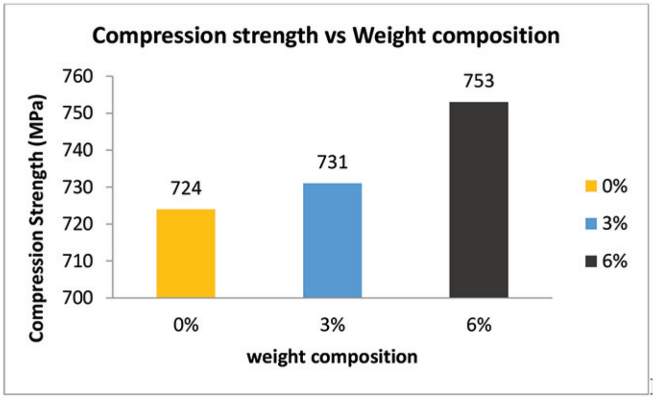

Figure 5: Compression strength of composites

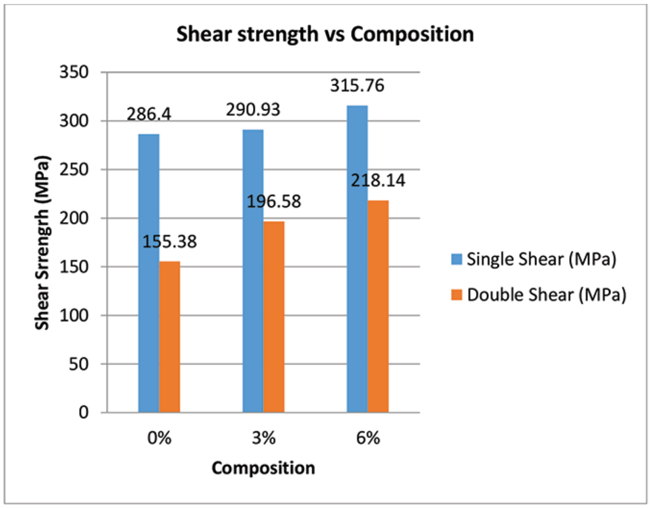

Figure 6: Shear strength of single and double shear specimen

is an increase in value of shear strength due to the addition of hard reinforcing materials which makes the composite dislocations to move slower and taking up maximum load in turn maximum shear strength.

3.1.4 Bending strength of composite

Results obtained are showing superior bending strength upon addition of hard ceramic boron carbide particulate. From Fig.7 we can observe that the trend for bending strength is high for hybrid material than that of aluminium alloy.

3.2 Analysis of Wing Root Fitting

3.2.1 Meshing of wing root fitting

As we all know that meshing is most important process in any of computer simulation. Meshing is the method creating mesh of grid points known as nodes. Here in this work we

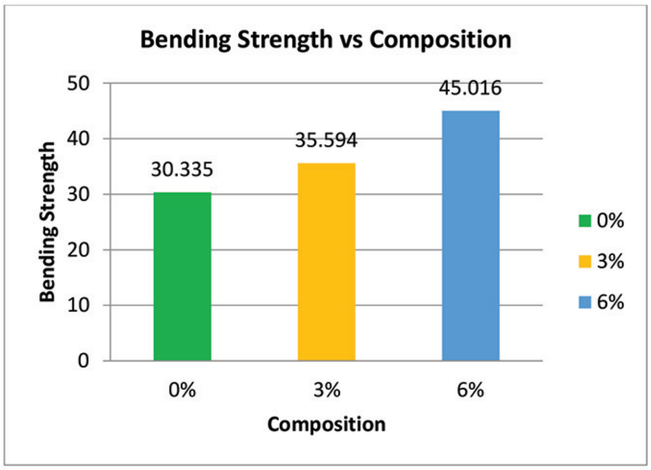

Figure 7: Bending strength of composite

are gone with mesh size of 15 as we go with finer mesh it is taking more time to calculate the analysis solutions. The meshed model of wing root fitting shown in Fig.8.

3.2.2 Loading and boundary conditions of wing root fitting

The calculated load that is bending load is applied at the I section of the wing root fitting beam and the constraints here are holes which remains fixed during static analysis. From Fig.9 we can see the two holes fixed and a load applied at one end of the part which creates the bending moment which in turn bending stress.

