Exploring Nanomaterials in Carbon Fibre Sizing: Pilot Line Optimization

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ABSTRACT

With market demands in the composite sector and annual productivity continually on the rise, the global carbon fibre & carbon fibre reinforced polymers market is projected to hit 35.5 billion USD by 2025, showing a compound annual growth rate of 12.4% during the forecast period. This demand is driven by heightened needs for carbon fiber in aerospace and wind energy industries due to the enhanced mechanical and physical properties that carbon fibre reinforced polymers present. In addition to technological advancements, there's a pressing need for comprehensive scientific exploration to enable multifunctionality in advanced composite materials. This research examines both optimal operational conditions and nano-enhanced sizing solutions to deliver optimum outcomes in surface morphology and mechanical properties of carbon fibres [1-3].

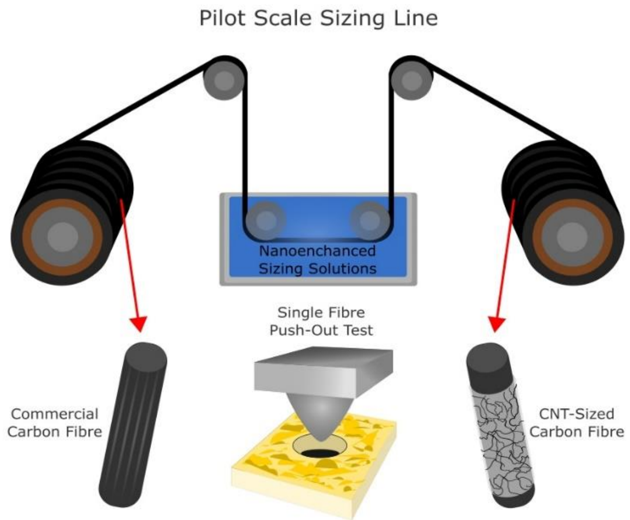

Figure 1: Graphical presentation of the main process.

The development and optimization of a pilot-scale sizing line aims at achieving uniform sizing on carbon fibers for enhanced production efficiency. The main aspect of the investigation focuses on identifying critical parameters essential for achieving uniform sizing and determining optimal conditions to maximize production efficiency.

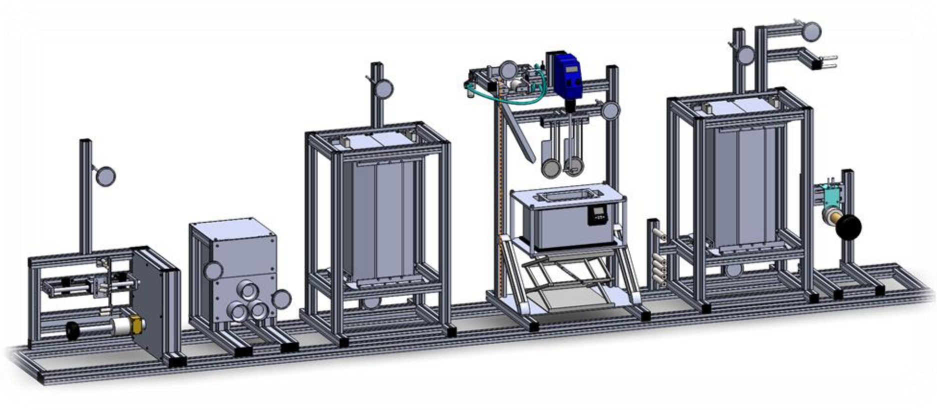

Figure 2: The pilot scale sizing line via SolidWorks.

The study achieves a production rate of 1 meter of sized carbon fibers per minute by employing specific parameters, such as a desizing temperature of 550°C, drying temperature of 250°C, and residence time of 1 minute. Additionally, the research explores various sizing solutions, including carbon-based nanomaterials with different surface functionalizations and concentrations. In-depth analyses, including scanning electron microscopy and contact angle goniometry, demonstrate the successful attainment of a uniform coating on the carbon fiber surface, enhancing the affinity between fibers and the polymeric epoxy matrix. Notably, the incorporation of nanomaterials, such as N_2-plasma-functionalized carbon nanotubes and few-layer graphene, leads to significant improvements in interfacial shear properties, as confirmed by mechanical and push-out tests.

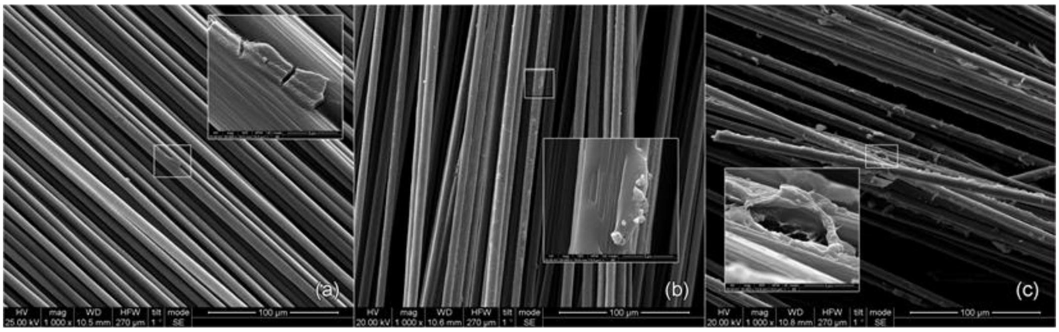

Figure 3: Solid content concentration study of (a) 1, (b) 2.5 and (c) 5% wt at 1000× magnification and 20,000× magnification.

KEYWORDS: sizing, carbon fibre, fibre matrix interface, push-out test

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