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EXPERIMENTAL INVESTIGATION OF POLYMER COMPOSITE GEAR

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Abstract: Nylon 6 and Glass fibre is a thermoplastic polymer widely recognized for its excellent impact resistance, toughness, and dimensional stability. However, its relatively moderate mechanical strength and thermal resistance limit its application in highperformance systems such as polymer composite gears. This study explores the potential of as a base material for gear manufacturing, focusing on improving its properties through reinforcement with materials like glass fibers, carbon fibers, PTFE, graphite, and nano-fillers. These reinforcements aim to address the stringent requirements of gears, including high wear resistance, low friction, and durability under operational loads. The investigation adopts a multi-faceted approach, including experimental testing and computational simulations. Mechanical testing, such as tensile strength, fatigue life, and impact resistance, evaluates the material's structural integrity, while thermal testing measures heat deflection temperature and thermal expansion properties. Tribological analysis assesses wear rate and friction behavior under operational conditions. Additionally, Finite Element Analysis (FEA) simulations provide insights into stress distribution, thermal effects, and dynamic performance, complementing experimental findings.

Results from these analyses are benchmarked against traditional gear materials like Nylon and POM to identify composites' strengths and weaknesses. The incorporation of fillers significantly improves the mechanical and thermal properties of making it a strong candidate for light- and medium-duty gear applications. The study also evaluates the cost-effectiveness of -based composites, highlighting their potential to provide a balanced solution between performance and economic feasibility. This research demonstrates the viability of composites for use in lightweight, highperformance gears, particularly in cost-sensitive markets. By optimizing the formulation of composites, the study contributes to advancing gear material technology and offers a sustainable alternative to conventional materials. These findings pave the way for further exploration of polymer composites in advanced engineering applications.

CHAPTER 1

1.1 INTRODUCTION

In now recent days, technology wants a high demand for the development of future generation. Hence, in order to manufacture a high-quality product which needs to satisfy the customers, it should be developed at an economical with the easiest way, excellent quality with minimum possible time challenging among the competitors. In order to satisfy the present scenario, a material for the new product plays a vital role in engineering industries. Hence, there is a need of quality, economy, and feedback to satisfy the current needs. In the past, the materials have high influential with that the name in the historical days. In modern days, there are enormous materials came into existence like polymers, metals, ceramics and composite materials. In present years, even high technology materials like Nanomaterial’s, smart materials, and Meta-materials dominate the field. So many works are initiated in the area of material science which led to daily needs. Polymer composite materials are the latest trends among them showing major developments in recent years in material technology. They show very high importance and impact on industries and the method of manufacture improves as they proved combined properties of reinforcement and matrix for stronger materials when compared to the individual materials. The main aim of the hybrid structure is lightweight, stability, eco-friendly, noncorrosive in nature, etc.

1.2 HISTORY OF COMPOSITES

The Engineers and artisans had been continuously developed the composites of broad range for more sophisticated application materials from ancient times. The earliest well-known use of composite materials is certified to the Mesopotamians. These peoples have glued wood strips at several angles to manufacture plywood in 3400 B.C.In 4000 B.C's, Egyptian humankind revealed that fiber composite from papyrus plant can be utilized as the composition material.

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Around 1500 B.C. old Egyptians utilized straws for fortifications in mud blocks to manufacture developments, ceramics, and vessels. In 1200 A.D, Mongolians took a stab at utilizing composite materials with a blend of bone and creature paste is utilized for delivering bows, which are massively incredible.

In the 1870s, the polymerization procedure was created which permitted new engineered tar for stage change in a substance structure. The engineered gums utilized in beginning times are Bakelite, celluloid, and melamine. In the 1920s, carbon strands were presented as the primary strengthened support in airplane industries and wearing equipment In 2000s composite materials are broadly used in, textile, automobile industries, defense, marine, building, etc. which the main concern is about efficiency when compared to cost becomes the initiative of advanced composites.

