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Composite Material Chassis Frame and its Components for Commercial Vehicle Application

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Abstract: This paper highlights the benefits of using composite materials over traditional metals in chassis frame component manufacturing. Some previously unknown and unstructured knowledge on the multifunctional

The phenomena of composite materials are driven by their production importance, with researchers improving composite variations to achieve higher performance in various sectors, including the automotive industry. Ballistic performance composites are used because they are highly durable, strong, lightweight, and corrosion-resistant. Additional features, such as fire and lightning protection, can also be incorporated through a simple and cost-effective fabrication process. Composite materials are used extensively in chassis, braking components, steering systems, battery and charging devices, and differential and suspension systems.

Systems. Composite materials may appear difficult, but their overall value in terms of introducing new types of materials, it is significant.

Composites are already regarded as the new turning point in material research. It will soon offer several options, such as natural fiber, utilized to ensure Biodegradability. The use of composites has significant constraints in automotive components. Overall, output is continually improving, with modern technology and safety for both the environment and humans. Manufacturing costs vary greatly depending on the components and metal features involved.

Even so, composites are generally less expensive than other traditional materials, which expands the potential for vehicle producers. Other novel perspectives, such as piezoelectricity, magnetostrictive characteristics, self-healing capabilities, and electromagnetic shielding, can help propel this field in the long run, as discussed in this review study.

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Key words: Automobile chassis, carbon fiber, composites

1. INTRODUCTION AND BACKGROUND.

Composite materials consist of two or more materials that perform better than unique materials. Egyptians and Mesopotamians first used it back in 1500 BC to make bricks with mud and a mixture. But in 1200 AD, Mongol's first use composite materials for making Bow. Thus, Composite materials are first used in military activities for elevated performance.

The Modern era of composites was started in 1900 s by developing plastics (i.e. polyester, vinyl). In 1935, first fibre composites were introduced due to their higher strength and lower weight. The fibre reinforced composites were developed during World War II. After the war, those were introduced in other markets along with military weapon.

The first composite materials were introduced with automobiles in 1947. In 1974, Japan thought to reduce weight of the vehicle for decreasing high fuel consumption. That time they gave importance of composite materials in vehicle's bodywork. Although Rolls Royce in UK was experimenting glass fibre reinforced thermoset polymers in gas turbine engine fan, this experiment didn't get significant success. In between 1960 s and 1990 s, this period is considered as development period of composites in automobile industry. In these all periods, SMC type's composites were developed and in 1990, world first carbon road car was introduced by McLaren. In 20th and 21st century, composites are signified as pioneer in automobile industry, due to their low weight, less fuel consumption, accidental safety.

Now natural fiber is also used in research and trial because of Green Technology. It controls pollutions, environmentally biodegradable and available in nature. Composite materials are used because of some specialty such as low corrosion, easy maintenance and design variability. The primary benefit of composite materials is their combination of strength, rigidity, and lightweight. Manufacturers may develop qualities that perfectly meet the needs of a specific construction for a particular purpose by selecting the right combination of reinforcement and matrix material. Fig. 1 shows the beneficial characteristics of composite materials. As composite materials have multiple layers, each of them combined carries different properties. Compared to other traditional materials, composite material shows some unique characteristics that can be fabricated according to necessity. Unlike other materials, composites have been used in the automobile industry and aerospace and military vehicles in recent times for high-performance and lightweight, composite materials are used in low-volume vehicles and motorsports. Even for the natural fibre composites,

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it shows higher weight-to-strength ratio, than other homogeneous metal.

Composite materials show 15 times higher tensile strength than conventional material. That consumes low fuel economy. In the case of thermal and corrosion resistance, this multipurpose material is economical in overall cost. This eco-friendly material shows high damage tolerance properties for ensuring passenger safety. Composite materials show some effects on recycling, which are very convenient for Green Technology. These materials are generally sufficient for environmental safety. Though receiving good quality surface finishes at a cheap rate is challenging, it shows benefits in manufacturing, designing, repairing, lightweight, joining, and recycling and safety issues.

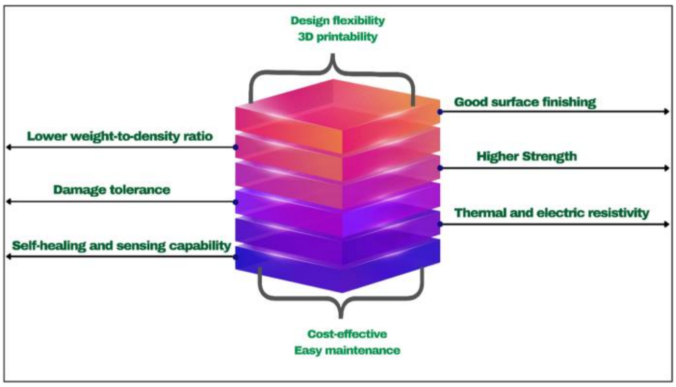

Fig.1

1.1 Main Components of a Composite chassis frame

Cross Members: Horizontal elements that connect the main beams, providing lateral stability and mounting points for other vehicle components.

Long members: Longitudinal components that form the sides of the chassis, supporting the vehicle's body and load.

