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 focus is on "Embedded Sensors" to implement certain sensors within components that are manufactured in the Laser Beam Melting process (LBM).

PROJECT OVERVIEW

DURATION

2017 / 2018 / 2019
(one year each)

PARTNER

Industrial Consortium of DMRC

FUNDED BY

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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 the potentials of AM 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. With a focus on the application in the design process, a clear and uniform form of presentation is 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.

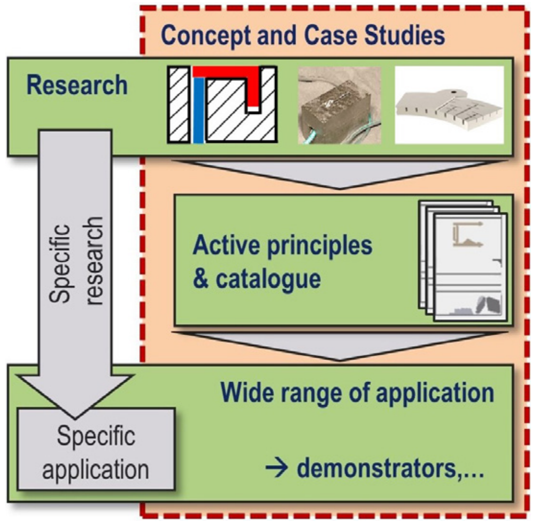

FIGURE 1 Project concept and process phases

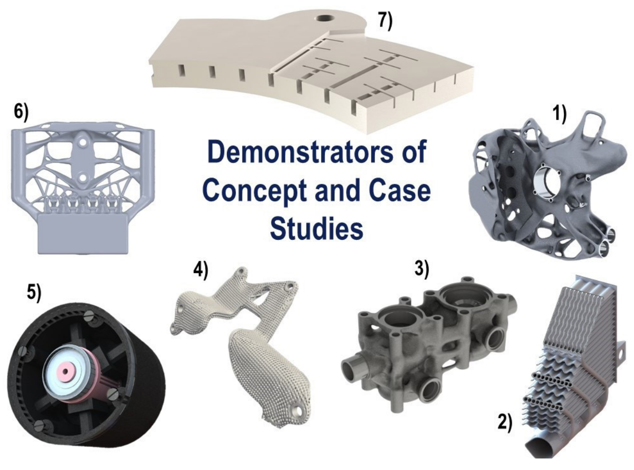

FIGURE 2 Selection of demonstrators developed in CaCS

In the concept phase of the general 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 gain that experience for the corresponding subject area, industrial demonstrator components are optimized and analysed 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), structural optimization (3) and combinations of both topics (1 & 6). In the following year the topics magnetic flux guidance (5) and structure damping (4) were investigated. Due to the generic approach and the use of function-orientated active principles, the application of the active principles is not limited to the demonstrators. They have a broad applicability and can be used in various components and application fields.

Results in 2019

In the field of sensor embedding, it was shown in 2019 that the three-dimensional freedom of design and the layer-by-layer build-up of additive manufacturing can be used specifically to integrate sensors within components. For this purpose, geometric and thermal boundary conditions were defined for the selection of sensors in order to provide the necessary sensor characteristics for a target-oriented embedding. The location and shape of the cavities must be taken into account in the design to insert the sensor at a specific location and with a specific orientation. Experimental tests have shown that various aspects have to be considered when designing the cavities and channels of the sensor cables in order to be able to perform the embedding process reliably and easily. The possibilities for the integration of further functions, such as cable strain relief, are taken into account. Additional challenges during implementation are the removal of powder, the embedding process in the build chamber and the process-related temperatures during manufacturing. Furthermore, temperature measurements of embedded sensors during the manufacturing process have been recorded in order to be able to make predictions about the minimum temperature resistance of the sensors and actuators which have to be embedded.

As a demonstrator a thrust washer of a brake was designed (7). During operation, the thrust washer is in contact with rotating friction linings. The occurring friction leads to a heating of the thrust washer. By embedding a large number of thermocouples, distributed underneath the entire friction surface, it was possible to implement a temperature monitoring system which can detect local temperature peaks.

Based on these findings, active principles and design guidelines were identified which support the user in embedding sensors during the LBM manufacturing process.