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Tailored natural components – functional geometry and topology optimization of technical grown plants

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Abstract

The prominence of ecologically produced and sustainably operable goods is constantly increasing and society's acceptance is rising. For ecological reasons and for society's demand sustainable materials are thus also of increasing importance in the manufacturing industries. Substituting conventional substances such as metals or plastics is therefore an important issue in the field of product development. Until now, most of the eco-design approaches are limited to the selection of the right material but the industrial processing to manufacture the desired design is done in a conventional way. Consequently a better eco balance can only be expected for material extraction, recycling and disposal while manufacturing is not considered in a way it should be.
The authors of this contribution are scientists from the areas of cell-biology, eco-toxicology, structural-, engineering- and industrial-design. They teamed up to analyse the potential and the behaviour of bio-materials being influenced during their growth period into predefined shapes, which can be produced on an industrial scale and which are used as semi-finished products. The aim is to minimize conventional production steps and thus decrease the amount of resources needed for manufacturing. To find out which products and plants offer promising potential, in the first step possible plants are categorized and analysed in general and on a structural cell level. In addition, requirements and main elementary functions for different sorts of products are defined, and matching parts of both databases are identified. For a systematic approach, engineering methodology e.g. according to Pahl and Beitz is taken as a basis.
It is expected that plants being influenced during their growth will go through a natural topology optimization compared to a plant being reformed and shaped during a manufacturing process after the plant has been cut. A higher grade of mechanical stability can therefore be predicted if the plant is absorbing the same strain while it is growing as it will during usage as a technical product. The aim of this project is to investigate these structural differences in mechanical testing, on a cell level in the laboratory as well as in simulations using Finite Element Analysis. Bamboo is taken as a first exemplary plant for its high pace of growth.
For a holistic view the potentials of the renewable materials will be evaluated by a comparison to conventional materials considering mechanical properties. Moreover, the assessment of the eco balance of the entire life cycle of a product, the Life Cycle Assessment (LCA), is employed

to compare the impact of conventional and renewable materials. The outcome will be a data base with mechanical, ecological and economic information to help the developer to decide which material to choose for which technical product and what ecologic impact is implicated.