Design and Analysis of Landing Gear using Composite Material

Fahaz Firoz[1], Rupika Raj[2] & G. Diju Samuel[3]
[1,2]Student, [3]Professor
Department of Aeronautical Engineering
Rajadhani Institute of Engineering and Technology, Kerala, India
DOI: *https://doi.org/10.34293/acsjse.v3i1.63*

Abstract - *Aircraft frames are supported physically by the system of assembly which is an important component of aircraft which helps in transferring the load bearded by the wing to the ground while landing this is known as landing gear therefore it is a vital part to construct a landing gear which could withstand external force and could show least deformation the experimental structural analysis conducted was to find the best alternate of titanium alloy mainly used for the manufacturing of triple bogey type of landing gear the structural analysis of landing gear which was designed in solid works has been analysed using the Ansys software from the obtained data we can understand least deformation shown by composite AL Sic.*
***Keywords**: Landing Gear, Composites, Aluminium 7075, Titanium, Reinforcement, Aluminium Silicon Carbide Aluminium Graphite Composite, Deformation Analysis*

I INTRODUCTION

The landing gear is most vulnerable to failure as landing produces veritably high impact loads on this structure. The loads generated can be used as a parameter for the designing of the fuselage. A typical curvaceous shock absorber strut uses energy-absorbing rudiments like nitrogen and hydraulic fluid to absorb and dissipate shock loads [1]. The external or the Oleo cylinder is fixed to the aircraft while the inner cylinder is free to rotate and move over and down within the external cylinder. Constrained movement is delivered to these cylinders by 'torque links' which themselves are connected by the help of a torque arm as a pin joint. This torque arm connects the inner and steering collar that is located at the external cylinder A compound material is defined as a structural material created synthetically or instinctively by combining two or further materials having different characteristics [2]. The ingredients are combined at the macroscopic position and are not answerable to each other. One element is called as Matrix phase and the other is called the Reinforcing phase. The reinforcing phase is lodged in the matrix to give the asked characteristics. Reinforcing phase filaments, flakes, particulates, whiskers etc. Matrix phase nonstop phase [3]. The ingredients are combined at infinitesimal positions and are not answerable to each other. Generally, a compound material is composed of underpinning (fibres, patches particulates, flakes and/ or paddings) bedded in a matrix (essence, polymers). The matrix holds the underpinning to form the asked shape while the underpinning improves the overall mechanical parcels of the matrix [4]. When designed duly, the new concerted material exhibits better strength than would each individual material. The most primitive man-made compound materials are straw and slush combined to form bricks for putting up construction. Illustration Concrete, Boron fibre-supported polymer, Glass Fibre supported polymer, and Epoxy resin supported with graphite fibre [5]. The bracket of mixes is hung on both figure of supporting material and the type of matrix material. Essence matrix mixes (MMCs), as all mixes correspond to at least two chemically and physically distinct phases, suitably distributed to deliver parcels not accessible with either of the individual phases [6]. For illustration, Aluminium Oxide fibre is supported in a copper matrix for superconducting attractions and silicon carbide (Sic) atoms are supported within the Al matrix mixes used in aerospace, automotive and thermal operation operations [7]. For numerous types of research, the term metal matrix mixes are frequently equated with the term light metal matrix mixes (MMCs). Substantial progress in the development of light metal matrix mixes has been achieved in recent decades so that they could be introduced into the most important operations [8]. In business engineering, especially in automotive diligence, MMCs have been used commercially in fibre-supported pistons and aluminium crankcases with strengthened cylinder shells as well as atom-strengthened brake disks [9]. These innovative materials open unlimited possibilities for ultramodern material wisdom and development; the characteristics of MMCs can be designed into the material, custom-made, dependent on the operation. Aluminium blends are blends in which Al is the predominant substance. The alloying rudiments like copper, magnesium, manganese, silicon, and zinc [10]. There are two top groups, namely cast blends and wrought blends. The International Alloy Designation System is the most extensively accepted naming scheme for wrought blends. Each alloy is given a four-number, where the first number indicates the major alloying rudiments. 1000 series is basically pure aluminium with a minimum 99 aluminium content by weight and can be work hardened.