The primary load-bearing elements, typically manufactured using fiber-reinforced composites like carbon fiber or glass fiber reinforced polymers (FRP). These beams provide structural support and rigidity.

Mounting Brackets and Attachments: Reinforced areas or embedded inserts for mounting suspension, drivetrain, and body components.

Reinforcements: Areas requiring additional strength, such as around mounting points or joints, may include metal inserts or additional composite layers.

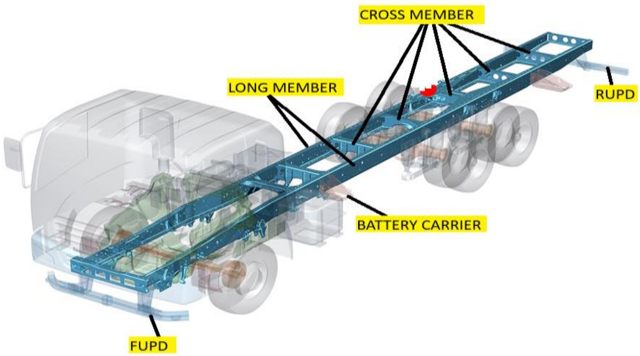

Fig 1.1 - Truck chassis with its some important parts mountings

1.2 Composite Materials

The word composite in the term composite material signifies that two or more materials are combined on a macroscopic scale to form a useful third material. It consists of two or more constituents and that are not soluble in each other. One constituent is called the reinforcing phase and another one in which it is embedded is called the matrix phase. The reinforcing phase available in the form of particles, fibers or flakes and it is harder than matrix phase. The matrix phase materials are generally ductile and continuous

Classification of Composites –

On the basis of the matrix phase, composites can be classified into-

1. Metal matrix composites (MMCs)
2. Ceramic matrix composites (CMCs)
3. Polymer matrix composites (PMCs)

Classifications according to types of reinforcement-

1. Particulate Composites (composed of particles)
2. Fibrous Composites (composed of fibers),
3. Laminate Composites (composed of laminates)

Composites in Structural Applications Having Following Characteristics

1. Composite generally consist of two or more physically distinct and mechanically separable materials.
2. MMCs are developed by mixing the separate materials in such a way that to achieve controlled and uniform dispersion of the constituents.
3. Composite has superior mechanical properties and sometimes their properties are uniquely different from the properties of their constituents

2. ADVANTAGES OF COMPOSITE MATERIALS

Composites now have a permanent place in modern production because of cutting-edge engineering methods that arise from the creative blending of various materials and chemical compounds. The following are some benefits of using composite materials in the automotive industry over traditional materials:

2.1 Strength to Weight Ratio

The strength-to-weight ratio of a substance, commonly known as its specific strength, compares its strength to its weight. Composites' excellent strength-to-weight ratio is arguably their most significant benefit. Although carbon fibre is stronger and stiffer than both materials per unit of weight, it weighs

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approximately one-quarter as much as steel and 70% as much as aluminium.

Multilayer composite laminates absorb more energy than conventional single-layer steel, enabling high-end automotive engineers to reduce vehicle weight by as much as 60% while enhancing crash safety

Material	Specific mass ($g.cm^{-3}$)	Tensile strength (MPa)	Modulus of elasticity of tensile E(GPa)	Specific strength (N.m/kg)
Steel	7.8	1300	200	167
Aluminum	2.81	350	73	124
Titan	4	900	108	204
Magnesium	1.8	270	45	150
Fiberglass	2.10	1100	75	524
Aramid	1.32	1400	45	1060
IM Carbon	1.51	2500	151	1656
HM Carbon	1.54	1550	212	138

Table 1-Comparison of material strength of different types of composites and alloys

2.2 Impact Resistance

Composites can be designed to deflect blows, such as the sudden force of a bullet or the blast from an explosion. Due to this characteristic, composites are used to create bulletproof jackets and panels and protect buildings, military vehicles, helmets and aircraft from explosions

2.3 Corrosion resistance Composites

Corrosion resistance Composites-based products offer long-lasting resistance to harsh chemical and temperature environments. There have been numerous instances of glass fibre-reinforced polymer ductwork functioning in corrosive chemical conditions round-the-clock, every day of the week, for more than 25 years in chemical industrial facilities [40]. Composite materials including carbon fibres, glass fibres, and rapid-cure resins have qualities that resist corrosion from oxygen and moisture as well as corrosive substances, saltwater, and humid environments. Because of this, composites are an essential component of maritime industries or companies that move products and chemicals through pipelines and into containers

2.4 Thermal Conductivity

Composite materials exhibit low heat and electrical conductivity, making them excellent insulators for components that require insulation. But if it's necessary to create thermally conductive parts, thermally conductive materials can be incorporated into the composite part, so this attribute isn't lost in creating composite parts. For example, Polyimide Composites are very high thermal conductive. It is less heavy than metals with a high glass-transition temperature. This material can be modified to have the best qualities dependent on the applications by switching out the carbon fibres which has low CTE

