Perancangan Strategi Manajemen Energi Berbasis Optimasi dan Rule-Based Berdasarkan Estimasi Kebutuhan Daya Kereta Hibrid = Design of Optimization and Rule-Based Energy Management Strategy Based on Estimation of Hybrid Train Power Demand

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Abstrak

Penggunaan bahan bakar minyak pada lokomotif diesel akan menghasilkan emisi khususnya senyawa CO2 yang menyebabkan terjadinya pemanasan global. Salah satu moda transportasi umum di Indonesia yaitu kereta khususnya kereta antar kota saat ini masih menggunakan mesin diesel sebagai sumber energi utamanya. Untuk itu, perlu dikembangkan solusi penggunaan sumber energi bebas emisi yaitu fuel cell beserta strategi manajemen energi (EMS) untuk kereta hibrid di mana kebutuhan daya kereta dapat didistribusikan dari sistem distribusi daya lainnya seperti baterai, supercapacitor, dan jaringan suplai daya DC. Besar kebutuhan daya kereta yang akan didistribusikan dari sistem perlu diestimasi dengan mengevaluasi profil kecepatan dan geometri lintasan di sepanjang siklus perjalanan kereta. Setelah estimasi kebutuhan daya kereta dilakukan, distribusi daya dari masing-masing sistem penyimpanan energi akan diatur menggunakan algoritma strategi manajemen energi berbasis aturan dan optimasi yang kemudian akan dianalisis performanya berdasarkan perhitungan biaya yang dihasilkan. Berdasarkan hasil simulasi pada model empiris kereta hibrid mode ganda, diperoleh biaya selama siklus perjalanan kereta yaitu sebesar 18,48 € untuk strategi state machine control (SMC) dan sebesar 17,6 € untuk strategi equivalent consumption minimization strategy (ECMS). Selain itu, dapat diketahui bahwa model electric-circuit dapat lebih menggambarkan perilaku dinamis konverter dalam meregulasi arus fuel cell dan baterai, serta tegangan DC bus.

.....The use of fuel oil in diesel locomotives will produce emissions, especially CO2 compounds that cause global warming. One of the modes of public transportation in Indonesia, namely trains, especially intercity trains, currently still uses diesel engines as its main energy source. For this reason, it is necessary to develop solutions for using emission-free energy sources, namely fuel cells along with an energy management strategy (EMS) for hybrid trains where the train's power demand can be distributed from other power distribution systems such as batteries, supercapacitors, and DC power supply networks. The amount of train power required to be distributed from the system needs to be estimated by evaluating the speed profile and track geometry throughout the train cycle. After the estimation of the train's power demand is made, the power distribution of each energy storage system will be adjusted using a rule-based and optimization based energy management strategy algorithm which will then be analyzed for its performance based on the resulting cost calculations. Based on the simulation results on a empirical model of dual-mode hybrid train, the cost during the entire train cycle is 18.48 € for the state machine control (SMC) strategy and 17.6 € for the equivalent consumption minimization strategy (ECMS). In addition, it can be seen that the electric-circuit model can better describe the dynamic behavior of the converter in regulating the fuel cell and battery currents, as well as the DC bus voltage.