II LANDING GEAR: CAUSES AND COMPOSITES

Causes of Failure

The landing gear is an enormously stressed-out structural part, and fracture or cracking or loss of integrity of the connection or attachment points can lead to serious consequences. The most common mechanically related causes for landing gear failures comprises of

- Indecorous rigging
- Indecorous repairs or conservation
- Region worn beyond their permissible service limits • indecorous installation of zone
- Inaptly secured zone
- Use of non-standard or unapproved parts
- Failure or fatigue of part
- Rupture of hydraulic lines.
- Failure of electrical line connections, relays, contactors, and/ or selectors
- Malfunctions of cautioning systems
- Inoperative limit and safety switches,
- Unlocks failed to release
- Down cinches failed to engage
- Lack of lubrication
- Lack of hydraulic fluid

Retraction of landing with hitch bar still attached Mechanical failure occurs due to inordinate deviation, Thermal shocks, Impact, Creep, Relaxation, Brittle fracture, Ductile fracture, Wear, Spring failure, erosion, Stress erosion, Cracking and Fatigue [6]. From the literature, it is observed that a significant measure of examination work has been conducted in the area of landing 295 IJISET. It has been established that there is a need to overcome problems associated with disagreeing demands similar to the strength and stiffness of landing gear, and at the same time suitable to repel the weight impact of the aircraft and avoid structural damage while landing. Experimenters have proposed suitable materials similar to aluminium, titanium, Mg, etc. that are suitable to repel the weight impact of the aircraft [7].

Aluminium Alloy

Aluminium blends are strong yet light essence that has innovative uses in nearly every request. An alloy is an admixture of substance that when together, are more useful than their ingredients alone. A base substance (in this case aluminium), can be allowed to be “enhanced” by small amounts of a different substances, known as alloying rudiments. Blends have been constructed to give stronger, more conductive, and/ or further flexible materials for designing new ideas, and have revolutionized our engineering capabilities [8]. Aluminium is a veritably common essence that has numerous useful blends; so numerous in fact that the Aluminium Association has defined classes of these blends using a numbered-appointment scheme grounded on alloying rudiments. The content of this composition is from the 7xxx series or blends that use zinc as their main alloying element, and its name is type 7075 aluminium alloy [9]. The other three integers in its name specify individual blends from each other within its series (for a more in-depth explanation of this picking convention, see our composition on 6061 aluminium alloy). This composition aims to show the parcels and uses for 7075 aluminium, and punctuate its strengths as an engineering material [10].

‘7’ Series

The 7000 series blends have the topmost strength in the aluminium blends, but lower fatigue properties than the 2000 series blends. Therefore, 2000 series blends account for a large proportion of the aircraft factors for their better fatigue parcels than 7000 series blends have not been clarified yet. Either, the 7000 series blends are far more sensitive to hydrogen embrittlement than the 2000 series blends. In order to explain the difference in the fatigue crack growth actions in the two series blends, the effect of the test terrain on the fatigue crack growth of the two series blends will be researched in this study, considering the relationship to hydrogen embrittlement

‘7075’ Series

7075 aluminium alloy (A7075) is an aluminium alloy with zinc as the primary alloying element. It has excellent mechanical properties and exhibits good rigidity, high strength, durability, and good resistance to fatigue. It is more susceptible to embrittlement than numerous other aluminium blends because of micro isolation but has significantly better erosion resistance than the blends from the 2000 series. Likewise, it is one of the most generally used aluminium blends for largely stressed-out structural operations and has been considerably used in aircraft structural corridors. 7075 aluminium alloy's composition roughly includes 5.6 –6.1 zinc,2.1 –2.5 magnesium,1.2 –1.6 copper, and lower than half per cent of silicon, iron, manganese, titanium, chromium, and other essences. Likewise, it is produced in numerous tempers, some of which are 7075- 0, 7075-T6, and 7075- T651 The first 7075 was developed in secret by a Japanese company, Sumitomo essence, in 1935, but rear-machinated by Alcoa in 1943, after examining a captured Japanese aircraft. 7075 was formalized for aerospace use in 1945. 7075 was ultimately used for airframe products in the Homeric Japanese army.

