Review

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CNT-reinforced Metal and Steel Nanocomposites: A Comprehensive Assessment of Progress and Future Directions

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Abstract:

Carbon nanotubes (CNT) are rolled graphene sheets and are an exceptional invention in the field of nanotechnology. They have outstanding material characteristics such as high surface-to-volume ratio, high tensile strength, high thermal conductivity, and low density. Carbon nanotubes are many times stronger and yet lighter than steel and other metals, and thus a good candidate for reinforcing them. However the integration of CNTs into a metal or steel matrix is challenging and dispersion uniformity depends on processing parameters. The composite material properties are a function of the uniformity of CNT dispersion, interfacial bonding, CNT weight percent, length and alignment with the matrix. This paper reviews various methods of processing CNT-metal and CNT-steel nanocomposites, and their reported mechanical and material properties. Ways to overcome technical challenges are proposed and potential applications of CNT-steel composites as next generation structural material for the operationally demanding offshore oil petroleum industry are specifically discussed.

Keywords: nanocomposite, CNT, reinforcement, metal, steel, oilfield, challenges

1. Introduction

1.1 Carbon nanotubes

Carbon nanotubes have been the focus of intense research due to their many exciting physical and chemical properties since their discovery from a carbon arc discharge tube by Iijima in 1991 [1]. CNTs are rolled configuration of graphene sheets and depending upon the ways they are rolled up, they are given with various names such as zigzag, chiral, and armchair. Based on the chiral angle between the carbon hexagons and tube axis CNTs show insulator/semiconductor nature [2]. CNTs are generally classified into three types: single wall CNT (SWCNT), double wall CNT (DWCNT), and multiwall CNT (MWCNT). They differ from each other in length, diameter, densities and mechanical properties and hence their suitability for specific tasks [3, 4]. There are various ways of making CNTs, such as electric arc discharge [5, 6], chemical vapour deposition (CVD) [7, 8], plasma enhanced CVD (PECVD) [9, 10] and catalytic method [11, 12]. Carbon nanotubes are thermally conductive and strong like diamond while electrically conductive, light and flexible like graphite. Hence CNTs are said to have the properties of diamond and graphite. There are various other applications of CNTs such as in fabrication of transistors, voltage inverters, sensors, field emission sources [13, 14], and energy storage devices [15]. Mechanical properties and light density of CNTs are highly promising for making strong nanocomposites. The sp^2 hybridised