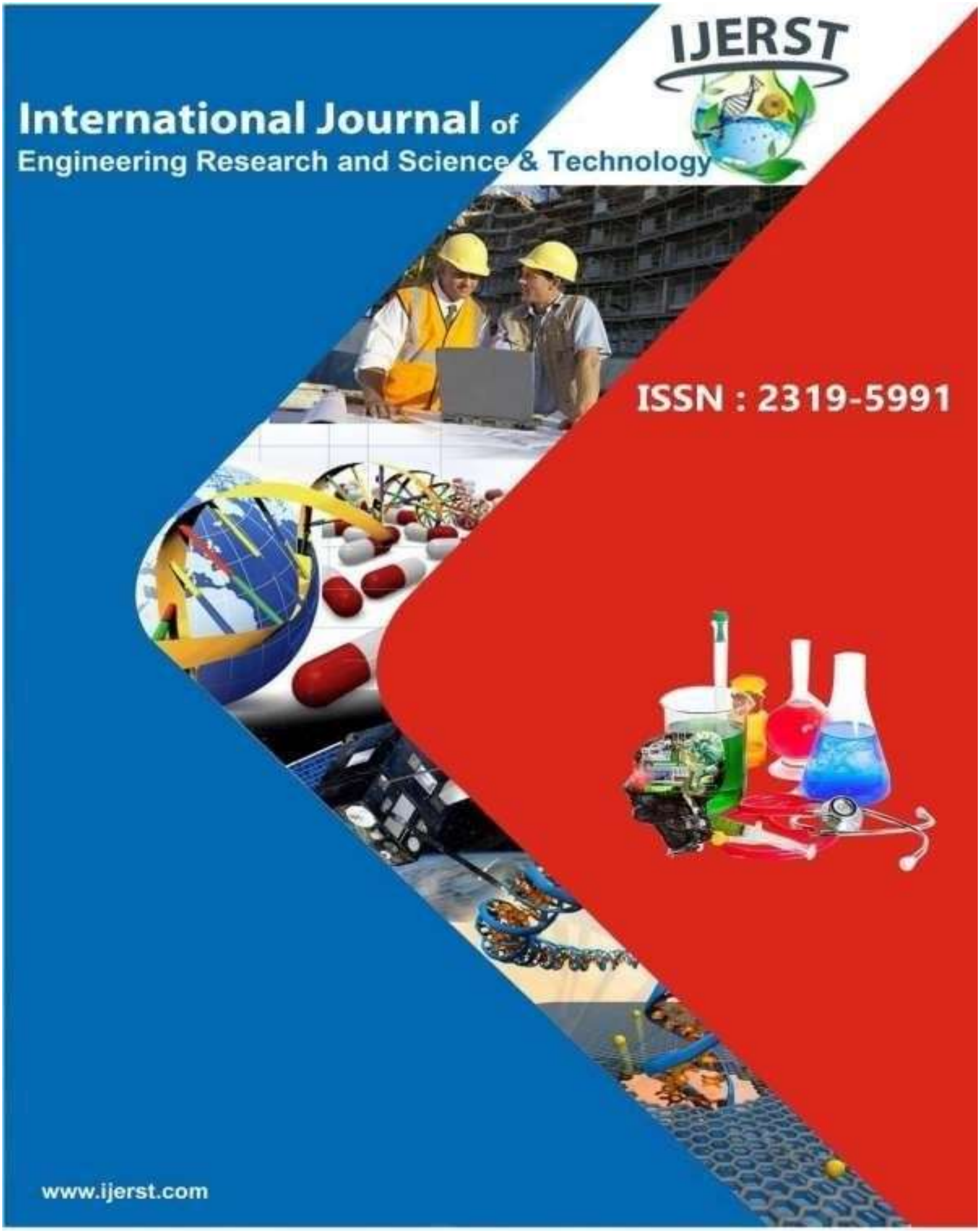

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THE ROLE OF COMPOSITE FIBERS IN REINFORCING AERO APPLICATIONS

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ABSTRACT
FRCs is used as primary structures for aerospace vehicles, launch vehicles/space craft for space exploration and in the field of spots and games. As long as weight reduction and cost reduction with improved efficiency remain important design consideration, FRCs remains to stay in aerospace and sports industries. Only FRCs can achieve the desired strength-to-weight ratio without compromising on any of the specification requirements. Fiber reinforced composites (FRCs) now became inevitable and markedly persuaded in the area of sports and games due to its classical properties such as lightweight, super strength, high intensity, good toughness, superior shock absorption and user easiness. From the building of homes for ancient civilizations to the development of cutting-edge technologies in the contemporary day, composites have played an essential role in human history at every stage. Among the many benefits offered by composites are their remarkable strength, low weight, long-lasting durability, ease of design to meet specific requirements, and remarkable resistance to corrosion. For military aircrafts and also for spacecrafts, increase in the payload capacity, which is the most important parameter for future missions, can be achieved only through FRCs due to the design flexibility and choices. Discovery of new fibers and matrices, development of novel process techniques and novel testing methods will accelerate the use of FRCs for aerospace applications.