Properties of 7075 Aluminium

Component Elements Properties	Metric	English	Comments
Aluminum, Al	82.6 - 98.3 %	82.6 - 98.3 %	Average value: 89.9 % Grade Count:146
Chromium, Cr	0.040 - 0.35 %	0.040 - 0.35 %	Average value: 0.140 % Grade Count:127
Copper, Cu	0.040 - 2.8 %	0.040 - 2.8 %	Average value: 1.26 % Grade Count:146
Gallium, Ga	0.030 %	0.030 %	Average value: 0.0300 % Grade Count:7
Iron, Fe	0.080 - 1.4 %	0.080 - 1.4 %	Average value: 0.272 % Grade Count:141
Magnesium, Mg	0.10 - 3.7 %	0.10 - 3.7 %	Average value: 2.07 % Grade Count:146
Manganese, Mn	0.020 - 0.80 %	0.020 - 0.80 %	Average value: 0.175 % Grade Count:141
Nickel, Ni	0.030 - 0.16 %	0.030 - 0.16 %	Average value: 0.0829 % Grade Count:7
Oxygen, O	0.050 - 0.50 %	0.050 - 0.50 %	Average value: 0.267 % Grade Count:3
Si+Fe	0.70 %	0.70 %	Average value: 0.700 % Grade Count:4
Silicon, Si	0.060 - 0.50 %	0.060 - 0.50 %	Average value: 0.208 % Grade Count:141
Titanium, Ti	0.010 - 0.20 %	0.010 - 0.20 %	Average value: 0.0919 % Grade Count:125
Vanadium, V	0.050 - 0.10 %	0.050 - 0.10 %	Average value: 0.0556 % Grade Count:9
Zinc, Zn	0.80 - 12 %	0.80 - 12 %	Average value: 6.10 % Grade Count:146
Zirconium, Zr	0.030 - 0.50 %	0.030 - 0.50 %	Average value: 0.134 % Grade Count:77
Zr+Ti	0.080 - 0.40 %	0.080 - 0.40 %	Average value: 0.209 % Grade Count:11

Figure 2.1: Element Properties

7075 aluminium is composed of 90.0 Al, 5.6 Zn, 2.5 Mg, 0.23 Cr, and 1.6 Cu, though these figures negligibly change depending on manufacturing factors. Its viscosity is 2.81 g/ cm3(0.102 lb/ in ^{3}), which is light for an essence. 7075 aluminium alloy is one of the strongest aluminium blends available, making it precious in high-stress situations. The copper content of 7075 aluminium increases its vulnerability to erosion, but this immolation is necessary to make such a strong- yet-workable material. 7075 aluminium alloy can be further upgraded by how it is strengthened using a process known as heat-treatment, occasionally appertained to as "tempering." This system uses high heat (300- 500 °C) to reconfigure the material's crystal structure to strengthen its overall mechanical properties, and can literally make- or- break a material. There are numerous styles of tempering 7075 aluminium, but to simplify this composition, we will emphasize T6 tempered 7075 aluminium alloy (7075- T6). 7075- T6 is a common temper for aluminium plate and bar stock; still, it's important to know that each tempering process gives 7075 aluminium its own distinct values and characteristics.

