

A Green Routing Approach for Integrated Disassembly Line Balancing with 3D Printing

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Abstract

Additive manufacturing technologies have become increasingly important in modern supply chains. Among these technologies, 3D printing offers new opportunities to improve the efficiency of reverse logistics operations. This study extends the integration of 3D printing and disassembly line balancing by explicitly considering carbon emissions generated during transportation activities. To this end, a novel optimization framework is proposed that coordinates end-of-life (EOL) product disassembly operations with environmentally sustainable distribution decisions. EOL products are disassembled at a disassembly centre, and the recovered components are used to satisfy demand. When the required number of components cannot be obtained through disassembly, additional components are produced using 3D printers. These components are then delivered to remanufacturing facilities by a fleet of capacitated vehicles. Unlike existing studies that primarily focus on economic performance, the proposed approach incorporates carbon emissions into routing decisions, enabling a more comprehensive evaluation of both economic and environmental objectives. To support environmentally sustainable logistics operations, the transportation process is modelled as a green vehicle routing problem in which both transportation costs and carbon emissions are considered. The integration of disassembly operations, 3D printing decisions, and green vehicle routing activities leads to a new problem called the Integrated Disassembly Line Balancing and Green Routing Problem with 3D Printers (I-DLB-GRP-3DP). A mixed-integer mathematical model is developed. Computational experiments are conducted under different operational conditions to evaluate the proposed approach. The proposed model contributes to the development of smart, efficient, and sustainable reverse supply chain networks.

Keywords

Disassembly line balancing, Additive manufacturing, Green vehicle routing, Smart manufacturing

Biography

Dr. Zülal Kenger is a faculty member in the Department of Industrial Engineering at Gaziantep University, Türkiye. Her research interests include operations research, mathematical modeling, supply chain management, reverse logistics, sustainable manufacturing, disassembly line balancing, vehicle routing, additive manufacturing, and smart manufacturing systems. Her work focuses on developing optimization models that integrate production, logistics, and sustainability considerations in forward and reverse supply chains. Dr. Kenger has contributed to academia through numerous journal articles and conference papers. During her doctoral studies, she was supported by the YÖK 100/2000 Doctoral Scholarship Program and the TÜBİTAK 2211-C Doctoral Scholarship Program.