2.5 Design Flexibility

Composite materials offer design flexibility in automotive applications, enabling engineers and designers to create structures more inventively and effectively than traditional metals. Composite materials can be molded into complex forms for aesthetic and economical designs, enhancing the aesthetic appeal and functionality of automobile exteriors. Composites can be designed easily for maintaining environmental safety. Engineers can customize composite materials' mechanical characteristics by altering fibre type, orientation, and stacking order, thereby ensuring components with precise stiffness, strength, and damping properties. Composite materials can be combined into a single part, simplifying design and eliminating the need for multiple components by acting as a noise barrier, thermal insulator, and structural element

2.6 Chemical Resistance

Composite materials' high strength-to-weight ratio, corrosion resistance, and other benefits are driving their increasing use in automotive applications, with the type and environment determining their chemical resistance. Glass fibres and epoxy resin are typically resistant to most chemicals, making them a popular choice for automotive applications due to their strong chemical resistance. Moisture absorption can significantly affect the performance of composite materials, even if some are designed to prevent it electrically non-conductive

The electrical non-conductivity of composite materials is crucial in automotive applications to prevent issues like interference and short circuits, and its conductivity depends on the fibres, matrix materials, and additives used. Glass fibres, being electrically non-conductive, make glass fibre-reinforced composites suitable for applications requiring electrical insulation. Carbon fibres are naturally conductive, but their electrical conductivity decreases when implanted in a non-conductive matrix like epoxy resin, making them commonly used in situations requiring high electrical non-conductivity and strength. Epoxy resins are suitable for applications requiring electrical non-conductivity due to their electrical insulation properties. Fillers or additives can be used in composite compositions to enhance electrical non-conductivity and overall insulating qualities

3. AUTOMOTIVE COMPOSITE COMPONENT MANUFACTURING METHODS

The operations used to shape, cut, or mould materials into things are called fabrication techniques. Cutting, forming, punching, stamping, shearing, and welding are standard fabrication techniques.

Composite materials open up new design possibilities for its versatility. When used with proper tool design and operating circumstances, conventional machining techniques can be used on composite materials, including drilling, turning, sawing,

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routing, and grinding. Other unconventional methods have also been used on these materials, such as water-jet, laser, electro-discharge, and ultrasonic machining.

Depending on the type of composite being utilized and the particular application, many fabrication methods for composite materials are employed in automobiles. Here are a few typical fabrication methods

3.1 Hand Lay-up

One of the earliest and most basic strategies is the hand lay-up which entails manually applying layers of reinforcement materials in a mould. A resin matrix is infused into the layers by hand lay-up. It is frequently utilized for prototyping or low-volume production. For making composite leaf springs, numerous methods might

3.2 Resin Transfer Moulding (RTM)

Dry reinforcing materials are inserted into a mould cavity as part of the closed-mould Resin Transfer Moulding process, which involves injecting the resin matrix under pressure. After curing, the composite item is removed from the mould after the resin has flowed through the fibres. Resin Transfer Moulding enables greater control over the resin content and part thickness and is appropriate for medium-volume production. Because of the potential for automation, intriguing product performances, and part reproducibility, which include RTM, appeal to the automobile sector [74]. Recent multi-gate Resin Transfer Moulding injection investigations have revealed that air voids are frequently created in weld lines, or the resin contact area, due to a front collision between opposing resin flows. RTM is a manufacturing process used in the automotive industry to produce composite components and parts in high scale production rate. RTM is well-suited for manufacturing parts requiring high strength-to-weight ratios, excellent dimensional accuracy, and complex geometries. RTM is a valuable manufacturing process in the automotive industry, enabling the production of lightweight and high-performance composite components that contribute to developing more efficient and advanced vehicles

3.3 Compression Moulding

Compression Moulding For the mass manufacture of composite products, compression Moulding is used. A prepreg, fabric is inserted into a mould cavity during this process. The mould is then sealed to cure the resin and shape the composite item. Compression Moulding large and relatively simple composite pieces like body panels, hoods, roofs, and spoilers are frequently produced using the compression Moulding

3.4 Automated Fibre Placement (AFP) Automated Tape Laying (ATL)

Robotic devices use Automated Fibre Placement (AFP) and Automated Tape Laying (ATL) to automatically apply continuous fibres or tape to a mould surface. With great fibre precision and repeatability, these techniques produce complexly shaped composite pro-technology. Numerous automated manufacturing techniques have been developed to create lightweight composite structures. Automatic tape laying and automated fibre placement are two of the most widely used prepreg technologies. AFP/ATL suits highly for complicated geometrical shapes and huge quantities

3.5 Filament Winding

Cylindrical or tubular composite items, including drive shafts or pressure tanks, are frequently made using filament winding. In this method, continuous fibres are incorporated in a particular pattern onto a rotating mandrel, and then resin is used to saturate the fibres. The portion is then dried and removed from the mandrel [88]. A filament winding procedure creates the axisymmetric components, including pipes, tubes, drive shafts, and pressure containers. Axisymmetric components are best suited for this method

3.6 Sheet Moulding Compound (SMC) and Bulk Moulding Compound (BMC)

Composite materials offered in sheet or bulk form is Sheet Moulding Compound (SMC) and Bulk Moulding Compound (BMC), respectively. Chopped fibres resin, and additives make up these materials [90]. They are frequently utilized in compression Moulding methods to create oversized, flat items like automobile body panels