Aluminium- (Silicon Carbide) Advanced Substrate

Aluminium- (Silicon Carbide) is a metal-ceramic compound material conforming to silicon carbide patches dispersed in a matrix of aluminium alloy. It combines the benefits of the high thermal conductivity of metal and the low CTE (a measure of thermal expansion) of ceramic. With its compound features, Al-Sic is an advanced packaging material for high-technology thermal operation. Al-Sic is fine-tuned with a wide range of metallic and ceramic substrate used in microelectronic packaging for aerospace, automotive, and microwave operations. Al- Sic allows for a new packaging technology that can replace traditional W- Cu, Mo, BeO, Kovar, Mo- Cu, AlN, AlSi, and Al2O3. 4. Aluminium graphite compound is one of the members of a new material called metal matrix mixes (MMC). The MMC has paved its way in the field of automotive operation due to its prospective parcels. The purpose of the study is to probe the effect of graphite underpinning on the parcels of the MMC, videlicet fluidity, hardness, and impact energy. Aluminium 7075 alloy is used as matrix essence, whereas graphite grease paint is used as underpinning in the quantum 8 independently, MMC materials are used to give advanced abrasive resistance and longer service life. Reinforced aluminium of MMCs is veritably popular due to its strength, advanced modulus and increased wear and tear resistance over conventional aluminium blends. On the other hand, the graphite patches introduced into the aluminium matrix have shown good eventuality for a variety of anti-friction

Design of Landing Gear using Solidworks

Different parts of landing gear system

- Axle
- Disc plate
- Disc unit
- Lower torque link
- Upper torque link
- Piston unit
- Oleo pneumatic cylinder
- Wheels

III EXPERIMENTAL DETAILS

Assembly of Landing Gear

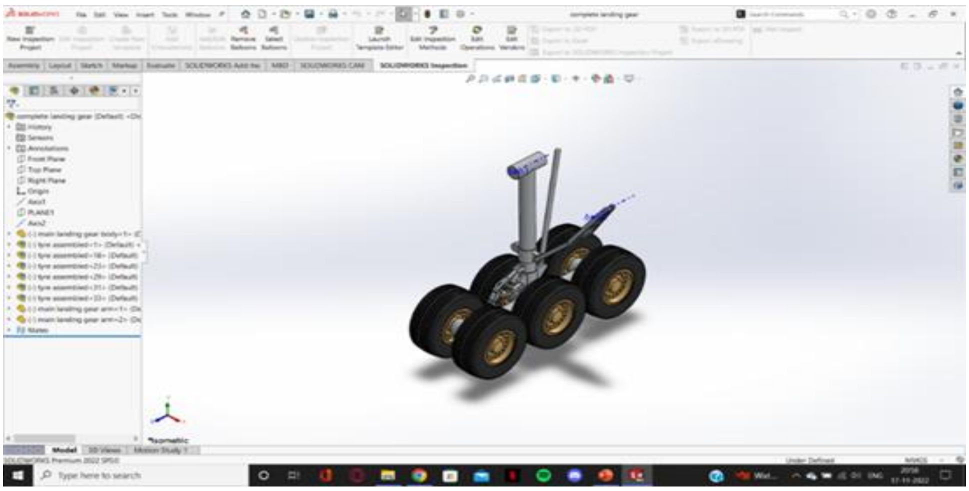

Figure 3.1: Triple Bogie Landing Gear Designed using Solidworks

Each part of the landing gear was created in solid works individually then mate function was used to combine and imported the constructed parts and assembled them hence the design of the landing gear is successfully completed

Static Structural Analysis using ANSYS

Static analysis is used to determine the deportation stresses, strains, and forces in factors due to loads that do not induce significant indolence and damping effects. Steady weight in response conditions is assumed and the kinds of loading that can be applied in the static analysis include the externally applied forces and pressures, steady state inertial forces like gravity or rotational haste, assessed (non-zero) deportations, and temperatures (for thermal strain). Structural and modal analyses are made for assaying the stability of the structure for finding out the deviation.

