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POST-INDUSTRIAL RECYCLING AND REUSE STRATEGIES: A COST MODEL ANALYSIS

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Summary: The disposal of industrial waste in the automotive sector presents significant economic and environmental challenges. This study explores post-industrial recycling and reuse strategies through a cost model and environmental impact analysis, focusing on the separation and valorization of multi-material components. The research centers on composite plates composed of two primary materials: a plastic component (PBT+GF) and multiple steel inserts. To enhance resource efficiency and minimize waste, a specialized separation system was designed to process parts that do not meet quality control standards. This system effectively disassembles rejected components, generating distinct waste streams that can be directed toward recycling or reuse.

The study evaluates the economic and environmental impacts of three key approaches: reusing the composite plates within the production process, selling them to third parties, and incineration as an end-of-life solution. The economic assessment was conducted using a cost model that measures the financial implications of eachMarco Leite strategy, including material separation, the need for specific molds, and logistics. Additionally, an aggregated cost model was developed to assess the continuous operation of the separation machine with different parts of the same product family. This broader approach enabled the analysis of cost variations under different production conditions, highlighting the economic feasibility of sustained material recovery.

To evaluate environmental impacts, a Life Cycle Assessment (LCA) was applied, considering emissions, waste generation, and material recovery efficiency. Results indicate that reusing the composite plates within the production process can lower costs and minimize environmental impact, provided that the recovered materials meet technical standards for reuse. Selling the materials to third parties emerges as a financially viable alternative, though it is highly dependent on market demand and logistical feasibility. In contrast, incineration presents significant drawbacks, as it reduces waste volume but results in high operational costs and negative environmental impacts, including pollutant emissions and the loss of valuable materials.

A sensitivity analysis revealed that the feasibility of each approach is strongly influenced by production volume. While reuse becomes more cost-effective in large-scale production, selling to third parties is contingent upon external factors such as market demand and transportation costs. Incineration, despite its straightforward implementation, is generally the least sustainable option due to high energy consumption and environmental harm. The study further highlights that certain recycling and reuse scenarios result in significantly higher cost impacts than others, with factors such as material composition, processing efficiency, and market conditions playing a crucial role in determining the financial viability of each waste stream.

Overall, this research contributes to the advancement of sustainable manufacturing practices by integrating cost modeling with environmental impact assessments. By providing a comparative analysis of recycling and reuse strategies, the findings support more informed decision-making in the industry, promoting waste reduction, resource efficiency, and financial sustainability.