Keywords: aerospace applications, Fiber reinforced composites (FRCs), low weight, cutting-edge technologies, future missions.

INTRODUCTION

The accelerated growth in the modern aviation industry has led to advancements in aircraft materials. The primary motivators include cost reduction, weight reduction, and the extension of the service life of the components in the aircraft structures. The use of lightweight materials improves mechanical properties and fuel efficiency, flight range, and payload, as a

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result reducing the aircraft operating costs. Thus, researchers are working on the development of materials with optimized properties for weight reduction, fatigue resistance, corrosion resistance, and enhanced damage tolerance. The development of fiber-reinforced polymer composite materials has resulted in significant advancement in the construction of lightweight structures. Recently, the use of CFRP (Carbon Fiber Reinforced Plastic) in airframes and engine parts has increased to reduce aircraft fuel consumption. Although aerospace materials have made significant advances, there exist some significant challenges such as inadequate strength, which is insufficient to meet the increasing demand for lightweight materials. This review aims to discuss the composites developed for aircraft materials. Materials with a high polymer content tend to be better able to endure very low temperatures. Strength, thermal expansion, heat resistance, and melting point are just a few of the important areas where ceramics excel beyond metals and polymers. Nevertheless, they are not appropriate for use in building due to their fragility. Because of this, composites were studied more thoroughly. A composite is a material system that combines several microelements that are insoluble in one other and have different forms and compositions. Steel reinforced concrete, vinyl-coated steel, and fibre reinforced plastics are all examples of composites that combine metals with ceramics or polymers with metals.

LITERATURE REVIEW

M. I. Kittur (2022) recent advances in aircraft materials and their manufacturing technologies have enabled progressive growth in innovative materials such as composites. Al-based, Mg-based, Ti-based alloys, ceramic-based, and polymer-based composites have been developed for the aerospace industry with outstanding properties. However, these materials still have some limitations such as insufficient mechanical properties, stress corrosion cracking, fretting wear, and corrosion. Subsequently, extensive studies have been conducted to develop aerospace materials that possess superior mechanical performance and are corrosion-resistant. Such materials can improve the performance as well as the life cycle cost. This review introduces the recent advancements in the development of composites for aircraft applications.

Sergey A. Gerasimov (2022) The objective of this research is to determine the self-interaction force of an electromagnetic system caused by Foucault currents. It is commonly understood that the average force resulting from the interaction between the alternating magnetic field source and the inductive Foucault current is negligible. However, when a conductor is placed in a non-uniform magnetic field, it can generate a self-force due to the interaction with displacement currents that are created by open Foucault conduction currents. The force exerted on the symmetrical conductor between the poles of an electromagnet is not zero. The area with the most significant fluctuations in the magnetic field provides compelling evidence of this force.

Aishwarya Brahmane (2021) Thanks to advancements in aircraft technology, the aerospace industry now relies heavily on cutting-edge composite materials for the production of each new generation of aircraft. The introduction of new categories, such as nanotube types, has greatly enhanced and broadened the application of composites, and the progress made in composites continues to advance at a rapid pace. Enhancing the processing and assembly of

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crucial substances to enhance their physical properties or customize them for future applications is a significant advancement in materials development. The aerospace industry has seen a significant increase in the use of advanced composite materials due to their ability to meet all the necessary requirements for aviation materials. This essay delves into the fascinating realm of aerospace vehicles and advanced composites, examining their potential applications in future aviation projects. In addition, this data allows us to gain a deeper understanding of the companies involved in their production.

Sinchai Chinvorarat (2021) This project's overarching goal was to enhance the lightweight amphibious aircraft's wing design and performance via the use of hybrid composite materials. Ansys Composite PrepPost and the Ansys Mechanical Module both use finite element modeling to evaluate and replicate the static structural test with pinpoint accuracy. Ply patterns made of carbon and glass fiber must be precisely adjusted in order to build a lightweight and economical composite wing. Particularly notable among the seventy-two case studies is the BII2 wing design. It cost 1,288 USD to produce and weighs 45.46 kg in total. An expert in mechanical engineering analyzed a composite wing prototype using a universal test rig, finding that it had exceptional design. The findings demonstrated that the optimal wing design was very robust, withstanding stresses of up to +6G and -3G without sustaining any structural damage. The Finite Element Method (FEM) model produced a respectable level of accuracy when compared to the experimental structural deformation and elastic strain.