IV RESULTS AND DISCUSSION

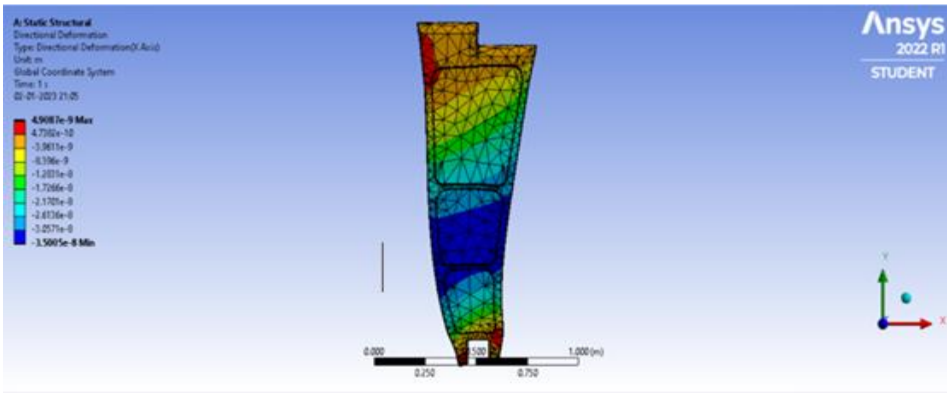

Figure 4.1: Deformation Analysis of T1023

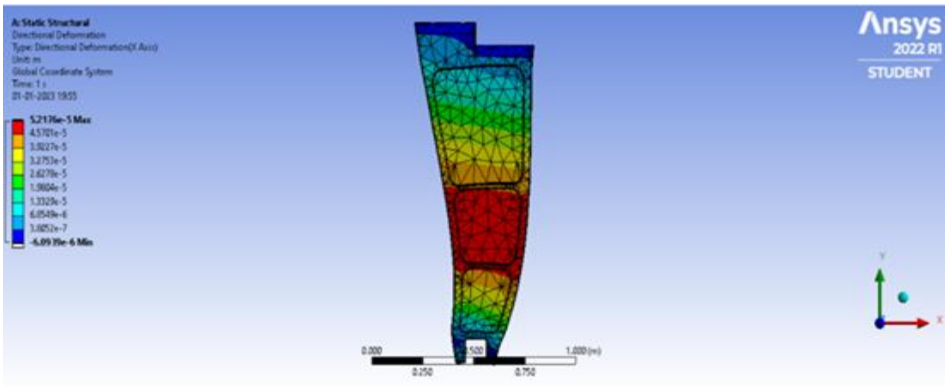

Figure 4.2: Deformation Analysis of Al + Graphite

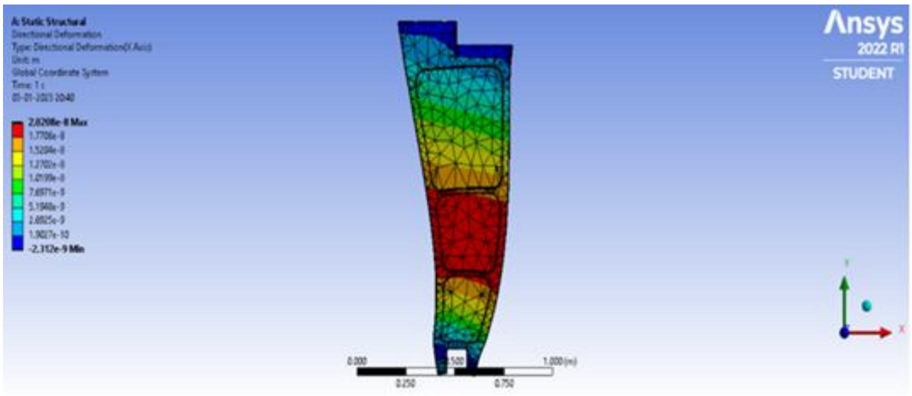

Figure 4.3: Deformation Analysis of Al + Sic

V CONCLUSION

The landing gear is needed to bear loads without any endless distortion and the stresses should be below the critical yield point to meet FFA regulations. It principally combines both normal stresses and shear stresses. All structural members of an aircraft are subordinated to one or further alternate stresses. Thus, the strength of aircraft materials must be great enough to repel forces of varying stresses. An elastic strain is a type of strain in which a distorted body can return to its original shape and size when the distorting force is removed. Elastic strain can be understood as the deformation of the crystal lattice and not a disturbance in the lattice. The materials used for aircraft factors should be tough enough to repel the elastic strains brought due by interspersing stresses. The landing gear was modelled In SolidWorks and analysed in Ansys19.2 using static structural analysis as the closeness of the result depends upon the quality of the mesh. The Arm of the landing gear was considered and meshed. A tetrahedron mesh has been used to insure accurate results. Also, the result has been compared for the three materials TI 1023, AL- SIC, and AL GRAPHITE. The results have been compared based on parameters namely total distortion, Material Aluminium Sic shows lower distortion and has much more repel capacity than the other two proposed materials. The distortion of the landing gear arm for the same payload condition has been reduced by 3.19 for the Aluminium SIC. So, the operation of Aluminium Sic would ameliorate the life of the landing gear arm and avoid landing gear damage.

VI REFERENCES

[1] Chawla, N. and Shen, Y.L. (2001), “Mechanical Behavior of Particle Reinforced Metal Matrix Composites,” in Advanced Engineering Materials, Volume. 3, Issue. 6, pp. 357-370.

