INVESTIGATION OF TUNGSTEN NANOPARTICLES IMPACT ON THERMAL PROPERTIES, STABILITY AND HEAT RESISTANCE OF GLASS FIBRE POLYMER COMPOSITES.

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Introduction

Most of the composite materials are made to obtain properties better than individual constituents. Composites are made of two or more components. The composites are custom-made to get better properties than individual constituents. Polymer composites reinforced with fibre are identified as Fibre Reinforced Polymers (FRP) composites. Composite materials are made up of two or more constituent phases, one is matrix, which acts as a continuous phase and the other the fibre acts as a reinforcing phase. Fibres increase the strength, stiffness, thermal and fatigue properties, better dimensional stability and electrical resistivity.

Due to high strength, low density and economical as compared to metals and their alloys, hybrid composites are widely used in various fields of applications like aerospace, marine, military weapons, automotive parts and windmill turbine blades. Plane polymer materials have certain disadvantages like, poor thermal stability, low-grade environmental and chemical stability, and low thermal conductivity. Hybrid Polymer Composites (HPCs) are the novel answer to high thermal resistivity and stability under varying thermal conditions. Hence, it is essential to improve the thermal and mechanical properties of polymer composites. To overcome such problems, composites need to be redesigned with various filler particles. In this context, the present research work aims to study the development of high thermal conductivity, high thermal stability and high strength polymer composites and carry out experimental investigations on the characterization of thermal properties for the enhancement of thermal resistivity of hybrid polymer matrix composites.

Objectives:

The objectives of the current work involve.

- Enhance the thermal conductivity of polymer composites by incorporating tungsten nanoparticles.
- Improve heat resistance and thermal stability for high-performance applications.
- Characterize the effect of tungsten nanoparticles on composite thermal properties using advanced analytical techniques.
- Develop high-performance materials for industries like electronics, aerospace, and automotive.

Methodology:

Glass fibres are first cut to the required dimensions and weighed. Epoxy resin, hardener, and fillers are measured according to standard calculations. The hardener and filler particles are added to the epoxy resin and thoroughly mixed until a thick paste is formed. A non-stick material is applied to the mould box, and a layer of epoxy resin-filler paste is spread. A sheet of glass fibre is placed on top, followed by another layer of paste, with additional layers of glass fibre and paste applied sequentially. Once all fibres are placed, the mould box is positioned in a compression moulding machine, where 20-25 bar pressure is applied without heating for 24 hours to allow for solidification. The prepared specimens are tested by conducting the Thermal conductivity, TGA and DSC experiments as per ASTM standards. The flow chart of the Methodology shown in below mentioned diagram.