Tom Stokkermans (2020) helicopters with auxiliary lift and thrust may experience intricate aerodynamic interactions between the main rotor and the auxiliary lift and propulsion components. This research effectively captured the various aerodynamic interactions of the Airbus RACER compound helicopter through the use of high-fidelity computational fluid dynamics analysis. The helicopter features a box-wing design that enhances lift during cruising, along with lateral rotors positioned on the wingtips in a pusher configuration. These rotors serve to counteract torque during hovering and also provide extra thrust during cruising. While the study focused on a particular design, the findings and impacts can be reasonably extended to compound helicopters and wingtip-mounted rotors in a pusher configuration. By excluding specific components of the aircraft during simulations, it becomes possible to quantitatively assess the impact of aerodynamic interaction effects.

Aerospace Expands Its Reach

The aircraft sector had a substantial overhaul after the successful moon landing in the late 1960s. Aerospace continues to be a vital participant in space activities, while also exploring new areas. This organization has a formidable level of knowledge and skill in the fields of healthcare, transportation, energy, and ecological protection. Aerospace did comprehensive investigations on body armour during their work with the LEA. This study had a substantial influence on Kevlar, the material used in ballistic-resistant vests. The Strategic Petroleum Reserve idea, developed in the late 1970s by the United States Department of Energy, extensively relied on knowledge and skills derived from the aviation sector. The primary objective of the project was to establish a petroleum reserve in order to safeguard the country against any possible interruptions in the supply of oil. During the 1970s, the aerospace sector

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had a vital part in the progress and supervision of the space shuttle project. As the project progressed, the design requirements integrated the data acquired from Aerospace's assessments.

Materials for Aerospace Composites

The reinforcing fibers and matrix resins those are highly valued in the aerospace industry as effective material systems. Autoclave molding is a widely used method for producing prepare composites, particularly in the aerospace sector. Glass fiber composites commonly used in small, low-speed aircraft can be cured either in an oven or at room temperature. Composite tooling is a popular option for moderate to low production rates. When a large quantity of parts is needed, metal conventional tooling is the ideal choice. Resin injection molding is utilized to manufacture randoms and other specialized components. An comprehensive overview of the main systems and their required components in a standard high-performance aero plane.

Composite Materials in Aerospace Designs

The use of simulation software to assess the impacts of different aero plane materials is very beneficial. Aerospace engineers may identify cost-effective composites that comply with safety criteria by using design simulations and performing material performance studies. Utilizing their experience, they may make well-informed recommendations that lead to substantial savings in both weight and expense. The effort not only enhances manufacturing efficiency but also aids in the preservation of industrial resources. This area encompasses competence in automated fastener installation, fiber insertion, tool design, airframe hole drilling, and first item inspections.

Use of Composites in Aerospace Structure

Specified requirements that materials must have in order to be considered suitable these factors have contributed to composites' meteoric rise in popularity. There are several benefits of using composites: This product's lightweight design is a direct result of its extraordinary specific rigidity and strength. Unparalleled power and the ability to bounce back fast Maximizing efficiency by fine-tuning of stiffness and vectorial force I can create complex shapes with a wide range of dimensions and a tight deadline because of my extensive knowledge in mechanical engineering. I can streamline the assembly process and cut down on the number of components needed by employing this method. Projects requiring thin walls or extensive curvature are ideal candidates for this product. When it comes to maintaining exact measurements and spatial alignments, it excels.

Manufacturing of Composite fibers

Fiber-reinforced plastics (FRP) have been used in a lot more engineering projects over the last forty years. This is because engineers have a lot of experience and information about them. These materials are now used in a lot of different things, from sports gear to high-performance cars, aero planes, and, more recently, business planes. Sometimes, when you mix the right materials together, composites can do amazing things that would be hard to do with just one material. Engineering composites often use plies made of carbon, glass, or armed threads that are straight and haven't been broken. It is normal for fibers to be mixed into polymer frameworks like phenolic, polyester, or epoxy. Something that is finished and

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made up of joined layers. For complex fiber-reinforced composites to be made, both the material and the structure have to be made at the same time. Defects in the making process can affect how strong and hard materials and structures are. Every detail is important, no matter how small.

RESEARCH METHODOLOGY

This research methodology is framed to develop the novel compatible lightweight composite vehicle component and to improve the material quality and properties by selecting the appropriate material and production technique. The key features considered in this paper are as follows;- (i) Selection of a suitable raw material (fiber and resin) and manufacturing process. (ii) Mechanical, thermal and environmental impact tests. (iii) Design and analysis of composite part and part manufacturing. The selection of composite ingredients and production technique taking into account the above features is carried out from literature survey. The continuous fiber, mat, and woven patterns of fiber are preferred to form a composite. The composite material used for this research work is a prepreg unidirectional carbon fiber reinforced plastic. During curing, the epoxy converts into a hard rigid solid by chemical cross-linking. The low-cost polyester resins were examined for composite stability and bonding properties. In addition, VARTM production method was selected to produce high quality products as per literature survey and compared to the existing hand layup method. The quality composite material is determined by identifying a suitable material based on mechanical, thermal, environmental and safety aspect. The FEA is carried out by extracting the vehicle bonnet component design using reverse engineering technique and the novel composite part must be produced based on the FEA decision.

RESULTS AND DISCUSSIONS

The forces applied on the body I.e on the composite particle is an magnitude force which is normal to the plane of the surface and on the top surface of plane where bottom surface is fixed Support. The pressure of 1000N is force don the top surface, and the further deformation of the cuboids haped composite (E-glass) is studied.

Table 1: The table shows the forces and supports given to cuboid shaped composite

Definition		
Type	Fixed Support	Force
Suppressed	No	
Define By		Vector
Applied By		Surface Effect
Magnitude		1000. N (ramped)
Direction		Defined

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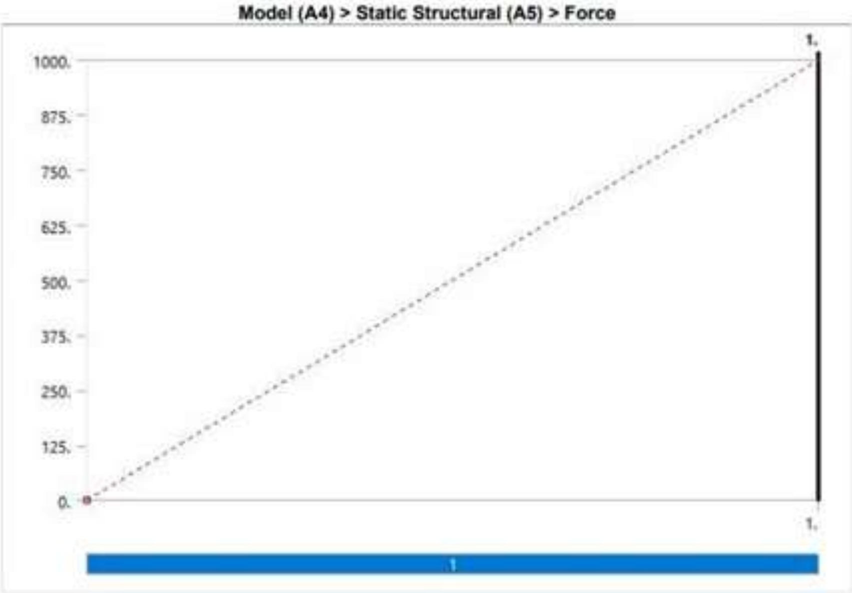

Graph 1: The graph shows gradual increase in pressure from 0 to 1000N with in 1 sec time interval Given, pressure on y axis and time on x axis

Total deformation-

The total deformation of the E-Glass after the analysis gives the minimum deformation of 0mm and the maximum value of 1.4377e-003mm and on the average of 6.3107e-004mm as mentioned in the below table. The values of the total deformation are the output of the pressure of 1000N in the annoys software.

Table 2: Table shows the value soft total deformation of E-glass

Time [s]	Minimum [mm]	Maximum [mm]	Average [mm]
1.	0.	1.4377e-003	6.3107e-004

Strain-

The strain developed of the E-Glass after the analysis gives the minimum deformation of 3.8518e-006 mm/mm and the maximum value of 1.1458e-004mm/mm and on the average of 3.7018e-005mm/mm as mentioned in the below table values of the strain developed are the output of the force 1000N in the Ansys software.

Table 3: Table shows the values of strain of E-glass

Time [s]	Minimum [mm/mm]	Maximum [mm/mm]	Average [mm/mm]
1.	3.8518e-006	1.1458e-004	3.7018e-005

The red on the top of the scale indicates the highest peak of strain developed and it is 0.00011458 mm/mm maximum under 1000N pressure load and the blue indicate the lowest strain developed occurrence ranges from 0.0000038518 mm/mm. The colour changing from red to blue indicates the strain developed is lessening gradually from top to bottom. The strain is optimum as the average strain at 1000N is 0.00003 7018mm/mm.

