CONCEPT AND CASE STUDIES

To enable the use of AM in broad industrial practice, specific tools are required. Function-orientated active principles are a proven tool in the design process to find solutions. Within the project corresponding active principles are developed, especially for AM, and verified on demonstrators and applications. The potential of a function-orientated AM-design is illustrated and examined on industrial applications. In 2017, the focus was on the topics "heat transfer"and "structural optimization". The project framework was continued 2018 with the topics "Magnetic Flux Guidance" and "Structural Damping". For 2019, the project will focus on "Embedded Sensors" to implement certain sensors within components that are manufactured by using the Laser Beam Melting process (LBM).

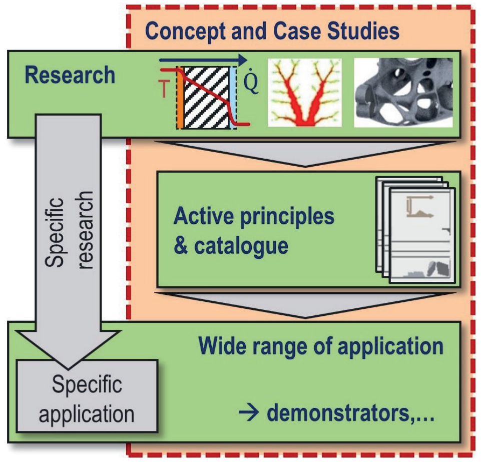

FIGURE 1 Project concept and process phases

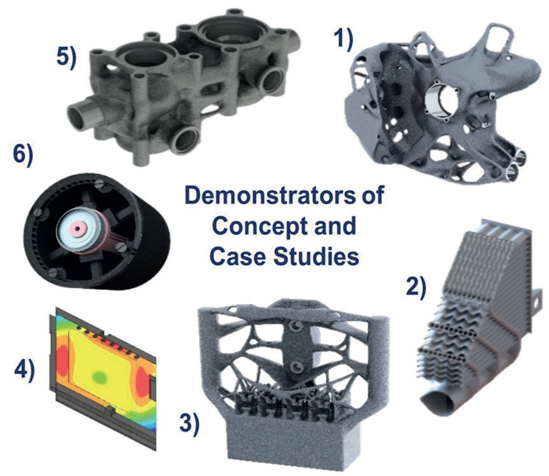

FIGURE 2 Selection of demonstrators developed in CaCS

PROJECT OVERVIEW

DURATION
CaCS 2017 / 2018 / 2019
(one year each)

PARTNER
Industrial Consortium of DMRC

FUNDED BY
Industrial Consortium of DMRC

RESEARCHER
Research leader
Prof. Dr.-Ing. Detmar Zimmer
Research assistent
Sebastian Magerkohl, M.Sc.
Michael Haase, M.Sc.

DMRC DIRECT MANUFACTURING RESEARCH CENTER
RESEARCH INNOVATION EDUCATION

Objective

Additive Manufacturing (AM) is a technology that provides a high level of design freedom. The full potential of AM can only be used if possibilities and challenges of the technology are known and taken into account. In this context, information on the expected changes in performance data due to a suitable AM-design is important.
The idea of the project is to deduce active principles for defined topics using the advantages of AM. To show the practical application, active principles are used to develop generic case studies that are relevant to the industry. For this purpose, suitable design drafts are developed according to VDI 2221 and analyzed with regard to achievable performance enhancement to compare the AM-design with conventionally manufactured components.
As a long term objective, the idea of "Concept and Case Studies" shall be applied to different topics:

- heat transfer (2017)
- structural optimization (2017)
- magnetic flux guidance (2018)
- structural damping (2018)
- embedded sensors (2019)

The results show potentials of additive manufacturing for the respective topic and can be used to inspire design engineers and to emphasize the technical benefits by using AM.

Procedure

The procedure in each year is divided into three phases (Figure 1). The first phase is a general research on the subjects. The investigation does not focus exclusively on the application of AM, but on the thematic objective itself. This approach allows a systematic and comprehensive examination of the topics in general. In addition to the identification of already existing concepts, new approaches can be detected by using the AM-specific possibilities.
The general research approach merges into the second phase, the identification of suitable active principles. In the process already known and new approaches are considered. In some cases simulations were performed to estimate the influence on performance data. With a focus on the application in the design process, a clear and uniform form of presentation was important. Accordingly, all active principles were recorded in a uniform table form which contains a graphic illustration, descriptions of practical relevance, application examples and their quantitative impact on the performance development. The tables are presented in a catalogue which contains the active principles as well as application examples.
In the concept phase of the design process, promising concepts must be selected, which are to be examined in greater detail. To support the decision in this early phase, experience is helpful. In order to make that available for the corresponding subject area, industrial demonstrator components are optimized using a design for AM (Figure 2). These components can be used to verify and demonstrate the applicability of the active principles for each topic. In 2017 the topics were heat transfer (2 & 4), structural optimization (5) and combinations of both topics (1 & 3). Due to the generic approach and the use of function-orientated active principles, the application of the results is not limited to the demonstrators. The active principles allow a broad applicability and can be used in further components.

Results in 2018

In the field of magnetic flux guidance, it could be shown that the three-dimensional freedom of design of additive manufacturing could be used specifically to generate a preferred magnetic direction. For this purpose, corresponding specimens were manufactured from an iron-silicon alloy on an SLM machine. Although the specimens showed that solid structures have the best conduction properties, the targeted introduction of air gaps allows a clear preferred direction. In this context, the constructive implementation of three-dimensional magnetic flux paths in components would be possible. As a demonstrator (Figure 2), a valve (6) was designed whose rotary motion is caused by the use of the preferred magnetic direction. The principle of actuation is similar to a compass that aligns itself in a magnetic field.
An influence could be identified on the structural damping with lattice structures. Experimental tests have shown that the damping properties of the lattice structures can be influenced. However, computer-aided simulation and optimization currently fail at the limits of the software systems, which are only able to map damping in fine lattice structures to a limited extent. The results show the potential to integrate lattice structures into components in a targeted manner and thus to enable the damping properties also in the context of lightweight construction requirements.

Results in 2019

The research topic for 2019 is „embedded sensors". In this context, the integration of the sensors during the manufacturing process in an SLM system will be investigated. The aim is to identify active principles and design guidelines with which it should be possible to integrate sensors into components manufactured using the SLM process. Particularly problematic are the powder removal and the process-related temperatures during the manufacturing process. The general guidelines should take these aspects into account and make the implementation of such sensor solutions easier in the future.