1.3 CHARACTERISTIC OF COMPOSITE

- Composite materials having excellent mechanical characteristics when compared to other materials.
- Owing to their considerable mechanical applications in automobile, textile industries and marine, their fatigue power and fatigue break tolerances are tremendously good.
- Composites have tiny coefficients of thermal expansion, excellent vibration energy orption and great damping capacity.
- Composites need fewer energy and pressure for manufacturing process when compared to metals.
- Composite materials show good maintenance very high strength even at extremely high temperature

1.4 CLASSIFICATION OF COMPOSITE

Composite materials are made by two more different phases. The phase is a dispersed phase and matrix phase. it has bulk characteristics considerably dissimilar form those any of the constituents.

1.4.1 Matrix Phase

The main phase, having a nonstop character, is called matrix. Matrix is generally more ductile and fewer hard phase. It holds the scatter phase and distributes a load with it.

1.4.2 Reinforcing Phase

The subsequent stage is fixed in the grid in an unpredictable structure. This optional stage is called scattered stage. In this stage is commonly more grounded than the network it is at times called strengthening stage. Huge numbers of general materials compounds, doped Ceramics, and Polymers blended with added substances likewise have a little measure of scattered stages in their structures, in any case they are not considered as composite materials since their properties resemble those of their base constituents.

1.5 POLYMER MATRIX COMPOSITE

Polymer lattice composite material blended of a few short or long filaments. Polymer networks are intended to move the heaps between strands through the framework. Polymer grid incorporates their lightweight, high quality along the course of their fortifications. It is separated into two degrees of mechanical properties

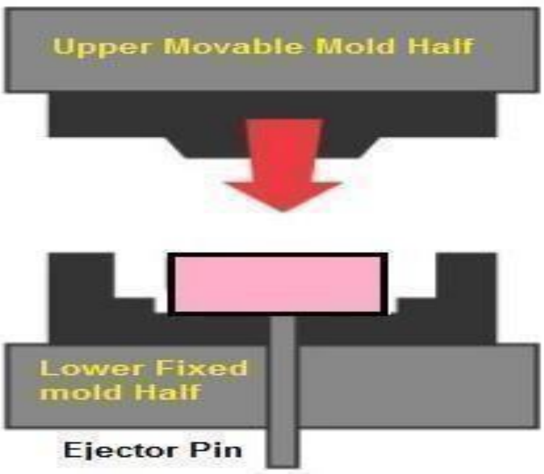

Figure No 1.1 Examples of PMC Fabrication

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1.5.1 Fibrous Composites

(i) Short-fiber strengthened composites.

- Short fiber reinforced composites include a framework sustained by a dissipated stage in a sort of sporadic strands length < 100*diameter I
- Composites with the arbitrary direction of filaments.
- Composites with the favored direction of strands.

(ii) Long-fiber strengthened composites.

- Long-fiber strengthened composites comprise of a framework fortified by scattered stage in a type of ceaseless strands.
- The unidirectional direction of strands.
- The bidirectional direction of strands (woven).

1.5.2 Laminate Composites

At the point when a fiber fortified composite comprises of a few layers with various fiber directions, it is called multilayer (edge handle) composite.

1.5.3 Base Constituent Materials

One or more than two materials united to form distinctive properties. At macroscopic level inside the composite, the materials will remain its properties. Fibers can withstand heavy force because of stiffness and strength. In addition to fibers, some fillers/additives/Modifiers are added to the composite for better specific properties is to improve enhanced bonding with reinforcing fibers, and also to care for damages from loads and ecological conditions.

General resin materials include thermos plastics and thermosetting resins which are epoxy resin, polyester, vinyl ester, phenolic resin, poly urethane, etc. Among all these resins, epoxy resin shows higher mechanical properties and higher adhesion and got low shrinkage when compared to other resins.

1.6 METAL MATRIX COMPOSITE (MMC)

The MMC are materials with any two rate consist parts one being a metal basically another material might be an alternate metal or another material, for example, an artistic or natural compound.

