Focus on biomimetics standardization

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Abstract

The starting point for the international standardization of biomimetic terminology, strategies, materials and methods was a set of bilingual VDI Guidelines (VDI 6220 to VDI 6226) developed in the “Fachbereich Bionik” of the VDI Society Technologies of Life Sciences. The first step towards transferring the VDI guidelines to the international standardization level was the establishment of the Working Committee NA 062-08-60 AA "Bionik" in the DIN Standards Committee for Materials Testing (NMP). By now three ISO standards are available, dealing with biomimetic terminology and methodology (ISO 18458), with biomimetic structures and materials (ISO 18457) and with biomimetic optimization (ISO18459).

The DIN ISO 18457 standard “Bionik – Bionische Werkstoffe, Strukturen und Bestandteile” (Biomimetics - Biomimetic materials, structures and components; ISO 18457:2016) was published in July 2018. On this occasion, we look back on the previous activities that have led to the publication of a total of three basic standards in the field of biomimetics.

Starting point

The starting point was a set of VDI Guidelines (VDI 6220 to VDI 6226) developed in the “Fachbereich Bionik” of the VDI Society Technologies of Life Sciences. The bilingual guidelines VDI 6220 Part 1 " Biomimetics - Conception and strategy - Differences between biomimetic and conventional methods/products ", VDI 6223 Part 1 " Biomimetics - Biomimetic materials, structures and components " and VDI 6224 Part 2 " Biomimetic optimization - Application of biological growth laws for the structure-mechanical optimization of technical components" were particularly relevant for the definitions and definitions of terms and industrial applications in the field of biomimetics. They were therefore selected to serve as a basis for the preparation of international standards within the framework of the TNS funding project ISOBIONIK, which was funded by the Federal Ministry of Economics and Technology under the funding reference FKZ 01FS10008. The funding project was the financial basis for the establishment of ISO/TC 266 "Biomimetics" in 2012, which guaranteed the necessary infrastructure for the creation of biomimetic standards.

Establishment of standardization bodies

The first step towards transferring the VDI guidelines to the international standardization level was the establishment of the Working Committee NA 062-08-60 AA "Bionik" in the DIN Standards Committee for Materials Testing (NMP). The constituent meeting of this working committee took place on 13.9.2011 in Berlin. With Dr. Olaf Rehme from Siemens AG an industry representative could be won for the office of chairman. The working committee now founded concentrated on the establishment of the International Technical Committee ISO/TC 266 "Biomimetics", which was concluded on 9/10 October 2012 with the founding meeting in Berlin. Dr. Olaf Rehme also assumed the chairmanship of this committee.

At the constituent meeting of ISO/TC 266, the three VDI guidelines had already been submitted to ISO/TC 266 in English as adopted standardization proposals. Therefore, three working groups could be founded, each dedicated to one of the standardization projects.

ISO 18458 "Biomimetics - Terminology, concepts and methodology"

ISO/TC 266/WG 1 "Terminology and methodology" chaired by Prof. Dr. Heike Beismann (Germany, Westfälische Hochschule) dealt with the development of ISO 18458 "Biomimetics - Terminology, concepts and methodology", which is based on the guideline VDI 6220 Part 1.

ISO 18458 deals with the question of what biomimetics is and when a product or process is "biomimetic". For example, "biomimetics" is defined as "interdisciplinary cooperation of biology and technology or other fields of innovation with the goal of solving practical problems through the function analysis of biological systems (2.6), their abstraction into models, and the transfer into and application of these models to the solution" [1]. A typical biomimetic development process according to this definition is shown in Figure 1. The development process with Technology Pull, which is based on a concrete question, is shown in Figure 1. However, a development process with Biology Push, which is based on basic biological research, is also possible.

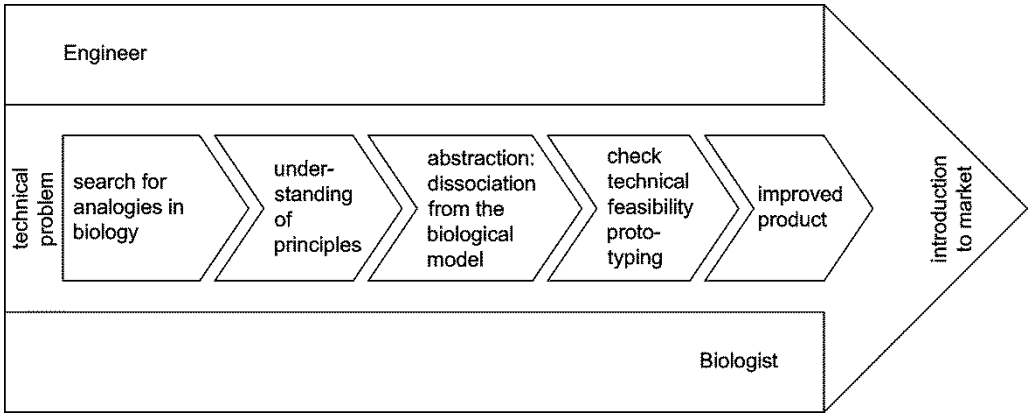

Figure 1 - Typical biomimetic development process for a technology pull (Source: ISO 18458:2015 [1])

