DESIGN AND DEVELOPMENT OF COMPOSITES BASED ON BASALT/ARAMID FIBERS FOR AEROSPACE APPLICATIONS

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ABSTRACT

Composite materials are widespread technical materials that are designed and manufactured for a wide range of objectives in automotive components, sporting goods, aerospace parts, consumer goods, and the marine and oil sectors. The application of lightweight components leads to a boom in composite usage in the worldwide market. Steel and Aluminium were replaced with composite materials with better performance. Composite materials have played a significant part in weight reduction, and as a result, they are utilized for both structural applications and components of all spacecraft and aircraft, from gliders and hot air balloon gondolas to combat jets, space shuttles, and passenger airliners. The development of next-generation composite materials that are additionally lightweight and resistant to high temperatures will aid in the design of high-performance, economically viable aircraft. Development of composite materials based on nano filled epoxy resins for the development of structural aerospace components that provide effective lightning strike protection. The epoxy matrix is produced through the combination of a tetra functional epoxy precursor with a reactive diluent, resulting in decreased moisture content and enables the dispersion of Nano fillers. The reactive diluent further serves to improve the cure degree of Nano loaded epoxy mixes. It promotes reactive group mobility, resulting in a greater cure degree than the epoxy precursor alone. My research primarily focuses on the development, study, and review of mechanical properties such as tensile strength, impact strength, strain, hardness, wear, and fatigue of 100% Basalt fabric epoxy composite, 100% Aramid fabric epoxy composite, and 100% Basalt and Aramid fabric epoxy hybrid composite using various variables. Following the development and testing of the relative mechanical properties, the performance of 100% Basalt, 100% Aramid, and Basalt and Aramid fabric epoxy hybrid composites in aerospace applications is examined using finite element analysis and contrasted to an existing composite product used in passenger aircrafts.

Keywords: *Composite, epoxy precursor, Basalt Fabric, high performance, Aramid fabric, Nano fillers, Aerospace applications.*

INTRODUCTION:

The aerospace industry's never-ending quest to improve the reliability of military and commercial aircraft drives the constant advancement of high-performance structural materials. Composite materials are one such type of material that is significant in both contemporary and future aerospace components. Composite materials are especially desirable for use in aviation and aerospace applications due to their superior durability and stiffness-to-density ratios, as well as their remarkable mechanical characteristics. However, lower assembly times must be weighed against the lengthier time necessary to develop the component in the first place. Aramid fibers are essential for composites that must be lightweight and damage resistant. Because of their strength, stiffness, and dimensional stability, these fibers are utilized as reinforcement in a broad variety of composite products. Kevlar's low compressive strength and fiber structure may be used to your advantage in hybrid composite systems. Hybrid composites are frequently formed by reinforcing two or more components with a single matrix. Epoxy resin is a high-performing resin due to its mechanical properties and resistance to environmental degradation. Because of its high adhesion to the implanted fiber, epoxy resin is used in advanced composite applications. In this study, the alternative choice is basalt fiber, an inorganic fiber with excellent characteristics that is coupled with Kevlar to create hybrid composites that solve the limitations while also increasing properties compared to the standalone properties of both fibers. Basalt fibers are becoming increasingly popular because to their high strength, exceptional chemical resistance, nontoxic nature, low cost, and ease of manufacturing.

MATERIALS AND METHODOLOGY:

The materials required for the designing and development of composites are as follows

