

## A Sustainable Design Model by Integrated Evaluation of Closed-loop Design and Supply Chain Using a Mathematical Model

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**Abstract :** The paper presented a sustainable design model for integrated evaluation of the design and supply chain of a product for the sustainable objectives. To design a product, there can be alternative ways to assign the detailed specifications to fulfill the same design objectives. In the design alternative cases, different material and manufacturing processes with various supply chain activities may be required for the production. Therefore, it is required to evaluate the different design cases based on the sustainable objectives. In this research, a closed-loop design model is developed by integrating the forward design model and reverse design model. From the supply chain point of view, the decisions in the forward design model are connected with the forward supply chain. The decisions in the reverse design model are connected with the reverse supply chain considering the sustainable objectives. The purpose of this research is to develop a mathematical model for analyzing the design cases by integrated evaluating the criteria in the closed-loop design and the closed-loop supply chain. The decision variables are built to represent the design cases of the forward design and reverse design. The cost parameters in a forward design include the costs of material and manufacturing processes. The cost parameters in a reverse design include the costs of recycling, disassembly, reusing, remanufacturing, and disposing. The mathematical model is formulated to minimize the total cost under the design constraints. In practical applications, the decisions of the mathematical model can be used for selecting a design case for the purpose of sustainable design of a product. An example product is demonstrated in the paper. The test result shows that the sustainable design model is useful for integrated evaluation of the design and the supply chain to achieve the sustainable objectives.

**Keywords :** closed-loop design, closed-loop supply chain, design evaluation, supply chain management, sustainable design model

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