- MMCs are made by scattering a strengthening material into a metal grid. The fortification surface can be covered to counteract a concoction response with the framework. For instance, carbon strands are ordinarily utilized in the aluminum network.
- The initial level of categorization is generally completed with respect to the matrix constituent. The primary composite classes contain MMCs, OMCs, and CMCs. The organic matrix composites are generally assumed to contain two types of composites, PMCs, and CMCs.
- The one second from now level of classifications alludes to the fortifying structure laminar composites and fiber fortified composites critical composites. It is isolated into two kinds specifically series and not series fiber.
- The composites are considered to be unendingly fiber raise quality. Filaments are little in size and when squeezed pivotally, they contort effectively however they have amazingly great malleable properties. These filaments ought to collaborate to remain singular strands from bend and clasping.
- Laminar composites are coordinated layer of material joined by a matrix. Sandwich structures are under this classification.
- Specific Composites are made out of particles dispersed or implanted in a framework body. The particles might be pieces or in powder structure. Cement and wood molecule sheets are instances of this class.
- Laminar composites are coordinated layer of material joined by lattice. Sandwich structures are under this class.
- Particulate Composites are made out of particles dispersed or inserted in a network body. The particles might be pieces or in powder structure. Cement and wood molecule sheets are instances of this class.
- They comprise of clay filaments inserted in an earthenware grid. The grid and material, carbon and carbon filaments can likewise be viewed as a fired material

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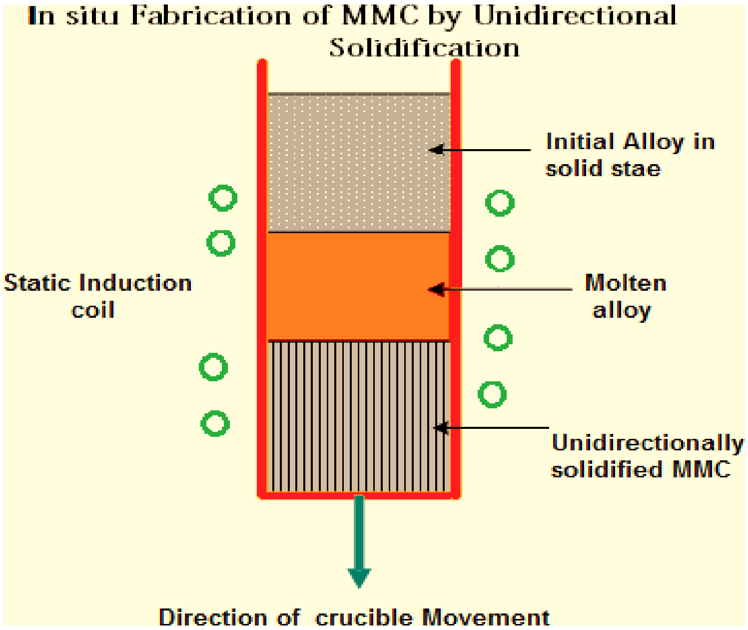

Figure No: 1.2 Fabrication of Metal matrix materials

1.7 CARBON REINFORCED POLYMERS (CRP)

Carbon reinforced polymers (CMM) are another subset of polymer matrix composites, specific to epoxy and polyester-bonded carbon fibers. The fibers are pre- impregnated with thermally activated resins, so the flexible cloth is laid-up and then compressed and baked to liquify and then cure the resin to create a rigid, tough result.

1.7.1 The Manufacturing Processes

- Laptop shells and other high performance cases.
- carbon fiber arrows and bolts, stock (for crossbows) and riser (for vertical bows), and rail
- Final machining and, whenever required, further treatment like

1.7.2 Applications

- Advancements for applications in space
- Advancements for gas turbine segments
- Use of oxide CMC in the burner and hot gas pipes
- Application in the brake plate

1.8 MANUFACTURING AND FORMING METHOD

1.8.1 Solid State Methods

Powder mixing and solidification (powder metallurgy): Powdered metal and broken support are blended and after that reinforced through a procedure of compaction, degassing, and thermo-mechanical treatment (conceivably by means of hot isostatic squeezing (HIP) or expulsion) Foil dispersion holding: Layers of metal foil are sandwiched with long strands, and afterward squeezed through to shape a grid