There is also a differentiation from terms that are often used synonymously with biomimetics, but convey different contents. For example, the term biomimicry, under which "philosophy and interdisciplinary design approaches taking nature as a model to meet the challenges of sustainable development (social, environmental, and economic)" [1] are understood, as well as the term bionics, which is a “technical discipline that seeks to replicate, increase, or replace biological functions by their electronic and/or mechanical equivalents" [1].
The definition of when a product is biomimetic can be understood as the central point of the standard. The decision whether a product or a technology can be regarded as biomimetic can be made on the basis of three criteria (steps). According to ISO 18458, a product can only be classified as biomimetic if it follows the following three steps of the biomimetic process:

- a functional analysis of an available biological system was performed;

- the biological system has been abstracted into a model;

- the model has been transferred and applied to design the product.

Natural and technical parallel developments, on the other hand, are not biomimetics. In the course of the technical development, technical products were developed, often without any prior knowledge of natural phenomena, which in their function and partly also in their form resemble biological structures with comparable tasks amazingly. This definition is clarified in the standard by means of several examples.

ISO 18458 was published in June 2015. The German version is available with issue date August 2016 as DIN ISO 18458 "Bionik – Terminologie, Konzepte und Methodik".

ISO 18457 "Biomimetics - Biomimetic materials, structures and components"

ISO/TC 266/WG 2 "Structures and materials" chaired by Mr. Stephan Hoornaert (Belgium) dealt with the development of the ISO 18457 "Biomimetics - Biomimetic materials, structures and components", which is based on the guideline VDI 6223 part 1.

ISO 18457 deals with biomimetics in relation to the development of materials, structures, surfaces, components and manufacturing technologies. It lists the principles of biological systems and deals in particular with the performance of biological materials, structures, surfaces, components and manufacturing technologies that provide the motivation and rationale for biomimetic approaches. For example, the Morpho butterfly (see Figure 2) creates the bright blue appearance of its wings through a structural colouring. Its wing scales have a lamellar structure that produces optical interference effects. The lamella structure of the wing scales could serve as a biological model for the colouring of biomimetic tissues. From the abstraction of the mechanism of structural colours, optical interference colours can be created by stacking two polymers with different refractive indices.

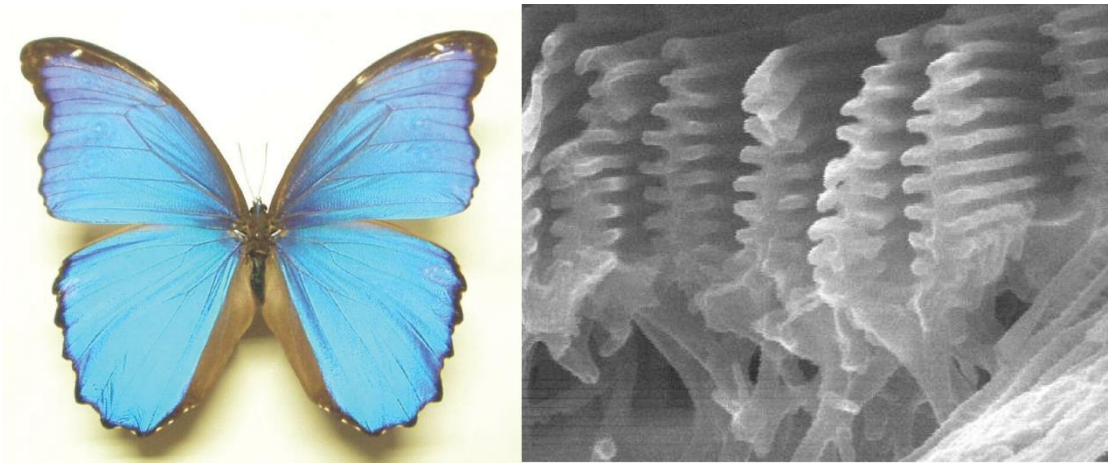

Figure 2 - Morpho butterfly and lamellate structure of the wing scales (source: ISO 18457:2016 [2])

The ISO 18457 standard defines the methodology based on the analysis of biological systems leading to analogies and abstractions. The transfer process from biology to engineering is described in the standard on the basis of numerous examples of biomimetic materials, structures, surfaces, components and manufacturing technologies. Measurement methods and parameters for the characterization of properties of biomimetic materials are also described. Thus ISO 18457 provides industry with information on the relevance of biomimetic materials, structures, surfaces, components and manufacturing technologies.