The automotive industry's most popular and effective use of fibre-reinforced thermoset composites is the Sheet Moulding Compound. The method makes it possible to build bulk composites at a reasonable cost [92]. A thermosetting resin matrix fortified with glass fibres and other additives makes up Sheet Moulding Compound, a particular kind of composite material. Typically delivered in sheet form, it is compressed-moulded or moulded to produce intricate forms and parts. SMC is implemented in automobiles: Body Panels, Bumper Beams, Engine Components, under body Shields, Interior Components, and Battery Enclosures [93]. Another form of composite material frequently utilized in the automobile industry and other production sectors is BMC. A polymer resin, several reinforcing fibres (usually glass fibres), and various additives make up Bulk Moulding Compound, a thermosetting plastic composite. It is prepared into a dough-like consistency that may be moulded into different shapes before being heated and compressed to cure it. Using Bulk Moulding Compounds in automotive applications such as Engine Parts, Exterior Trim and Body Parts, under hood Parts, Structural and Reinforcement Parts, Electrical and Electronics Parts

4. Application of Composite material in Vehicle

4.1 Commercial Vehicle cross member

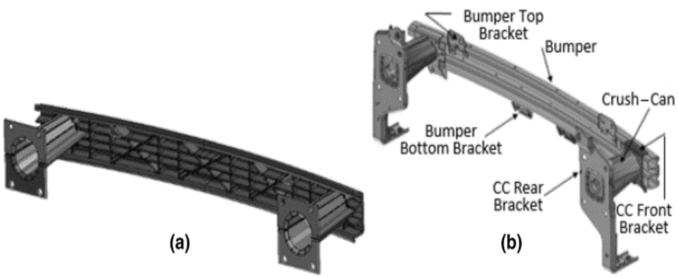

Fig 9- Commercial vehicle cross member

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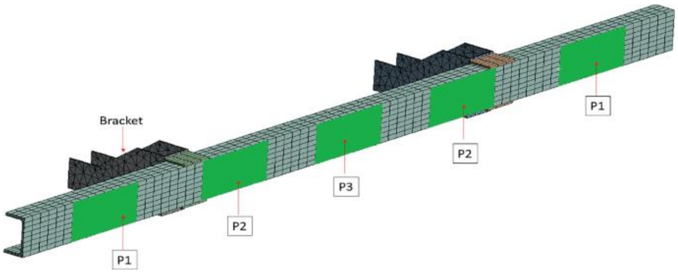
Conventional cross member are with steel material having more weight than composite material cross member. Weight saving potential from Option 1 and option 2 is 40% to 45% with composite material and different composite manufacturing processes

4.2 Commercial Vehicle Rear under run Protection Device

Rear under run protection device material changed from steel to Composite material we can achieve weight saving 37% over conventional steel material



4.3 Battery Carrier

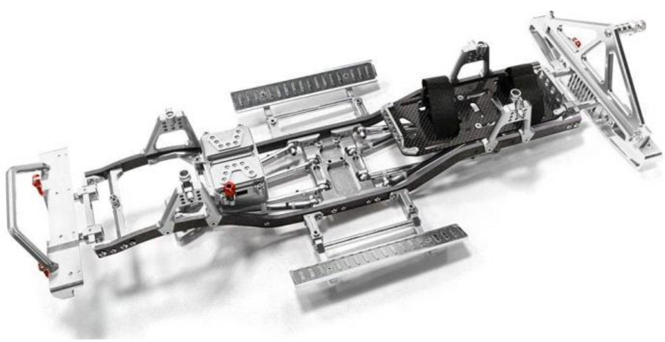
Composite battery carrier material changed from Steel to Composite material we can achieve weight saving 50% over conventional steel material

4.4 Chassis Frame Assembly.

Chassis Due to their lightweight nature, high strength-to-weight ratio, and corrosion resistance, composite materials are increasingly used in the automobile sector. Composite materials are being employed in the chassis, the vehicle's structural underpinning, to increase performance and economy. Syntactic foam is also used as a core material in modern automobiles to strengthen the rigidity of thin gage sheet metal sandwich structures. Cost-prohibitive high-performance materials like Kevlar honeycomb core materials are used. Using composite materials in the chassis contributes to the vehicle's total weight reduction, enhancing handling and fuel economy. Composite materials have built-in dampening characteristics that lessen noise and vibration transmission through the chassis. Composite materials may have excellent fatigue resistance, ensuring the chassis keeps its performance and structural integrity over a lengthy period of operation. A lot of research is already completed and also some implementation is started for composite materials in automobile sector. Every study shows positive alternative in terms of weight reduction, efficient fuel economy, damage tolerance for vehicle performance

Table 2
Characteristics of thermoset and thermoplastic carbon fibre material.

