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The concentration influence of multi-walled carbon nanotubes coating on fatigue edge crack growth and other mechanical properties of Al 7075-T6 thin plates

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ABSTRACT

In the current study, the incline edge crack growth behavior in an aluminum alloy 7075-T6 specimens (which were coated using nickel-carbon nanotubes electroless coating) has been investigated undergoes uniaxial tensile fatigue loading. High purity multi walled carbon nanotubes have been used in nano-coating solutions with various concentrations (1 g/l, 2 g/l and 3 g/l) to examine the improvement extent of fatigue crack growth resistance and other mechanical properties. Water jet technique was used to cutting aluminum plates to the required dimensions before the nano-coating procedure. Multi-purpose fatigue apparatus has been adopted to apply tensile fatigue loading with zero stress ratios. High magnification camera with image j software has been utilized to measure the propagated crack lengths with the number of fatigue cycles. To inspection the quality, thickness uniformity and homogeneity of the nano-coating layer over specimen surfaces, EDXRF and FESEM techniques have been adopted in this study. Numerical simulation using ABAQUS 2021 programming was performed for the purpose of the results validation. The measured results offered a 25.9 %, 44.5 % and 47.9 % increasing in the hardness of the coated specimens using 1 g/l, 2 g/l and 3 g/l MWCNTs respectively. The modulus of elasticity produced an increasing of 26.7 %, 44.4 % and 46.3 % for the coated specimens using 1 g/l, 2 g/l and 3 g/l MWCNTs respectively. The nano-coating with 2 g/l MWCNTs produced more homogeneous, uniform thickness coating layer and fatigue crack growth resistance than that of the coated specimens using other concentrations of MWCNTs. The similarity in the crack growth behavior was the major outcome of the results validation from the fatigue tests and numerical simulation.

1. Introduction

A few decades ago, the world scientific research focused on improvement, designation and then testing lighter-weight and highly effective materials in significant applications such as: automotive and aeronautic industries [1–3]. Among the most commonly used materials is aluminum alloy (AA7075), which has a wide range of uses, including the fabrication of aircraft parts like the fuselage and wings, for which it is necessary to have acceptable mechanical and thermal characteristics [4,5]. However, these parts and equipment which used in automotive and aeronautic fields often suffered from a variety of loading situations, especially fatigue loading over its operational lifespan. Therefore, the scientific improvement efforts resulted to production many new classes of materials like: hybrid composite materials and metallic alloys coated by nano-composite materials [6–11]. Generally, using nano-coatings which involves adding materials in nano-scale with various amounts to coating solution based on the used coating type, the purity and characteristics of the used nano-materials, the necessary coating thickness, as well as the intended application of the coating [12,13]. One of the most important nano-materials used in the process of coating metal materials is carbon nanotubes (CNT), which have received the attention of many researchers because of their superior physical, mechanical and thermal properties (high aspect ratio, low density, excellent strength and stiffness, exceptional thermal and electrical conductivities, as well as low coefficient of thermal expansion) [14–19].

A common coating technique for creating CNT-reinforced metal matrix composite with acceptable deposition and adhesion between the metal and CNT is electro-deposition coating. On the other hand, this

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