Stress-

According to the data shown in the table below, the E-Glass stress after analysis results in a minimum deformation of 8.3602e-002 and a maximum value of 7.9541MPa, with an average

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of 2.5436MPa. The calculated stress levels are the result of applying a force of 1000 N in the Ansys programmed.

Table 4: Table shows the values of stress developed of E-Glass

Time [s]	Minimum [MPa]	Maximum [MPa]	Average [MPa]
1.	8.3602e-002	7.9541	2.5436

The red on the top of the scale indicates the highest peak of stress developed and it is7.173MPa maximum under 1000N pressure load and the blue indicate the lowest stress developed occurrence ranges from 1.83MPa-0.083602 MPa. The colour changing from red to blue indicates the stress developed is lessening gradually from top to bottom. The stress is optimum as the average stress at 1000N is 2.5436MPa.

CONCLUSION

The modelling and analysis of composites in reinforced phase used in Aero application hasbeen made and concluded by using Analysis mechanical software, in the process of modeling the structure was suitable and able to determine the good results at the end of the process thus the static structural analysis has been carried out of each of the selected material in reinforced phase, the materials / fibers that are taken are s- glass, e- glass, epoxy resin these material are taken into consideration by keeping cost availability and popular resin out there in the market and thus these qualify for the further modeling and analysis process. The analysis is carried on each material at different force I.e 1000, 2000, 3000 and 4000 N as we consider this as the basic loads from the different journals and papers, the material had different results for different loads and the collective of such results for each material and at each force applied is studied and the graphs and tables are made to compare the difference in total deformation, total stress, total strain etc. and finally by comparing the values of each material at 1000N. This is due to their outstanding mechanical characteristics that include high stiffness and strength. The carbon fiber-reinforced polymer matrix composites have been explored extensively due to their high strength and lightweight but they are easily susceptible to stress concentration. The efficiency of the fabrication technique is determined by the type and volume of the fiber material or matrix used, as each material has distinct physical properties such as stiffness, tensile strength, melting point, and so on.

REFERENCE

1. M. I. Kittur (2022), "Scientific Advancements in Composite Materials for Aircraft Applications: A Review",Polymers (Basel),ISSNno:2073-4360,Vol. 14(22),Pages.5007.doi:10.3390/polym14225007
2. Sergey A. Gerasimov (2022), “Aerospace Electromagnetic Thruster with Average Foucault Currents”, Advances in Aerospace Science and Technology, Vol.7, No.1, pp 25-31.
3. Aishwarya Brahmane (2021) “Futuristic Approach and Usage of Advanced Composite Materials: Review”, International Journal of Advances in Engineering and Management, ISSN: 2395-5252, Volume 3, Issue 12, pp: 755 -766, DOI: 10.35629/5252-0312755766.

ISSN 2319-5991 www.ijerst.com

Vol. 20, Issue 3, 2024

4. Sinchai Chinvorarat (2021) "Composite wing structure of light amphibious airplane design, optimization, and experimental testing", Heliyon, ISSN:2405-8440,Vol.7, Issue 11,https://doi.org/10.1016/j.heliyon.2021.e08410.
5. Tom Stokkermans (2020), "Breakdown of aerodynamic interactions for the lateral rotors on a compound helicopter", Aerospace Science and Technology, Volume 101,https://doi.org/10.1016/j.ast.2020.105845.
6. Yanju Liu (2014), "Shape memory polymers and their composites in aerospace applications: a review", Smart Materials and Structures, ISSN 1361-665X,Volume 23, Number 2, DOI 10.1088/0964-1726/23/2/023001.
7. Yuye Zhu (2019), "Synthesis of UV-Responsive Self-Healing Microcapsules and Their Potential Application in Aerospace Coatings", ACS Applied Materials & Interfaces, Volume11, Issue36, Pp33314–33322,
8. Zaigham Saeed Toor (2018), "Space Applications of Composite Materials", Journal of Space Technology, ISSN 2411-5029, Vol. 8, No. 1.
9. Tracie Prater (2014), "Friction Stir Welding of Metal Matrix Composites for use in aerospace structures", Acta Astronautica,ISSNno: 0094-5765,Vol.93, Pages 366-373.https://doi.org/10.1016/j.actaastro.2013.07.023.
10. Ujjawal Kumar (2015), "Properties of Aluminum-Lithium Alloy – A New Aerospace Alloy", International Journal of Engineering & Technology Research, ISSN 2347-4904, Volume 3, Issue 3, pp. 29-35.