Property	Property	Thermoplastic T700/PA6	Thermoset T700/2510
Density	ρ (g/cm3)	1.45	1.52
Elastic modulus 1st direction	E_1 (GPa)	55	55.9
Elastic modulus 2nd direction	E_2 (GPa)	50	54.4
In-plane shear modulus	G_{12} (GPa)	2.5	4.12
Major Poisson's ratio	ν_{12} (–)	0.033	0.033
Longitudinal tensile strength	XT (MPa)	915	910
Transversal tensile strength	YT (MPa)	850	772
Longitudinal compressive strength	XC (MPa)	450	710
Transversal compressive strength	YC (MPa)	450	703
Shear strength	S (MPa)	85	131



5. TYPES OF COMPOSITES MATERIAL USED IN AUTOMOBILE

The concept of using composite materials is now at the pick of the table of manufacturer preference list. Multiples types of composites are used in automobile for various parts. Due to their variation of performance, they are used in different purpose. Table 4 shows that how the different types of composite material such as Carbon Fibre Reinforced (Polypropylene), Glass Fibre Reinforced (Thermoplastic), Ceramic Matrix composites, Epoxy SMC, Aluminium Matrix Composite, Natural Fibre Composites, Synthetic Fibre Composites play significant roles in different components. Each classifications have own advantages which bound to manufacture different components for running a vehicle

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Types of composites used in different automobile components.

Types of composites	Advantages	Usage in Automobile Components
Carbon Fibre Reinforced Polypropylene	Tensile and Flexural Strength, Hardness, Impact Resistance	Chassis especially Bonnet
Glass Fibre Reinforced Thermoplastic	Light Weight, High Strength and Rigidity, Durability	Front End, Seat Frame, Engine Noise Shield, Bumper, Instrument Panel Bracket
Ceramic Matrix Composite	Elevated Hardness, Wear Resistance	CAM
Epoxy SMC	Dimensional Stability, Low Thermal Expansion	Tire Frame, Outer surface
Aluminium Matrix Composite	High Quality to Weight Proportion, Malleability, Modulus, Low Warm Coefficient, Wear and Consumption Obstruction	Exhausts, Liners, Cylinder, Brake Plate, Brake Drum, Drive Shaft
Natural Fibre Composite	High Strength, Stiffness and Ductility, Moisture Absorbability	Seatbacks, Door Panel, Brake Panel
Synthetic Fibre Composite	Good Flexural Strength, and Interlaminar Shear Strength	Seat Cover, Door Panel

Fibre Reinforced Composites	Applications	Advantages
Carbon Fibre-Reinforced Polymer (CFRP)	Body panels, chassis parts, and interior elements.	Improved fuel efficiency and overall vehicle performance
Glass Fibre-Reinforced Polymer (GFRP)	Body panels, bumpers, etc.	Provides good strength and stiffness
Aramid Fibre-Reinforced Polymer (AFRP)	Armour panels and protective elements.	Excellent impact resistance.
Natural Fibre-Reinforced Composites (NFRC)	Interiors, door panels, and non-structural components	Renewable, lightweight, and environmentally friendly

5.1 Reinforcing form the components of reinforced composites include fibres or other reinforcing materials woven into a matrix material. When the matrix and reinforcement are combined, a material is produced that has better mechanical qualities than when the matrix material is used individually. The following list includes some typical forms of reinforced composites found in the automotive sector

5.2.1. Fibre reinforced composites

The automobile industry relies heavily on fibre-reinforced composites because they offer a unique blend of strength, stiffness, and lightweight characteristics. In order to create a material with improved mechanical characteristics, strong fibres are usually embedded into a matrix material in these composites. Basically, fibre reinforced is better than any other composites in automobile. Several fibre-reinforced composites that are frequently seen in automobiles are given in Table 5. It shows the advantages of their usage and where it is used in automobile. CFRP, GFRP, AFRP and NFRC are very frequent composites used in automobile.

5.2.2. Particle reinforced composites

In particle-reinforced composites, some qualities are improved by adding particles such as metal or ceramics to a matrix material. The automobile industry uses these composites for a variety of purposes to enhance mechanical or thermal qualities such as strength, hardness, and wear resistance.

5.2.3. Flake reinforced composites

The possible use of graphite flakes and a single layer of carbon atoms organized in a hexagonal lattice as reinforcing elements in composites have been researched. These materials have great conductivity and strength, among other mechanical qualities. Graphene or graphite flakes added to composite materials may improve their conductivity and structural performance, which might be advantageous in some automobile applications [208]. Flakes have the potential to enhance mechanical and thermal conductivity. Metallic flake-reinforced composites may be taken into consideration in the automobile sector for applications that call for strong thermal stability or heat dissipation.

5.2.4. Filler reinforced composites

In the automotive industry, composite materials that have a matrix reinforced by fillers are commonly referred to as filler-reinforced composites. Fillers are solid materials added to the matrix to improve certain composite qualities. These materials are frequently in the form of fibres or particles. To meet certain performance objectives, these composites are utilized in a variety of automotive applications. Composites used in car body panels, interior components, and structural elements can be made by adding fillers like fibres, microspheres, or nanoparticles to polymer matrices (such as thermoplastics or thermosets). Fillers can enhance the composite's dimensional stability, thermal conductivity, and mechanical qualities of automobiles. They could also help with weight loss and cost savings

5.3. Layer composites

In layered composites, several layers of distinct materials are stacked to produce a composite structure with improved qualities. These tiered constructions are adaptable to the unique performance demands of the automobile sector. Automotive body panels, including fenders, doors, and hoods, are made of layered composites. For increased strength, impact resistance, and safety, layered composites can be used in automotive windshields and glass. Reduced unsprang mass, enhanced performance and better handling are all benefits of using layered composites in suspension components

