

INTISARI

Peningkatan penggunaan kendaraan listrik sebagai salah satu strategi pengurangan emisi, perlu didukung dengan perancangan produk yang mempertimbangkan proses *product recovery* pada tahap akhir masa pakai. Kendaraan listrik memiliki arsitektur yang kompleks, sehingga proses pembongkaran, penggunaan kembali, dan daur ulang dapat menjadi sulit apabila arsitektur produknya tidak dirancang secara modular. Penelitian ini bertujuan untuk menilai tingkat modularitas arsitektur kendaraan listrik saat ini dan menyusun rekomendasi *redesign* yang lebih *eco-modular*.

Objek penelitian yang digunakan adalah mobil listrik Arjuna *series* E71. Penelitian dilakukan menggunakan metode *Design Structure Matrix* (DSM) untuk memetakan hubungan antarkomponen. Penilaian modularitas dilakukan berdasarkan empat *modular driver*, yaitu *interface complexity*, *material similarity*, *lifespan similarity*, dan *disassembly constraint strength*. Evaluasi dilakukan menggunakan nilai *Module Independence* (MI), *Module Similarity* (MS), *Disassembly Module Independence* (DMI), dan *Modularity for End of life* (MEoL). Selanjutnya, dilakukan *redesign* menggunakan *Markov Cluster Algorithm* (MCL) dengan *weighted average matrix*.

Hasil penelitian menunjukkan bahwa arsitektur eksisting memiliki nilai MI sebesar 0,572, MS material sebesar 0,418, MS *lifespan* sebesar 0,560, DMI sebesar 0,542, dan MEoL sebesar 0,523. Setelah dilakukan *redesign*, seluruh parameter meningkat, yaitu MI sebesar 0,678, MS material sebesar 0,688, MS *lifespan* sebesar 0,775, DMI sebesar 0,615, dan MEoL sebesar 0,689. Peningkatan nilai tersebut menunjukkan bahwa arsitektur usulan memiliki tingkat modularitas yang lebih baik dibandingkan arsitektur eksisting, sehingga lebih mendukung proses *product recovery* pada tahap akhir masa pakai.

Kata Kunci: *Eco-Modular, Design Structure Matrix, Kendaraan Listrik, Markov Cluster Algorithm, Product Recovery.*

ABSTRACT

The increasing use of electric vehicles as one of the strategies for emission reduction needs to be supported by product design that considers the product recovery process at the end of life stage. Electric vehicles have complex product architectures, which can make disassembly, reuse, and recycling processes difficult if the product architecture is not designed modularly. This study aims to assess the modularity level of the current electric vehicle architecture and develop redesign recommendations for a more eco-modular architecture.

The research object used in this study is the Arjuna E71 electric vehicle. The study was conducted using the Design Structure Matrix (DSM) method to map the relationships between components. The modularity assessment was carried out based on four modular drivers, namely interface complexity, material similarity, lifespan similarity, and disassembly constraint strength. The evaluation was performed using Module Independence (MI), Module Similarity (MS), Disassembly Module Independence (DMI), and Modularity for End-of-Life (MEoL). Furthermore, the redesign process was conducted using the Markov Cluster Algorithm (MCL) with a weighted average matrix.

The results show that the existing architecture has an MI value of 0.572, material MS of 0.418, lifespan MS of 0.560, DMI of 0.542, and MEoL of 0.523. After the redesign process, all parameters increased, with an MI value of 0.678, material MS of 0.688, lifespan MS of 0.775, DMI of 0.615, and MEoL of 0.689. These improvements indicate that the proposed architecture has a higher level of modularity than the existing architecture, making it more supportive of product recovery at the end of life stage.

Keywords: *Eco-Modular, Design Structure Matrix, Electric Vehicles, Markov Cluster Algorithm, Product Recovery.*