Cradle-to-Gate Lifecycle Assessment of a Steering System for a BFH Electric Race Car

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Sustainability is gaining importance in engineering. This thesis presents a tool to display the calculated cradle-to-gate Greenhouse gas (GHG) emissions, cost, and production time of CNC-machined parts in a race car steering system. Focused on the design phase, where most environmental impacts are generated, the tool visualizes trade-offs between materials and processes to support sustainable decisions.

Introduction

The Bern Racing Team (BRT) is a BFH initiative that annually designs and builds an electric race car. This year, alongside the usual cost and time analysis, the team must also provide an environmental lifecycle assessment (LCA) in order to compete. This thesis focuses on the CNC-machined components of the steering system, using a cradle-to-gate life cycle perspective, covering the process from raw material extraction to final production, while excluding use and disposal. As sustainability becomes increasingly vital in engineering, many teams face challenges in navigating this complex topic. This work addresses the need for an assessment method and tool that combines emissions, manufacturing time, and cost to support informed design decisions.

Research Design

The research process began with the collection of environmental, time, and cost data of CNC-machined steering components. To estimate the environmental impact, a LCA was conducted using OpenLCA, following the three stages: raw material sourcing and processing, transportation and CNC machining. Inventory data was sourced from the Ecoinvent database, paired with technical specifications obtained from CAD models of the CNC-machined steering components and supplier documentation. Time and cost data were obtained through a combination of internal data from the BRT team (e.g., machining durations, setup procedures) and supplementary research, including technical literature. All collected data was structured in Excel and linked to Power BI to generate interactive dashboards. The tool was designed to be scalable, allowing for future expansion to other vehicle subsystems assessments.

Results

A scenario analysis revealed that material sourcing (raw material extraction and processing) is the most impactful stage, accounting for approximately 77% of total CO_2 emissions, followed by CNC machining with 22%, and transport contributing only around 1%. Aluminum was found to be significantly more CO_2-intensive than steel. Switching the extraction from a Chinese to a Greek site led to a 57% reduction in emissions. For steel components, reducing the raw material weight by 10% resulted in an 11% decrease in emissions. The dashboards developed in Power BI provided a clear visual comparison across all components and criteria (emissions, time, and cost), supporting quick identification of optimization opportunities. These included evaluating alternative transport or material options for future iterations.

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Implications and Reccomendations

The tool shows that integrating environmental, time, and cost factors into early design stages can guide more sustainable choices. For student teams like BRT, this means gaining a clearer understanding of trade-offs and reducing the environmental footprint without sacrificing performance or budget. Based on the findings, BRT should consider sourcing aluminum from Greece or reducing material weight in steel components to lower emissions. Wider adoption of similar tools in professional settings could support the transition toward more environmentally friendly engineering practices. Further improvements could include automation of data input and expanding the scope to the full lifecycle.

Figure 1: BRT’s electric race car 2024