[2] Macke, B.F. Schultz, and Pradeep Rohatgi, FASM (2012), “Metal Matrix Composites Offer the Automotive Industry an Opportunity to Reduce Vehicle Weight, Improve Performance,” in Advanced Materials & Processes, Volume. 170, Issue, 3, pp. 19-23.

[3] Hashim, J., Looney, L., and Hashmi, M.S.J. (1999), "Metal Matrix Composites: Production by the Stir Casting Method", Journal of Materials Processing Technology, Volume. 92, pp. 1-7.

[4] Barekar, N, Tzamtzis, S, Dhindaw, B.K, Patel, J., Hari Babu, N. and Fan, Z (2009), "Processing of Aluminum-Graphite Particulate Metal Matrix Composites by Advanced Shear Technology," in Journal of Materials Engineering and Performance, Volume. 18, Issue. 9, pp. 1230-1240.

[5] Mavhungu, S.T., Akinlabi, E.T., Onitiri, M.A. and Varachia, F.M. (2017), "Aluminium Matrix Composites for Industrial Use: Advances and Trends," in Procedia Manufacturing, Volume. 7, pp. 178-182.

[6] Ramanan, G., Dhas, J. E. R., Rajan, R. N., Lewise, K. A. S., and Vishnu, S. (2022), "Fabrication and Wear Characterization of Stir Cast AA7075-TiCp Reinforced Composite", Materials Today: Proceedings, Volume. 52, pp. 1216-1222.

[7] Saravanakumr, K, Venkatesh, S, Harikumar, P, Kannan,K. and Jayapal, V (2015), "Studies on Aluminium-graphite by Stir Casting Technique," in International Journal of Scientific & Engineering Research, Volume. 4, Issue. 9, pp. 390-395.

[8] Oddone, V, Boerner, B. and Reich, S (2017), "Composites of Aluminum Alloy and Magnesium Alloy with Graphite Showing Low Thermal Expansion and High Specific Thermal Conductivity," in Science and Technology of Advanced Materials, Volume. 18, Issue. 1, pp. 180-186.

[9] Behera, R., Chatterjee, D. and Sutradhar, G (2012), "Effect of Reinforcement Particles on the Fluidity and Solidification Behavior of the Stir Cast Aluminum Alloy Metal Matrix Composites," in American Journal of Materials Science, Volume. 2, Issue. 3, pp. 53-61.

[10] Saheb (2011), "Aluminium Silicon Carbide and Aluminium Graphite Particulate Composites," in ARPN Journal of Engineering and Applied Sciences, Volume. 6, Issue. 10, pp. 41-46.