

# **A SYSTEMS APPROACH TO SUSTAINABLE TECHNICAL PRODUCT DESIGN: COMBINING LIFE CYCLE ASSESSMENT AND VIRTUAL DEVELOPMENT IN THE CASE OF SKIS**

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Abstract:

Many existing tools and methods for sustainable product design focus on ecological efficiency while lacking a framework of a holistic, sustainable design approach that includes social, technical, economical and ecological aspects in the whole product life cycle, and that provides guidance on a technical product development level.

This research proposes a framework for sustainable product design in the case of skis. We develop a ski benchmarked according to social, ecological, economical and technical targets, following an initial sustainability assessment, and delivering the first Life Cycle Analysis (LCA) of skis. The framework then applies a virtual development process as a combination of LCA to calculate the ecological footprint as carbon equivalents of all materials and processes and a technical CAD (computer aided design) and CAE (computer aided engineering) simulation and optimization, using parameter studies for the nearly prototype free development of the benchmarked ski.

The feedback loops between LCA and virtual simulation led to the elimination of highly energy intensive or health hazardous materials, to the pioneering use of Basalt fibres in skis, to the optimization of natural materials by protective coatings from natural resins and to the optimization of the production process. By coupling a numerical optimization tool, a pre-processor for parameterizing the simulation model (parameters: geometry and stacking of Basalt fibre layers) with a Finite Element Solver a fully automated calculation and optimization of product performance and eco efficiency could be implemented. The virtually developed skis have been tested and verified by skiers according to the individual and benchmarked socio-technical product performance on snow, and have been successfully established on the market. From an ecological perspective a minimum of 40% reduction in carbon equivalent emissions in regard to other comparably performing skis has been achieved, as well as a pioneering step forward towards transparent communication of the environmental performance of a product by its individual, comparable and first published ski carbon footprint per volume unit.