DESIGN WITH ADDITIVE MANUFACTURING TO FOSTER INNOVATION

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1 INTRODUCTION

As Additive manufacturing (AM) evolved from a prototyping process to a manufacturing one, the design stages have been adapted to consider this process. a standard for this processes as "process of joining materials to make parts from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing and formative manufacturing methodologies" according to ASTM 52900.
Furthermore AM is more and more adopted by industrials as shown in the Wolhers report[1]. This evolution creates requirement as design methodology for design compliance and design improvement. This two point are part of the state of the art.
The evolution of each product is due to one thing, innovation, as the additive manufacturing development. Innovation is the clue for firms to gain market or keep their customers. To suit to the market needs, an evaluation of the innovative aspect of the product is requested as early as possible in the design process. This aspect not yet exists as an entire method and therefore will be investigated during the state of the art.
The state of the art will introduce the scientific research on the subject of innovation, additive manufacturing and early design stages. This research will be structured around the capacity of evaluation the innovative aspect and the integration to early design stages theory and AM. Objectives and a proposal methods result to this state of the art.
This article aims to develop a method to evaluate the innovative aspect of a product during the early design stages and use the design with additive manufacturing to increase it.

2 STATE OF THE ART

The definition of innovation is the mix between creative/newness product and value success (economic, environmental or societal) according to Fernez-Walch et al [2] and AFNOR (FD X50-271). Among Trela said [3], it's complicated to anticipate the result of the design choice, if the product is innovative. But some methods existed to estimate the newness of a product [2, 4], and tools existed too to identify the value creation of the proposal design, moreover innovative products have specific characteristics according to [5].
The innovative process deduces to design process [6], the creativity of a product is produce during the early design stages. In the Pahl and Beitz design process [7], one of the most widespread design theory in industry because of his concrete and generalist aspect according to Tomiyama [8], the early design stages are defines [9] as the first step from the clarification of the task to the preliminary layout including the embodiment design.

Due to the democratization of AM, the need of design method is claimed [10]. The Design for X (DfX) [11] "focuses on the optimization of the product's properties in the various processes in the product life-cycle, denoted with the X" and were adapted to the manufacturing cycle and to AM, Design for Additive Manufacturing (DFAM), current methodology has for main goals [12, 13]:

- Functional optimisation: it's intended to suit the CAD part to the functional requirements and performance requirements;
- Geometry optimisation: locally the part is modified to achieve better performance such as weight, heat dispatch or dynamic properties with topological optimisation [14].
- Manufacturing path optimisation: from the initial part, method allows to generate the manufacturing path with the characteristic of the process [12].

This methodologies developed are dedicated to the end of the design process, in case of Pahl & Beitz [7], these are used between the embodiment design and the solution. The previous methodologies need as an input, functional requirements and first architectures of the product. To generate concept and integrate the possibilities of Am, Laverne et al [15, 16] developed a methodology which identify the AM knowledge needed by designers to increase their innovative potential. The position of this methodology is exposed on Figure 1. A tool is deduced from it, and provide the knowledge of AM at the right time for the purpose of being more creative. The main problem for innovation is to select which concept you have to develop during the design phases. But what are the rules to select the one or two concepts more innovative than others, the more adapted for AM?

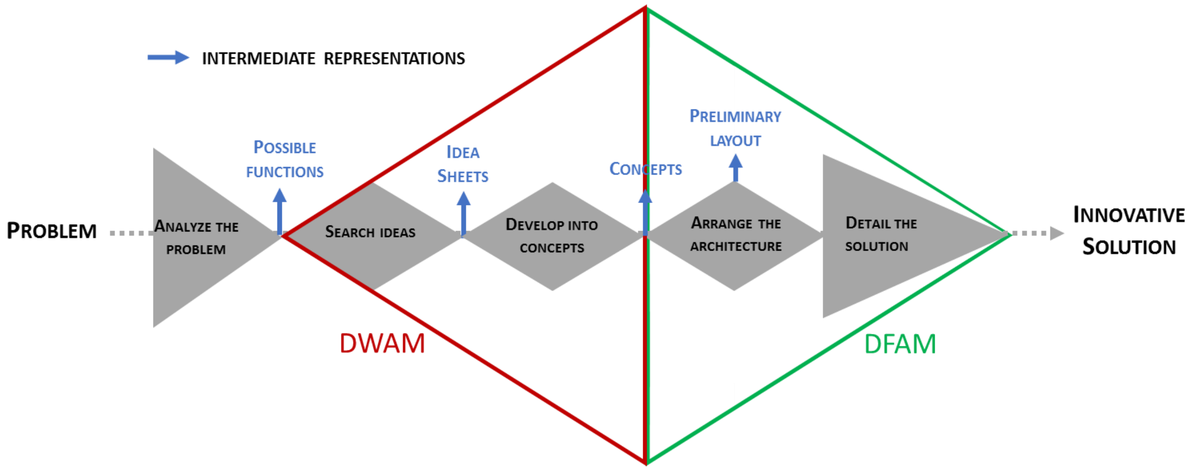

Figure 1: Position of DWAM and DFAM on Pahl and Beitz process, adapted from [16]

3 RESEARCH OBJECTIVE AND PROPOSED METHOD

This article aims to develop a method to evaluate the innovative aspect of the product to link the DWAM and DFAM. The objectives are to answer the following questions:

- How much innovative is the AM product?
- Is it possible to combine proposed concepts to increase an innovative score? And how is it possible with AM?

The following method aims to select the more innovative concept for AM. Its placement is the interface between DWAM and DFAM. The method will focus on 3 indicators (the societal benefits will not be evaluated in this method):

- The newness (Utilities, functions) [2]
- The economic benefits (life-cycle optimization, market target) [17] [18]
- The environmental benefits (Impacts) [19]

To evaluate the product on these aspects, the method is based on the tools mentioned in the state of the arts. The weight of each indicator will be figure out from the objective of the design.
The inputs of the method are the concepts proposed with the method established by Laverne et al [16]. The evaluation is modelled by a matrix where every indicators is split into multiple items to take into account every type of product.

4 CASE STUDY AND EXPECTED RESULTS

The methods will be tested with industrial projects developed with the laboratory. These are dedicated to design innovative products.

The results of the proposed method are the most innovative architecture and the benefits of this architecture in comparison with the inputs. The results suit to AM and the functional requirements.

This article aims to develop a method to evaluate the innovative aspect of a product during the early design stages and use the DWAM to increase the potential of the product and limit the time of the design phases. The choice made at the end of the early design stages is crucial for the success of the product, this method aims to limit the risk.

5 CONCLUSION

This article has the goal to ease the selection of the concept during the early design stages. The proposed method is using as inputs the results of the DWAM methodology which permit to develop creative concept. The output of this work is an architecture of product with the innovative concepts and AM suitable.

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