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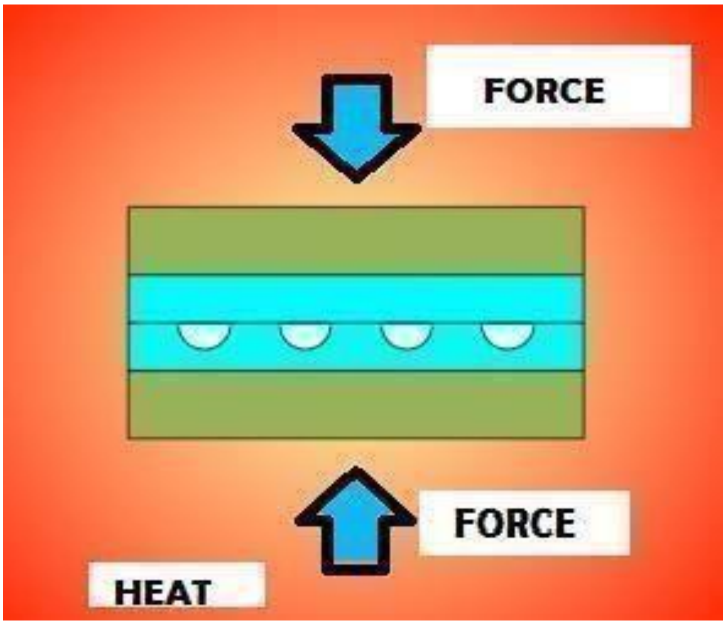

Figure No: 1.3 Examples of Solid-state strategies

1.8.2 Liquid State Methods

- Electroplating and Electroforming
- Stir casting
- Pressure infiltration
- Squeeze casting
- Spray deposition
- Reactive processing

1.8.3 Semi-Solid State Method

- Solid Powder Processing

1.8.4 Vapor deposition

- Physical vapor deposition

1.8.5 Applications

- Some tank armors may be made from metal matrix
- Some tank armors may be made from metal matrix composites

1.9 CERAMIC MATRIX MATERIALS (CMM)

Artistic framework composites (CMC) are a subgroup of composite materials just as a subgroup of earthenware production. They comprise of clay filaments inserted in an earthenware grid. The grid and strands can comprise of any artistic material, whereby carbon and carbon filaments can likewise be viewed as a fired material.

1.9.1 The Manufacturing Process

- Lay-up and obsession of the filaments, formed as the ideal part
- Penetration of the matrix materials
- Final machining and, whenever required, further treatment like covering or impregnation of the characteristic porosity .

1.9.2 Manufacturing Procedures

- Matrixframing through pyrolysis of C-and Si-containing polymers
- Matrix framing through concoction response
- Matrix framing through sintering
- Matrix framed through electrophoresis