6. Key Benefits of Composites material

Composite materials, including fibres and resins, come with benefits that their components do not have individually. Improved strength, fatigue life, toughness, corrosion resistance, damage resistance, stiffness, thermal insulation, and wear resistance are just a few of the characteristics a composite material that has been correctly developed and manufactured may display above its constituent parts. Additionally, the mechanical features of composite materials, such as their specific strength (MPa/kg/m3) and modulus, are several times higher per unit density than conventionally engineered metallic materials

The composites materials have some advantages over Conventional materials are as follows:

1. Lightweight,
2. High specific stiffness and strength,
3. Easy moldable to complex forms,
4. Easy bondable,
5. Good dumping,

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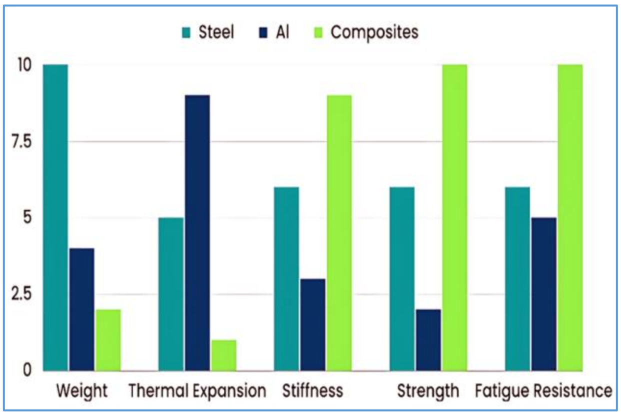
6. Low electrical conductivity and thermal expansion,
7. Good fatigue resistance,
8. Part consolidation due to lower overall system costs,
9. Low radar visibility
10. Internal energy storage and release



7. Technical challenges for using composite material in automobile industries

The technical challenges that automotive composites face in their uptake stem mostly from the fact that composites are more commonly used in high-precision, low-volume applications, such as in the aeronautical sector. Technologies that are used in cost-intensive

7.1.1 Recycling process

The recycling process for automotive composites is not as straightforward as the recycling process for metallic materials. There are three reasons behind this. Firstly, fiber reinforced parts are often joined to other parts such as metal fixings. The complexity of disassembly, de-bonding and separating the parts from the automobile to be recycled presents an obstacle. Secondly, even if the parts can be separated from each other, it is difficult to extract individual materials from the composite. This stems from the fact that composites are a mix of different materials and cannot be melted down and recycled. Lastly, the recycling of composites is hampered by the lack of suitable processes that allow the recycled composites to maintain their original characteristics applications need to be developed, adapted and applied to the automotive industry, where volume and the length of production cycles are significant factors in making automotive composites more attractive for high volume commercial applications.

7.1.2 Manufacturing process

Firstly, the cost of the raw materials in composite manufacturing process remains too high for manufacturers to offer a competitive price to OEMs and consumers. CFRP materials cost much more than its component base material due to the complex processes involved in manufacturing carbon fiber. Processes such as weaving, non-crimp fabrics and pre-impregnation of fibers drive the cost of CFRP above what is economically viable. GFRPs are cheaper to obtain and thus see more applications in a wider range of sectors. Obtaining lower cost carbon fibers is a prerequisite for greater uptake by automotive manufacturers

7.1.3 Methods determining damage to materials

As composite materials contain fibers, they are less ductile than metals and suffer damage differently. The damage is often beneath the surface, resulting in barely visible impact damage. At the same time, the non-destructive testing techniques that can be applied to smaller composite items cannot be applied to components that are integrated into vehicles. This is essential for structural parts where damage detection and assessment is crucial.

Once the damage is assessed, techniques to repair the damaged material are also limited. Replacing the entire part made of composites is often the most accessible method, which leads to increased costs and difficulty. Traditional mechanics and workshops lack the suitable equipment or infrastructure to repair the composite parts of such vehicle

7.1.4 Joining techniques

The introduction of composite materials into vehicles reduces the total vehicular weight. These materials are used in conjunction with existing metal parts as metals have some structural characteristics that are more suitable to certain applications compared to composites. This combination results in multilateral car bodies where components and car bodies are composed of several types of materials. These materials need to be joined together by stable and reliable processes. The surface of composite materials also needs to be prepared for joining techniques. Joining techniques commonly used in joining metals such as welding are not a possibility when it comes to composite materials. Besides joining composites to metals, joining composite materials to other types of composite materials also presents a challenge. Although techniques such as adhesive bonding are used for multi-material car bodies, they could be made more cost effective. Increased automation and faster forming adhesive bonds could contribute to this. At present, the industry has not standardized these processes or materials across suppliers. The evaluation of the structural strength, reparability and performance of these joining techniques is also not standardized and this detracts from the applicability of composite materials in multi-material car bodies

7.2 Transversal Challenges

The transversal challenges of the automotive industry run throughout the industry and are not limited to one link in the value chain. This requires not just technical know-how and the resolution of technological challenges, but a concerted push to integrate the expertise that can be found laterally and vertically across the industry

7.2.1 Cascade of knowledge and multi-material design process

Some parts of the automotive value chain do not possess composite knowledge although they play crucial roles in the vehicle production process. With composites having different properties and joining techniques, it is challenging to determine where and how they should be used in cars. Engineers from Tier 1/2 suppliers also need to adapt their component designs to satisfy new criteria. Depending on where composite materials are used in the vehicle, engineers have to take into account the revised characteristics that composite materials have, such as the strength and integrity of the entire structural chassis, its structural crash resistance and energy absorption during crash behavior. Composite usage has to meet the minimum standards in these aspects. To take full advantage of the benefits of

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advanced materials, composite knowledge needs to be shared through education and training in the value chain, as the chemical industry experiences a similar learning curve as OEMs and tier suppliers, especially compared to the metal industry.

