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**Name:** NAPISAH BINTI SAPIAI  
**Title:** MECHANICAL AND WEAR PROPERTIES OF FUNCTIONALISED CARBON NANOTUBES MODIFIED KENAF COMPOSITES  
**Supervisor:** ASSOC. PROF. DR. AIDA JUMAHAT (MS)  
ASSOC. PROF. IR. DR. JAMALUDDIN MAHMUD (CS)

Natural fibres reinforced polymer composites have been gaining great attention in several applications due to its eco-friendly nature, sustainability, stronger and cost effective. Among all natural fibres available, kenaf fibre has been identified as an attractive option for reinforcing fibres due to its availability, high aspect ratio and superior toughness properties. However, limitation arise with respect to the mechanical properties when kenaf fibres and epoxy resin are used. The combination of these materials has been reported to have poor-matrix interfacial adhesion due to hydrophilic kenaf fibres and hydrophobic epoxy resin in nature. In addition, majority of epoxy systems are degraded by their brittleness property, low impact strength and low fracture toughness.

The objective of this study is to improve the properties of the kenaf fibres reinforced composites by incorporating carbon nanotubes (CNT) in epoxy matrix and hybridised with glass fibres. Moreover, the study was focused on the functionalisation of CNT surface via concentrated acid and amino silane. This surface modification aims to enhance the dispersibility of CNT into epoxy matrix and improve the interfacial adhesion bonding between three phases (CNT/epoxy/kenaf fibres) composites. In this study, the modified epoxy with 0.5, 0.75 and 1.0 wt% pristine CNT (PCNT)/ acid treated (ACNT)/silane treated (SCNT) was impregnated with kenaf fibres to fabricate the kenaf fibres reinforced composites system. The woven glass fabrics (G) plies were placed at top and underneath kenaf fibres (K) in fabrication of hybrid G/K fibres composites system. The effect of CNT addition and functionalised CNT on the longitudinal and transverse tensile, flexural, compressive, impact and wear properties of kenaf and hybrid G/K composites were studied. Several types of analytical methods such as X-Ray Diffractionmetry (XRD), Transmission Electron Microscopy (TEM), Fourier Transforms Infrared Spectroscopy (FTIR) and Scanning Electron Spectroscopy (SEM) were used to examine these composites. FTIR tests showed the presence of Si-O and Si-OH functional groups on silane treated CNT surface at peak 803 and 1070 cm⁻¹, respectively. This results in improved dispersion and interfacial bonding between CNT and epoxy resin as shown in TEM and SEM micrographs. The inclusion of SCNT improved the mechanical properties of kenaf and hybrid glass/kenaf composites. The maximum improvements were achieved at 1.0 wt% of SCNT loading. For example, the 1.0SCNT-modified kenaf composites were improved about 43.39% for longitudinal tensile strength, 28.2% for transverse tensile strength, 21.1% for flexural strength, 20.15% compressive strength and 130.6 % for impact strength when compared to kenaf composite. In addition, the 1.0SCNT-modified hybrid glass/kenaf composites were improved about 48.78% for longitudinal tensile strength, 19.36% for transverse tensile strength, 11.36% for flexural strength, 7.73% compressive strength and 24.45% for impact strength when compared to hybrid G/K composite. However, the inclusion of SCNT did not improve the wear properties due to rougher worn debris produced that induced the three-body abrasive wear effect, thus increased the wear rates of the kenaf composites. When hybridised with glass fibres, the kenaf composites showed improvement of 40.0% for longitudinal tensile strength, 86.9 % for transverse tensile strength, 155% for impact strength and 49.1% for flexural strength. In contrast, there is insignificant improvement in compressive and wear properties due the premature failure of the specimens when subjected to compressive load and glass fibres were easily pulverised when exposed to abrasive roller.

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**Name:** SUHADIYANA BINTI HANAPI  
**Title:** APPLICATION OF SYSTEM IDENTIFICATION METHOD COUPLED WITH EVOLUTIONARY ALGORITHMS FOR THE OPTIMIZATION OF POWER CONSUMPTION IN A PEM FUEL CELL PROPULSION SYSTEM  
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Fuel cell vehicles have the potential to address the problems surrounding the ICE vehicle, without forcing any significant restrictions on vehicle performance, driving range or refueling time. The fuel cells will however need to work at different operating points because of the dynamic load characteristic where current is drawn instantaneously from the load source connected to the fuel cell stack during transient conditions. Research on fuel cell vehicle design is therefore imperative in order to improve vehicle performance in terms of energy usage and durability, increase efficiency and reduce the fuel costs. This thesis makes a number of key contributions to the advancement of fuel cell vehicle design within two main research areas; powertrain system design based on quality energy and optimization system based on biology based algorithms. With regards to powertrain design, this research first evaluates the quantitative and qualitative energy efficiency and fuel consumption of the hydrogen fuel cell propulsion system under various system design configuration conditions. Exergy analysis was performed for each type of plant. Three alternative configurations of a vehicle system were considered namely, without DC/DC converter, with DC/DC converter on the supercapacitors side and with DC/DC converter on the PEM fuel cell side. In the process of evaluating the best system configuration, Multi-Criteria Decision Making technique (MCDM) through the Analytical Hierarchy Process (AHP), was used for evaluation, comparison and applicability assessment. The ability to construct accurate mathematical models of real systems is an important part of the control parameters in prototype PEM fuel cell systems for vehicles. Secondly, in this research, an empirical dynamic model of the PEM fuel cell system in vehicles was analyzed and validated using the system identification method. This thesis involved the development of an empirical mathematical model for offline identification based on the commercial PEM fuel cell stack from Horizon to predict the dynamic behavior in the fuel cell system. The system identification is used to locate approximate models of PEM fuel cell stack in vehicles based on observed input-output data pairs. The PEM fuel cell can be modeled as a Multi-Input Single-Output (MISO) system, where the inputs are hydrogen pressure, air speed and vehicle speed, and the output is power. The parametric identification of the fuel cell stack using Least Squares (LS) with Auto-Regressive Exogenous input (ARX) model structure was considered. Finally, to optimize the PEM fuel cell system parameters, two different optimization techniques, namely the Particle Swarm Optimization (PSO) and Differential Evolution (DE) techniques were incorporated into the system. The main objective of this investigation is to optimize the PEM fuel cell system parameters using two different types of intelligent optimization techniques for different constant speed in vehicles. The optimum parameters identified were tested through experimental work to evaluate the performance of the system. The outcome was decided that the system with DC/DC converter on the PEM fuel cell side is the best configuration with power as the main weighted (0.6). The findings of the study also demonstrate that the DE optimization technique is the best method with lower Integrated Absolute Error (IAE) value and fast convergence compared with PSO method for the vehicle system for excellent performance.