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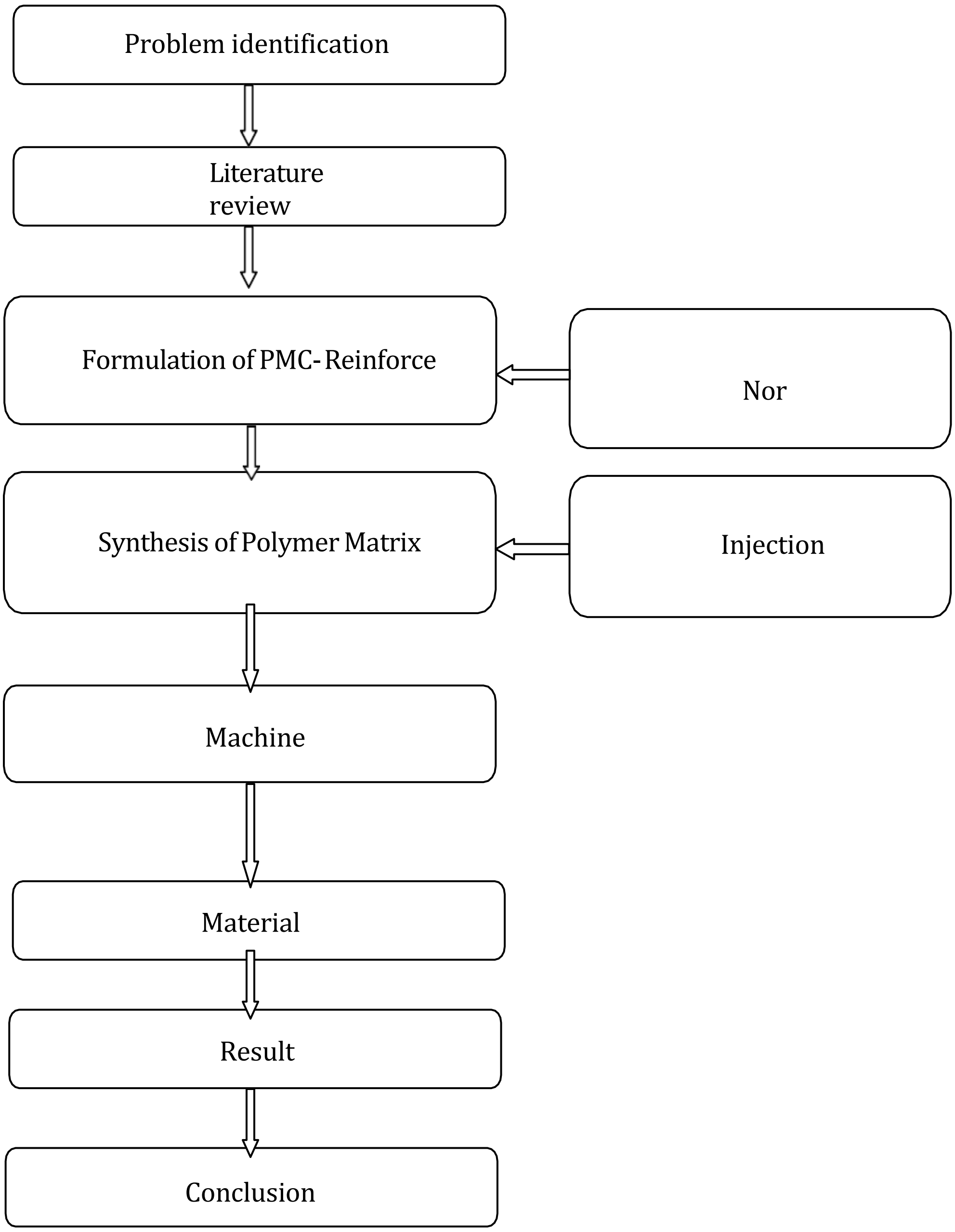
1.9.3 Applications

- Advancements for applications in space
- Advancements for gas turbine segments
- Use of oxide CMC in the burner and hot gas pipes
- Application in the brake plate
- Application in slide heading

CHAPTER-2

2.1 METHODOLOGY



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CHAPTER-3

3.1 CONCLUSION

In tensile test, it is observed the higher load values gradually withstand the percentage of the elongation and also it gives capacity for withstanding the higher load. The increase between 6.66 % and 18.5 by % elongation of 70 wt % noryl blend with 30 wt % glass fiber polymer composites showed the range of increase in material toughness and reflected the variation in yield stress. In flexural test, 70 wt % noryl blend with 30 wt % glass fiber polymer matrix composites specimens showed better flexural strength results. The flexural strength in the sample was observed to be higher in the range of 0.185 kN that showed that 70 wt % noryl blend with 30 wt % glass fiber is the ideal material for polymer matrix composites. Compressive stresses between 97-116 MPa verified that polymer matrix composites are more than 80 MPa ideal validating 70 wt % Noryl blend with 30 wt %. Composites are subject to compression stress in high toughness material conditions. Based on the results of the above studies, 70wt % noryl with a 30 wt % glass fiber polymer composites and 80wt % noryl with a 20 wt % glass fiber polymer composites were taken for testing gear.

CHAPTER-4

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