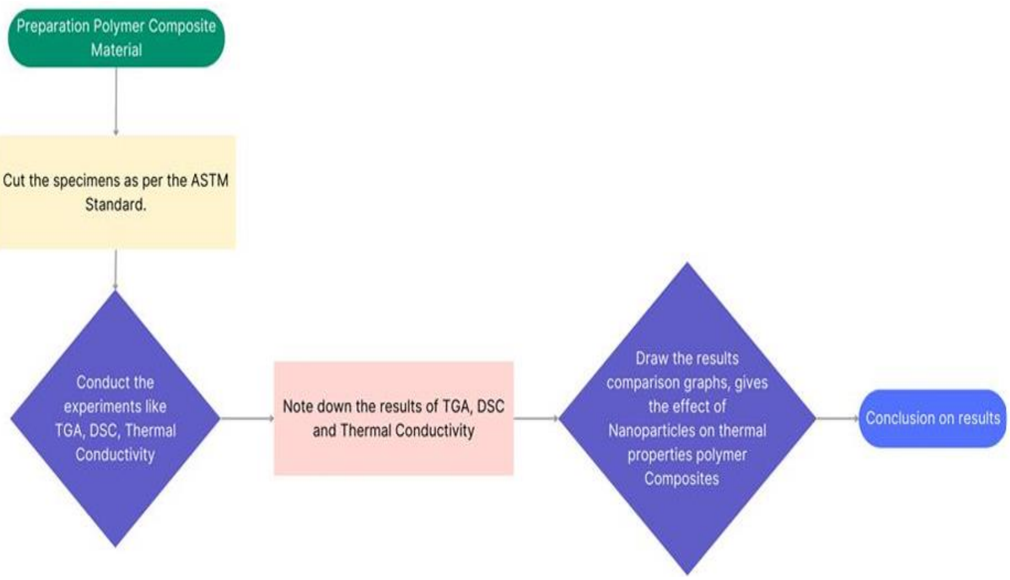

Figure 1: Methodology Flow Chart.

Results & Conclusions

- The thermal conductivity of Tungsten Nanoparticle Polymer composites improves as the percentage of tungsten nanoparticles increases. This enhancement occurs due to the high intrinsic thermal conductivity of tungsten, which facilitates better heat transfer within the polymer matrix. As more tungsten nanoparticles are added, they create additional conductive pathways, reducing thermal resistance and enhancing overall conductivity. The uniform dispersion of nanoparticles further optimizes heat flow by minimizing phonon scattering. Consequently, TNP composites become more efficient in thermal management applications, making them suitable for advanced electronics, aerospace, and automotive industries where superior heat dissipation is essential for performance and durability.
- Residue at 800°C in Thermogravimetric Analysis (TGA) refers to the remaining mass of a material after thermal decomposition. It indicates the presence of thermally stable components, such as inorganic fillers, metals, or ceramics, that do not decompose or volatilize at high temperatures.
- Transition temperature, particularly Glass Transition Temperature (Tg), is a critical property of polymer composites, defining the temperature at which the epoxy matrix transitions from a rigid, glassy state to a soft, rubbery state. Incorporating Tungsten Nanoparticles influences the thermal and mechanical performance of epoxy resin glass fiber composites by affecting Tg and related properties.

Project Outcome & Industry Relevance

- Increasing tungsten nanoparticle content in polymer composites effectively enhances thermal conductivity, making them suitable for high-performance thermal applications.
- Residue at 800°C in TGA provides valuable insights into a material's composition, thermal stability, and filler content. It is particularly useful for assessing polymer composites, ceramics, and nanomaterials in industries like aerospace, electronics, and thermal management applications. A high residue percentage confirms the presence of thermally resistant materials, while a low percentage suggests more organic content.
- The addition of tungsten nanoparticles generally increases the transition temperature of epoxy resin glass fiber composites, leading to improved thermal

and mechanical stability. However, excessive loading may reduce Tg due to agglomeration effects. Optimal nanoparticle dispersion is crucial for maximizing benefits.

- In polymer composites, residue analysis helps determine the fraction of reinforcing fillers like metal oxides or carbon-based materials. This data is crucial for evaluating thermal stability, composition, and material performance in high-temperature applications like aerospace and electronics.

Working Model vs. Simulation/Study:

Experimental Study analysis of thermal properties of Tungsten Nanoparticles polymer composite materials.

Project Outcomes and Learnings:

- Enhanced thermal conductivity of polymer composites through the integration of tungsten nanoparticles.
- Improved heat resistance and better thermal stability under varying environmental conditions.
- Increased material durability with superior performance in high-temperature applications.
- Insight into nanoparticle dispersion effects on composite properties.

Future Scope

- Different nanoparticles (Copper, Manganese, SiC, etc.) added to glass fibre epoxy resin composites and finding their thermal properties, helps in finding the comparison results.
- Varying the percentage of nanoparticles in the glass fibre epoxy resin composites and finding their thermal properties, will help in finding the suitable composites based on applications.
- Establishing the new combination of composite materials, studying their thermal properties according to the application needs.
- Cryogenic behaviour of hybrid polymer composites at drastic temperature variations.
- Development of advanced materials for industries like aerospace, automotive, and electronics.
- Experimental data for optimizing composite formulations for specific thermal requirements.