ABSTRACT

Polymer Electrolyte Membrane (PEM) Fuel Cell is a source of an electrical energy for electric vehicles in the future because it has a distinctive when compared with other energy sources. PEM Fuel Cell has a high specific energy of 508Wh/kg and can supply a high electrical power. This study used to determine the characteristics of the fuel cell has been done by previous researchers using both conventional approaches and artificial intelligence-based. A conventional model is a complex system because it involves mathematical model, theory of electrochemistry, thermodynamics, hydrodynamics and mass transfer. A developed model based on artificial intelligence relies on numerical calculations and iterations that done by computer to simplify step of the modeling.

This dissertation discusses two main topics, namely modeling of PEM Fuel Cell based on neural network and modeling of electric vehicle system with a PEM Fuel Cell. Neural network model is used to determine and analyze the characteristics of the stack voltage of PEM Fuel Cell to changes in pressure, temperature and current stack. The model was developed using one hidden layer with 4 neurons. Back propagation algorithm is used to train the neural network. The data for the training is obtained from the PEM Fuel Cell characteristic that was first modelled in mathematical equations.

The next major topics discussed in this dissertation is a model of electric vehicle system that integrated between components such as the vehicle model, the PEM Fuel Cell model based on neural network, and the fuel consumption model. The vehicle model contains calculations to determine the consumption of electric energy with the speed and acceleration of the vehicle as the input. The PEM Fuel Cell model based on neural network predicts the stack voltage in the event of change of the electric vehicle speed. Input of the PEM Fuel Cell model based on neural network is the electric vehicle energy consumption. Slew the load current is used to determine the consumption of the hydrogen and air. Integration of the three models are then used to determine the power requirements and efficiency of PEM Fuel Cell, the required hydrogen tank size, the range and driving time of the electric vehicle and the product of PEM Fuel Cell in the form of heat and water.

PEM Fuel Cell model based on the neural network was able to predict the stack voltage from the input of the stack pressure, temperature and stack current with results close to the desired target. The average error of the neural network model is 0.37%, while the equivalent circuit model has the average error of 1.29%. The vehicle system model with the PEM Fuel Cell is able to predict the stack voltage from the change of the vehicle speed with an average error of 0.52% of the target set.

The integration model that consists of the vehicle model, the model of the PEM Fuel Cell based on the neural network and the fuel consumption model is able to predict of the stack voltage to changes in the vehicle speed. By using a testing standard ECE-15, 1200kg of vehicle weight, 3.92 kg of hydrogen and 2x6 kW of the PEM Fuel Cell, the developed model is able to predict the hydrogen usage of 0.2286 kg/h, the driving range of 368.5 km, the required average electrical power of 5kW, the PEM Fuel Cell stack voltage of 107.8 V and stack current of 46.51 A.

Key words: Neural Network Model, PEM Fuel Cell, Electric Vehicle