ISO 18457 was published in September 2016. The German version is available as DIN ISO 18457 " Bionik - Bionische Werkstoffe, Strukturen und Bestandteile " with an issue date of July 2018.

ISO 18459 "Biomimetics - Biomimetic structural optimization"

ISO/TC 266/WG 3 "Biomimetic optimization" chaired by Dr. Iwiza Tesari (Germany, Karlsruhe Institute of Technology (KIT)) was involved in the development of ISO 18459 "Biomimetics - Biomimetic structural optimization", which is based on the guideline VDI 6224 Part 2.

ISO 18459 describes the functions and applications of biomimetic structural optimization methods. Linear structural problems under static and fatigue loads are considered. The described methods are illustrated by examples. For example, the process of building up and decomposing bone substance can be used as a biological model for topology optimization. For example, lightweight components are designed for the development of vehicle frames by removing underloaded material using the soft-kill option method (see Figure 3).

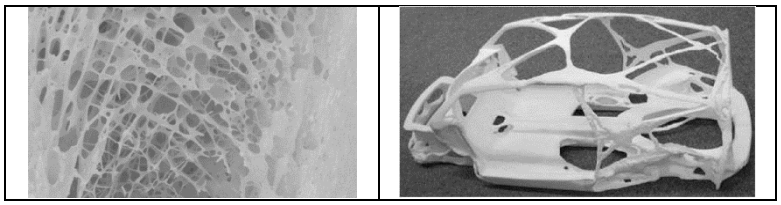

Figure 3 - Topology optimization for designing lightweight components by removing underloaded material (Source: ISO 18459:2015 [3])

The paper describes in detail computer-aided optimization techniques based on the biological model of natural growth and FEM optimization techniques for technical components such as Computer Aided Optimization (CAO), Soft Kill Option (SKO) and Computer Aided Internal Optimization (CAIO). The purpose of these techniques is to optimize the use of materials for weight reduction or to improve the performance and lifespan of these components. In addition, a simpler and faster "Method of Tensile Triangles" is described that can be used by any designer. The wide range of applications of the biomimetic optimization methods, together with the relatively simple applicability of the methods for users, enables users to perform component optimization early in the design process.

The purpose of ISO 18459 is to familiarize the user with bimimetic optimization techniques as effective tools for increasing the life and reducing the weight of components and to promote the widespread use of these techniques in support of sustainable development. The standard is therefore aimed mainly at designers, developers, engineers and technicians, but also at all persons involved in the design and evaluation of load-bearing structures.

ISO 18459 was published in June 2015. The German version is available with issue date August 2016 as DIN ISO 18459 " Bionik - Bionische Strukturoptimierung ".

Further Activities

The standards described above form the core of the activities of ISO/TC 266. Another activity is a Japanese initiative, which is being worked on in the Japan-led ISO/TC 266/WG 4 "Knowledge infrastructure of biomimetics" working group. Under the ISO/TR 18887 series of standards, a three-part technical report is in preparation which has set itself the task of providing technical aids with the help of which a person concerned with an engineering problem can come across key words that lead to biological models for problem solving.

Apart from this initiative, ISO/TC 266, following the completion of ISO 18457, ISO 18458 and ISO 18459, is currently in a phase of developing a strategy for future activities. This is therefore an excellent time for newcomers to implement their own ideas.

Summary

On German initiative, ISO/TC 266 "Biomimetics" was founded in 2012, in which three basic standards based on VDI Guidelines were published under German management. These are be completely available in German from July 2018:
DIN ISO 18457, Bionik — Bionische Werkstoffe, Strukturen und Bestandteile
DIN ISO 18458, Bionik — Bionische Werkstoffe, Strukturen und Bestandteile
DIN ISO 18459, Bionische Strukturoptimierung

Literature

[1] ISO 18458 "Biomimetics - Terminology, concepts and methodology"
[2] ISO 18457 "Biomimetics - Biomimetic materials, structures and components"
[3] ISO 18459 "Biomimetics - Biomimetic structural optimization"

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