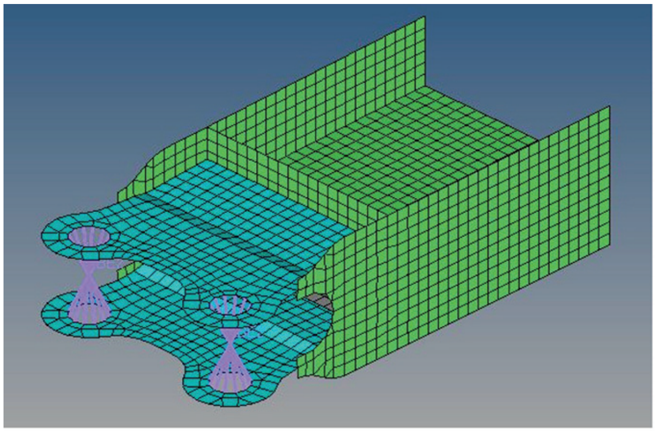

Figure 8: FEA model of wing root fitting

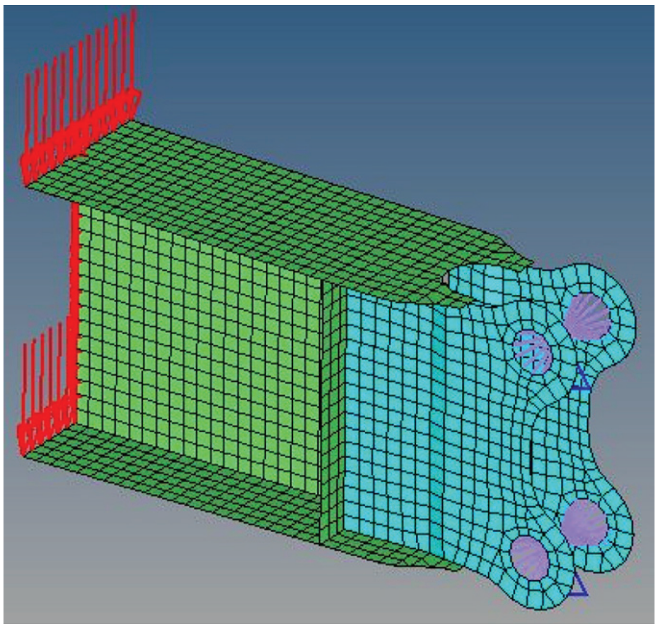

Figure 9: FEA model of wing root fitting with loading and boundary conditions

3.3 Results and Discussion on FEM Analysis

Finite Element Analysis (FEA) is carried out for obtaining solutions to the problems by using hyper works optisolve software. Here we obtain approximation functions in finite elements which are determined in terms of nodal values of a physical field element.

There are 4 stages involved in FEA analysis:

1. Creating the geometry
2. Preparing FEM
3. Solving the problem
4. Checking the results

The bending tests are performed by considering each material property and applying the same before loading the component. The results obtained are maximum bending stress for both aluminium alloy and the cast hybrid composite. Also deformations were obtained for both the materials. Figures 10 indicates bending stress of aluminium alloy with high value when compared to bending stress of hybrid composite shown in Fig.11.

As we can see from Fig.12 results, here there is decrease in the value of bending stress as well displacement for the hybrid composite in Fig.13. This is obtained by incorporating