7.2.2 Intra-industry cooperation

Within the automotive sector, more intense collaboration is happening as the industry realizes that there are common challenges that can be tackled more efficiently by pooling resources and sharing insight and knowledge. All automotive players need to meet increasingly stringent international regulations and adapt to global trends. To this end, many OEMs actively seek to create synergy with each other and prevent resources from being invested in competing against each other, when they could instead be invested to meet societal needs. The chemical industry could follow the example of the automotive industry and increase its intra-industry value chain cooperation. As in the automotive industry, there are challenges that span the industry. Better coordination on how to face these challenges could save resources and create an impact for all industry players.

8. Composite material cost comparison and trends.

Cost of the product is the major factor prohibiting the wide spread use of carbon composite industry**.**

Low system cost Composite materials show cost-effectiveness in all sectors. Compared to other materials, the overall design, production, labor, and tooling costs are much lower than any other materials for automobiles and aero planes. It is very cost-effective to produce larger or bulkier products for the automobile industry. In Fig. 10, Compared to Carbon-reinforced thermoplastic and glass-reinforced thermosets, steel is far less expensive. However, compared to steel, the cost of tooling and equipment is far cheaper. The total computation indicates that the greatest quantity of materials calls for the least number of tools and equipment. The labor cost of carbon-reinforced thermoplastics is likewise significantly less than that of glass-reinforced thermosets. For a certain number of demands, the cost of the materials is relatively constant. However, because different

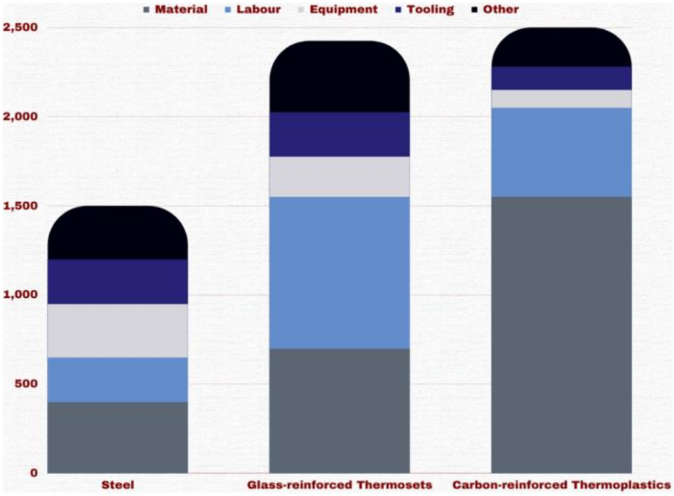

Fig. 10. Comparison of the Cost Structure of Body-in-White Design

The following factors contribute to reduction of cost

1. Reduction in cost of carbon fiber
2. Availability of high performance resins meeting production automation requirements
3. Cost effective production methods and automation with repeatable high quality
4. Availability of relevant design and environment data on selected composite systems
5. High volume processing

8.1 Key Drivers for composite material cost reduction.

The effort to produce economically attractive composite components has resulted in several inventive manufacturing techniques. It is obvious that improvement in manufacturing technology alone is not enough to overcome the cost hurdle. It is essential that there be an integrated effort of key cost drivers shown in figure 4 for composites to become competitive with metals.

Figure 4. Key drivers for Cost reduction

Raw Material:-

Main raw material of carbon composites are polymeric resins and carbon fibers. Cost of carbon fiber is directly related to the cost and yield of precursor from which it is obtained and cost of conversion. At present carbon fiber is Polyacrylonitrile (PAN) based and its average cost of non-aerospace grade is around \$21.5/Kg, with a conversion efficiency of only 50%

The following advances are taking place to reduce the cost of carbon fiber:

Development of low cost and high yield precursors for manufacture of commercial (heavy-tow) carbon fibers which will significantly reduce the carbon fiber cost. Industrial grade fibers are expected to be available at \$13.8/Kg by 2017. Figure 3 shows how the cost of carbon fiber is going to get reduced in future, till the year 2020, due to some of these advances in raw materials.

Chopped carbon fiber/epoxy prepreg in sheet molding compound (SMC) form for structural applications with 3-D molding capability that results in dimensionally controlled surfaces on both sides.

Development of highly moldable fast cycle prepreg, uni-directionally arrayed chopped strand prepreg

Development of highly reactive resins to reduce cycle time

Combining fibers to create hybrids and weaving forms.re-use of waste fibers by combining and consolidating dry fibers into a mat

Development in preform technology: multi-ply curved complex preforms such as skin-stringer. Frame intersections.

