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NEURAL NETWORK-BASED PREDICTION MODELS FOR PHYSICAL PROPERTIES OF OIL PALM MEDIUM DENSITY FIBERBOARD

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AUTHOR'S DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulation od Universiti Teknologi MARA. It is original and is the results of my own work, unless otherwise indicated or acknowledged as referenced work. This topic has not been submitted to any other academic institution or non-academic institution for any degree or qualification.

I, hereby, acknowledge that I have been supplied with the Academic Rules and Regulations for Post Graduate, Universiti Teknologi MARA, regulating the conduct of my study and research.

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ABSTRACT

Medium Density Fiberboard (MDF) is an alternative to solid wood used in furniture industries. As an engineered wood, MDF needs to establish the strength level to guarantee its quality. The test procedures for mechanical and physical properties of MDF should conform to a specified standard, prior to releasing processed fiberboards for manufacturing. These tests are costly for they involve a high amount of resources, especially to research institutions. The primary aim of this research is to reduce testing time of three lengthy procedures; namely, 24-hour thickness swelling, 24-hour water absorption and 48-hour moisture content. An intelligent predictive model will replace the lengthy procedures by predicting the properties using known fiberboard characteristics. Back-propagation algorithm is a training method widely used in a multilayer perceptron Neural Network model. It optimizes random values for network weights and biases. However, the result normally faces local optima problems. This situation can be solved by embedding Genetic Algorithm (GA) in the network to replace back-propagation method. GA uses its reproduction capability to evolve from local minima scenario through crossover and mutation opèrators. Crossover and mutation activities contribute towards the quality of offspring and the operators' probability rates control the chances of reproduction. Nevertheless, a fixed probability rates will cause convergence to be slower; for the activities constantly take place regardless of the changes in population fitness. Therefore, adjustment for suitable rates is important. Adaptive mechanism adapts the best parameters of current generation for optimum performance in the next generation. A variable rate adapts with the current population environment and therefore increases the searching ability. A new adaptive mechanism is done by scanning through the fitness mean and median of the population using the prediction error. Through rank selection technique, the chromosomes are sorted based on the fitness function to learn about the population of current generation. The adaptive mechanism on GA has allowed earlier convergence as compared to the ordinary GA with fixed probability rates. Comparison analysis shows the cost difference using the new method and the existing method to prove method efficiency. This research discusses three predictive models using multilayer perceptron NN with different optimizers. The first model uses BP; the second is hybrid GA-NN model; and finally a hybrid GA-NN model with an adaptive mechanism. The result has reduced time taken and experimental cost for the lengthy testing procedures. Consequently, during the experimental tests, pilot plants will only need to carry out tests, which consume minimum time to complete. The novelty of the research is a hybrid GA-NN model with new adaptive mechanism, along with contributions of reduction in experimental time and costs for MDF testing.

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CHAPTER ONE
INTRODUCTION TO THE RESEARCH

Medium Density Fiberboard (MDF) is a board panel made of fiber, which has been used in furniture industry for the past three decades. Malaysia is the world's top three MDF exporters with an annual total production of more than two million cubic meters. The country exports some 80% of its production and the remainder goes to the domestic consumption (Shahwahid and Rahim, 2009). The higher demand in MDF has called for more in-depth research in analyzing the product further.

1.1 BACKGROUND OF THE RESEARCH

Engineered wood product is a major competitor to solid wood with an advantage of free-form shapes. MDF is stronger and denser than plywood and any normal particleboard. The name derives from the distinction in densities of fiber content per meter cube. Fiber resources are mainly from wood leftover, which support green environment. On top of that, the success of MDF is due to its smoother surface, knot free (Figure 1.1) and it is certainly cheaper as compared to solid wood. It has been proven that MDF is able to maintain high durability as compared to particleboard, plywood and oriented strand board (Kojima and Suzuki, 2010). Among others, MDF is used for household products, building and automotive interior, and furniture.

The Malaysian wood-based sector has become one of the most important sectors in the country over the last two decades. MDF industry currently has 15 plants with a total annual installed capacity of 2.9 million cubic meters. In 2011, exports of MDF from Malaysia amounted to RM1.1 billion, hence, making Malaysia the world's third largest exporter of MDF, after Germany and France. MDF from Malaysia has attained international standards such as BS-EN (British Standard – European Norm) standards (Malaysian Investment Development Authority [MIDA], 2012a).