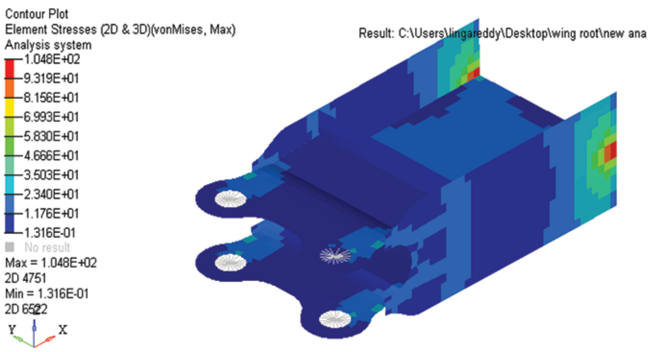

Figure 10: Bending stress of wing root fitting made of Al-7075 alloy

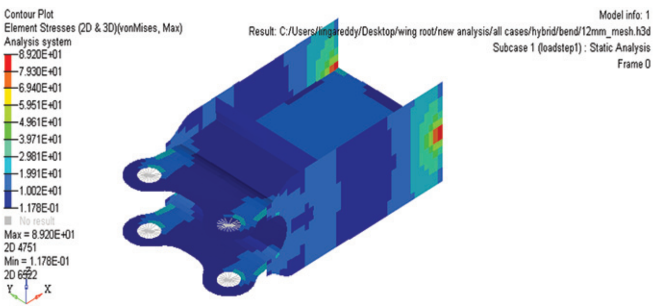

Figure 11: Bending stress of wing root fitting made of hybrid composite

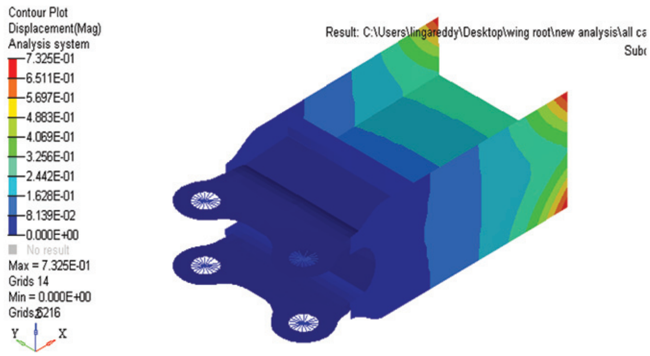

Figure 12: Displacement counter of wing root fitting made of Al-7075 alloy

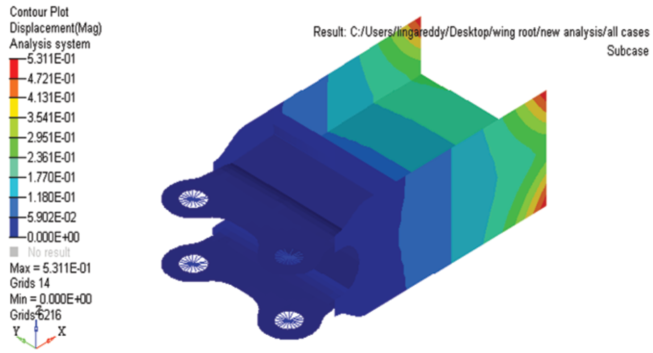

Figure 13: Displacement counter of wing root fitting made of hybrid composite

Table 1: Comparison of results

Material	Bending load(KN)	Maximum displacement (mm)	Stress (MPa)	Density (Kg/m^3)
Al7075	5.724	9.3	175.216	2800
Al7075+B_4C composite	8.538	7.2	213.364	2722

the calculated properties of material. Also it fixed at the holes and a bending load of 24279.75N is applied at the other end and the obtained stress values and displacements are as a shown in the above figures.

As we can see from Table 1 for the same loading conditions the values for stresses are different also displacements. This variation is due to the material property and also elastic modulus of reinforcements. This boron carbide having high value of elastic modulus also makes it more resistance for deformation.

4.0 Conclusions

The present work on studies of mechanical properties of Al7075-B_4C metal matrix composite by two stage novel stirring technique has led to following conclusions:

- Stir casting technique is successfully adopted for preparation of Al7075-B_4C composites.
- Density of the MMC is decreased due to the low density of B_4C.
- The micro structural study shows the uniformity in the matrix for ceramics addition in the matrix system.
- The ultimate tensile strength and yield strength increased with increase in B_4C content. The strength of composite improvements can be matched to the good bonding between the matrix and reinforcement material.
- Shear test is successfully conducted and the results showing better strength for reinforced composite than the alloy.
- Also three-point bending test is conducted and maximum strength obtained for composite.
- Upon the fractography analysis it can be concluded that the brittleness of the composite increases upon the addition of B_4C
- Mapping of this composite to wing root fitting and successfully analysis is carried out for maximum loading condition.

References

[1] Mahadev Nagral, V Auradi and Ravishankar M K, "Mechanical behaviour of aluminium 6061 alloy reinforced with Al_2O_3 and graphite particulate hybrid metal matrix composites", Vol.1, no.2, pp.193-198, 2013.

[2] Mithun B R, MahadevNagral, V Auradi, and Bharat V, "Microstructural and mechanical properties of Cu-coated Al_2O_3 particulate reinforced 6061 Al metal matrix composite", 2214-7653.

[3] A.T. Alpas and J.D. Embury, "Sliding and abrasive wear behavior of an aluminium 2014-SiC particle reinforced composite", Vol.2, no.5, pp.931-935, 1990.

[4] Umesh S. Ghorpade, Prof. D.S. Chavan, Prof. M.V. Kavade, "Static structural and modal analysis of engine bracket using finite element analysis," *IJERT*, ISSN: 2278-0181, Vol. 1 Issue 10, December 2012.

[5] Shashikumar.C, Nagesh.N, Ganesh, "Design and analysis of wing fuselage attachment bracket for fighter aircraft," *IJERGS*, ISSN: 2091- 2730, Vol. 4 Issue1, Jan-Feb 2016.

[6] Harish E.R.M., Mahesha.K, Sartaj Patel, "Stress analysis for wing attachment bracket of a six seater transport airframe structure," *IJIRSET*, ISSN: 2319-8753, Vol. 2 Issue 7, July 2013.

[7] B.K. Sriranga, Dr.C.N. Chandrappa, R. Kumar and Dr.P.K. Dash, "Stress analysis of wing-fuselage lug attachment bracket of a transport aircraft," ICCOMIM, July 2012.

[8] S.K. Varma, S. Andrews and G. Vasquez, "Corrosion wear behavior of 2014 and 6061 Aluminium alloy composites". *JMEPEG*, Vol. 8, pp. 98-102,1999.

[9] Prashant Mittal and Dr. Gajendra Dixit, "Dry sliding wear behavior of 2014 Aluminium alloy reinforced with SiC composites". Vol.5, no.6, pp.147-153,2016.

[10] M. K. Surappa, S.V. Prasad and P.K. Rohatgi, "Wear and abrasive of cast Al-Alumina particle composites". *Wear*, Vol.77, pp. 295-302,1982.

[11] Ajithkumar Mishra and R. Balasubramaniam, "Corrosion inhibition of aluminium alloy AA 2014 by rare earth chloride". *Corrosion Science*, Vol.49, pp. 1027-1044, 2007.