Production Technologies:-

1. Fast-cycle manufacturing techniques
2. Lay-up automation and automation of labor intensive activities
3. Flexible automated composite laying processes
4. Textile processes like braiding(3-D) and perform making,
5. Forming processes
6. Out of autoclave processes like resin transfer molding and resin infusion technology
7. Utilization of fluid based pressure/heating/cooling system
8. High speed compression molding
9. High pressure molding process-method of forging net shaped parts from prepreg bundles similar to metal forging.
10. Rapid cure resin technology combined with RTM for fabrics curing in 10 minutes.

Advanced software tools for composites product Development:-

Many advanced composite software tools and utilities are now available to automate many engineering processes to reduce design cycle time. These tools identify feasibility of manufacturing and associated issues upfront during design stage. These advanced software tools are helping to perform many engineering activities concurrently while reducing design cycle time and engineering cost. Few of these tools include:-

1. Knowledge based engineering tools
2. Advanced design, analysis and manufacturing, simulation software tools and utilities
3. Design of part integration and co-cure methods
4. Design Integrated virtual manufacturing software system
5. Cost modeling software.

9. CONCLUSION

Use of composite materials instead of traditional heavy cast iron & steel we can reduce the weight by 20-50%. Work on the composites to find out the properties of these composite materials and the associated manufacturing

The cost of lightweight composite materials in which carbon fiber, Al and Mg are used is much higher than the conventional materials. So it is essential for research and development in the field of lowering their cost, increasing their recyclability, enabling their integration and maximizing fuel economy benefits of automotive vehicles.

From the above description, it can be concluded that composite materials are not only an option but also a mandatory implementation in the automobile industry. The taste of composites in the automobile industry has gained significant attention with their attractive and efficient properties. Multiverse properties provide variations in materials. With the help of single composite materials, multiple features are ensured compared to numbers of homogeneous materials. The main advantage of using composite materials is their light weight with high strength. This type of adverse conditions cannot be compiled by single traditional metals. Lots of composite materials are signified already, but more working will tie up variable benefits to every sectors. With the increasing demand for composite materials in the automobile sector today, its use is expected to spread successfully in the future. The development of composite materials for use in automobiles has fundamentally changed the automotive industry, providing a multitude of advantages that improve sustainability, efficiency, and performance. Various composite applications have been included, like chassis, brake pads, hood, bumper, fender, engine cradle, interior and exterior essences, tires, sunroof, etc., to achieve lightweight, high strength, good fatigue resistance, toughness, damage resistance, stiffness, thermal insulation, wear resistance, and other worthy properties within a reasonable cost. Because of their outstanding strength-to-weight ratios, composite materials are perfect for use in a variety of automotive structural components. The main concern of automobile is passenger safety by resisting accidental damage. Their increased strength and resilience help to raise vehicle safety standards. Composites are the best fire and lightning protective because they are less conductive. The thermal and electrical conductance is very negative for composites which protects from accidents and danger from interior to exterior components. Another factor of thought is cost reduction after consumption. Vehicle weight reduction is largely dependent on composite materials. Lower emissions and increased fuel efficiency are the results of this weight reduction. 3D printing ability also reduces labor costs allow for different shapes and qualities as per requirement of a car. Many types of composites can be used simultaneously for different types of parts which are very unusual. Scientists have already found out the beneficial property of ongoing

10. FUTURE SCOPE

1. Chassis component with composite material introduction which is light weight and higher strength also corrosion resistance
2. Topology optimization is new approach will drastically improve design with a very less time through 3D design and analysis software's
3. 3D printing process introduction for making complex parts

12. REFERENCES

[1] Lightweight Composite Materials for Automotive - A Review. Murlidhar Patel1, Bhupendra Pardhi2, Sulabh Chopara3, Manoj Pal4
[2] Design and Analysis of Chassis for Green and Light Vehicle Using Composite material - Henok Getaneh , Naresh Kumar Doneti , Spoorthi Gopagoni
[3] Automotive Chassis Design Material Selection for Road and Race Vehicles
[4] Shiva Prasad U, Athota Rathan Babu, Bandu Sairaju, Saikrishna Amirishetty Deepak D
[5] Carbon composites are becoming competitive and cost effective – Shama Rao N, Simha T.G.A, Rao K.P and Ravikumar G.V.V
[6] Modeling and Analysis of Light Vehicle Chassis Made of Composite Material
[7] B. Narayana Swamy, C. Lakshmaiah, Dr. K.Tirupati Reddy

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ISSN: 2278-0181
Vol. 14 Issue 12 , December - 2025

[8] Polymer composites for automotive sustainability-CEFIC Jacques KOMORNICKI Innovation Manager and SusChem Secretary

[9] 7.Advances of composite materials in automobile applications – A review Fardin Khan a, Nayem Hossain a,*, Juhi Jannat Mim a, SM Maksudur Rahman a, Md. Jayed Iqbal a, Mostakim Billah a, Mohammad Asaduzzaman Chowdhury b a Department of Mechanical Engineering, IUBAT-International University of Business Agriculture and Technology,

[10] Dixit, Y., Dhaliwal, G.S., Newaz, G. *et al.* Comparative Investigation for the Performance of Steel and Carbon Fiber Composite Front Bumper Crush-Can (FBCC) Structures in Quarter-Point Impact Crash Tests. *J. dynamic behavior mater.* **6**, 96–111 (2020).