- BASALT FABRIC
- ARAMID FABRIC(KEVLAR)
- EPOXY RESIN
- EPOXY HARDENER
- FOIL SHEET

Basalt Fabric is a form of reinforcing material created from natural basalt fibres that is frequently used to offer strength and durability to composite constructions. Aramid Fabric is another reinforcing material derived from aramid fibres that is noted for its high-temperature resilience and lightweight qualities, making it suited for aerospace applications. Epoxy resin is a typical matrix substance used to bond and enclose reinforcing fibres, giving structural integrity and resistance to environmental influences. Epoxy Hardener is used in combination with epoxy resin to commence the curing process, ensuring that the composite material hardens and becomes firm. Foil Sheet can be used as a barrier or ornamental layer in composite buildings to offer strength and protection. Because of their superior heat resistance, chemical resistance, and mechanical qualities, epoxy resins are widely employed in composites for aerospace applications. These resins can endure temperatures of up to 300°C (572°F) or even higher, depending on the epoxy composition. They are frequently reinforced with hightemperature-resistant fibers such as carbon fiber or glass fiber to make composite materials that function well under intense heat conditions. Epoxy composites are employed in a variety of sectors, including aerospace, automotive, and the production of parts for high-temperature machinery. The particular epoxy resin and reinforcing components used will be determined by the application's requirements and desired performance characteristics.

FIBER PARTICULARS

BASALT FIBER

Properties	Values
Temperature withstand	-260° to 700°c
Thermal conductivity	0.031Wm^{-1}
Tensile strength	2.8–3.1 GPa
Elastic modulus	85–87 GPa
Elongation at break	3.15%
Density	2.67 g/cm^3

ARAMID FIBER

Properties	Nomex(meta)	Kevlar(para)
Density (gm/cc)	1.38	1.45
Melting temperature (°C)	500	400
Solvent	Sulfuric acid	Sulfuric acid
Tenacity(g/d)	12-15	15-22
Elongation (%)	20-30	3-20
Modulus (g/d)	113-120	120-130
Recovery (%)	100	100
Moisture uptake%	3.5%	3%

TESTING

After preparation of different composition of sample the following test are conducted:

1. Tensile strength

2. Flexural stress
3. Impact strength

TENSILE STRENGTH

Tensile strength tests for high-temperature composites are critical for determining the material's capacity to endure mechanical forces at high temperatures. This allows engineers to assess the structural integrity and compatibility of the composite for applications such as aerospace, automotive, and industrial operations, where high temperatures are prevalent. Tensile strength is measured under these conditions to guarantee that the material can sustain structural performance and safety in challenging situations. A tensile tester, also known as a pull tester or a universal testing machine (UTM), is an electromechanical testing instrument that uses a pulling force on a material to measure its tensile strength and monitor how it deforms until it breaks.

FLEXURAL STRESS

Flexural strength tests for high-temperature composite applications evaluate a material's capacity to bear bending force at high temperatures. This information assists engineers in determining if the composite can maintain structural integrity at such conditions, which is critical for applications such as aircraft or automotive components exposed to intense heat. It directs material selection and design in order to assure safety and performance in harsh conditions. The flexural strength of a material is the maximum stress the material can bear when bent before it begins to distort. A common approach for determining this strength is to do a transverse bending test utilizing a three-point flexural testing technique.

IMPACT STRENGTH

Impact strength is a material's capacity to withstand abrupt impacts without cracking or distortion. It is critical for determining how effectively a material can tolerate abrupt stresses. Metals, plastics, wood, composites, ceramics, and polymers are common materials for impact testing. These materials are frequently in the shape of sheets or rods, with results varying according to test type, loading speed, and temperature. Materials can fail ductile or brittle; brittle failure takes less energy to originate and propagate fractures until failure, whereas ductile failure requires a greater load to initiate and propagate cracks until failure.

CONCLUSION:

The utilization of basalt and aramid fibers in composite materials with epoxy resin is a promising option for aeronautical applications. Flexural strength tests demonstrated that they can endure bending loads, which is important in structural applications. Tensile strength tests have proved their resistance to stretching forces, highlighting its potential for heat stress applications. Furthermore, impact strength tests show that these composites can endure unexpected mechanical stresses, making them appropriate for a wide range of industrial and aerospace applications. This study emphasizes the significance of material innovation and the development of improved composites for high-temperature settings. However, continuous research and development are necessary to fine-tune production methods, optimize material ratios, and improve the overall performance of these composites. As a result, these discoveries pave the way for the further development of composite materials, which show considerable potential for applications in industries where severe temperatures and mechanical stresses are prevalent issues.

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