14th Global Conference on Sustainable Manufacturing, GCSM 3-5 October 2016, Stellenbosch, South Africa

Sustainable Lightweight Design – Relevance and Impact on the Product Development & Lifecycle Process

Jerome Kaspar\textsuperscript{a,\,*}, Michael Vielhaber\textsuperscript{a}

\textsuperscript{a}Institute of Engineering Design, Saarland University, Campus E2 9, 66123 Saarbruecken, Germany

**Abstract**

Nowadays new product developments often pursue different goals. In this way, for example, modern engineering systems should commonly be developed in terms of innovative lightweight designs and, at the same time, offer a wide range of environmental as well as economic advantages across the whole product lifecycle (PLC). However, are these objectives mutually exclusive or which specific correlations of a multi-criterial optimization within the product development process exist? Regarding this, the contribution presents the relevance and impact on the product development and lifecycle process of a sustainable lightweight design, including close interrelations within the individual lightweight design concepts, e.g. strategies vs. techniques, and in particular on application-independent and application-specific sustainable aspects inside a holistic cross-component lightweight and material-oriented design methodology along the entire value chain (material, production, use, end-of-life).

\textcopyright{} 2017 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license \(\text{(http://creativecommons.org/licenses/by-nc-nd/4.0/)}\).

Peer-review under responsibility of the organizing committee of the 14th Global Conference on Sustainable Manufacturing

Keywords: Lightweight and material-oriented design; Sustainability; Material selection; Lightweight design strategies and techniques

1. Introduction and Motivation

The shortage of raw materials and energy resources, along with the objectives on climate change (e.g. the reduction of carbon dioxide emissions), the constantly growing variety of customer needs and the considerably increased safety requirements lead to major challenges within the industrial product development. Especially for the
In the automotive industry, the issue of lightweight design constitutes one of the most predominant innovation drivers and technology trends.

Anyway, in terms of the continuously rising awareness of sustainable aspects and especially in view of the increasingly strict environmental regulations (target value of 95 g/km of CO₂ for 2020 of the EU CO₂ emission standards for passenger cars [1]), modern engineering systems should target a wide range of environmental advantages across the whole product lifecycle (PLC). Regarding this, high impacts on the concept of sustainability (meaning material and energy efficiency) can primarily be expected through methods and strategies applied as decisive levers in the (early) product and production development phases [2], even though this implies a mult-criteria optimization within a lightweight and material-oriented development methodology.

As a result, a comprehensive approach for sustainable and lightweight-oriented product engineering, focusing the entire triangle of the lightweight design framework (product, production and material) [3] in an integrated way and including specific correlations and/or close interrelations between sustainable aspects as well as individual lightweight design concepts, e.g. strategies or techniques, is needed and described hereinafter.

Thus, the structure of the paper is as follows. First of all, an overview of the state-of-the-art research and development activities in the domain of lightweight design and material selection, on the one hand, as well as approaches on sustainable product development, on the other hand, is given in section 2. Afterwards, a holistic and cross-component sustainable lightweight and material-oriented design (LMOD) methodology, taking product and production process equally into account, is emphasized in section 3. Based on that, section 4 highlights specific correlations within the individual lightweight design concepts and their interrelations with sustainable aspects across the whole product lifecycle (PLC) and along with an application-specific depiction. Finally, the paper will be discussed and concluded in section 5.

2. State of the Art

Before addressing a holistic and cross-component sustainable LMOD methodology, concerning a product and production engineering integration framework, a brief overview of the current state of the art in terms of approaches, methods and strategies for a sustainable, lightweight and material-oriented design is presented below.

Until now, there are several individual methods up to holistic development methodologies with regard to each separate domain, especially for lightweight design [4, 5, 6]. Thus, and due to the present progress in engineering materials and technologies, in particular in hybrid and/or multi-material construction techniques, the authors unite and expand the consisting definitions of lightweight design into one overall terminology in view of a holistic ideal solution regarding a combination of different (inter alia functional) aspects in addition to the primary focus of weight reduction [7]. However, today’s demand on a functionally integrative systematic lightweight design requires an integrated view of product design, material selection and production process (triangle of the lightweight design framework) [3].

Therefore, besides the common lightweight design strategies, techniques and principles aiming only primary features of basic constructive and minor material- and process-specific measures [5, 8], more and more complex systems with enormous requirements necessitate a detailed, geometry-related loadcase- and weight-optimized material selection process inside the regular product development process. For this purpose, the scientific literature contains numerous approaches, methods and procedures for a systematic choice of materials, e.g. Grosch [9] and Ehrleinspiel et al. [10], whereas Reuter [11] summarizes all these considerations into one ‘standardized’ approach for a systematic material selection integrated into the general product development process (e.g. VDI 2221 [12] or rather Ullman [13]). Furthermore, Ashby [14] developed in conjunction with the appropriate computer-based material data (Cambridge Engineering Selector / Granta Design) a very detailed material selection originating from the collation of material-related requirements, followed by a (material class) screening and a subsequent ranking process up to the final material selection based on so-called property charts. Even though material decisions are mostly still dictated by the product design, his attempt [15] as well as the approach by Faraq [16] (general manufacturing process) and Esawi et al. [17] (specific joining process) also target to interlink product-related material information closer with relevant process information.

An even more relevant factor for product engineering is represented by the objective of minimizing negative environmental impacts within the product lifecycle resulting from optimized materials use. Since the concept of
دریافت فوری
متن کامل مقاله
امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات