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2014

Killi, S. (2014). Emerging Design Processes for Emerging Technologies. Proceedings of the 1st International Conference on Progress in Additive Manufacturing (Pro-AM 2014), 30-35.

<https://hdl.handle.net/10356/84260>

https://doi.org/10.3850/978-981-09-0446-3_018

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Downloaded on 26 Apr 2023 19:00:31 SGT

EMERGING DESIGN PROCESSES FOR EMERGING TECHNOLOGIES

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ABSTRACT: Additive Manufacturing Technology (AMT) is expected to have a deep impact on the way we both produce and consume products in the future. Its technical benefits are well documented, but how it will influence the design process is less clear. This paper will deal with the influence AM technology has had on design processes, and also introduce some emerging aspects of how design perspectives may impact on AM. Key factors here are co-production and co-design.

INTRODUCTION AND BACKGROUND

Design methods and processes

Research and development of design processes started in the 1960s with quite simple models of how a product development process could be performed. Archer's (Archer 1965) three step model (see Figure 1) has subsequently been unpacked and developed further, leading to extensive number of design methods (Cross 1993). Over the years several techniques, methods and workflows has been developed, very often specialized for specific products (Petersen et al. 2005). The methods developed and typically refined over the years are never static though; they change, and very often this is due to a technical breakthrough (Verganti 2011).

Figure 1. Three phase summary model of the design process (Archer 1965)

Although these methods and processes may be extremely advanced and highly complex, in many instances they could very often be refined to Archer's model. Archer compared his model to a sandwich: *the bread of objective and systematic analysis may be thick or thin, but the creative act is always in the middle* (Evbuomwan et al. 1996, p. 307). This metaphor will be addressed later in this paper.

Additive manufacturing in the design process

When additive manufacturing technology was introduced to the market towards the end of the 1980s it was labelled as rapid prototyping (RP). The intention was to rapidly produce models of an intended design and mainly used towards the end of the development process (Gibson et al. 2009). The use of models in product development goes as far back as we can count in industrial design. Figure 2 depicts a possible design process I have devised. It utilizes what could be called rapid prototyping technology; the core of the model is a variation of Archer's three step model.

Figure 2. A Generic Design Process Model. The Øxseth-Killi model for a design process. A generic starting point. Visualisation: Emilie Strømmen Olsen and Steinar Killi

The model serves as a generic starting point for a discussion of an evolving design process. The model emphasizes the more unconscious use of RP models. Exactly when and where in the development process these RP models were used differs, but it seems like validation and during engineering are the most frequent used (Capjon 2004). For many companies this is still the case.

Over time AM technology became more accessible and more of a design tool than just testing of concepts. One of the core issues of new product development (NPD) is to have a more holistic approach to the development process, bringing in market analysts, sales department, engineering and other decision makers early into the process, very often facilitated by designers (Cohen et al. 1996). The ability to use models early and frequent in the development process serves as a catalyst for such an interdisciplinary group of stakeholders. These stages could contain different levels of

models: visiotypes, negotiotypes and prototypes (Capjon 2004). Figure 3 depicts then the next level of AM technology's impact on a design process.

Figure 3. A Process Design Model with Visualisation and Communication. Based on the Capjon-Øxseth-Killi approach to a design process. Rapid prototyping is used extensively through the process, as a visual catalyst in multidisciplinary decision making. Visualization: Emilie Strømmen Olsen and Steinar Killi

The process depicted in Figure 3 could also be stretched; rapid prototyping then transforms to AM as a whole or part of the manufacturing process. An example here is Freedom of Creation (FoC) who has built an extensive catalogue of products online. These products are made on order. This is nothing new and is merely a version of lean manufacturing (Womack et al. 1990)(Killi 2013), but it is faster and the actual production may easily be outsourced (Killi 2013). The core point of this model is an increased focus on communication through the design process and a closer relation between production and market, whether AM technology is used as the final production tool or not. If AM technology is used, it may also close the gap between the designer and the producers, but it is still a version of Archer's three step model.

CONSTRUCTING AND EMERGING DESIGN PROCESS

Co-value production and design

AM technology is closing the gap between development and production, and by realizing that we may benefit from considering models from other disciplines and domains, like for instance service

design. Three of the core models in service design are co-production, co-value production and co-design. Common for all three is the use of the fuzzy area between producers and consumers (Steen 2013). This has of course been adopted by producers of physical objects too, such as MyAdidas (Killi 2007) and the car industry already in the 1980s (Womack et al. 1990). In Figure 4, very popular 3D printing artifacts, cellphone casings, are mapped out, based on the continuum of production and consumption practices (Ebara 2004). The Apple i-Phone bumper casing is a result of an industrialized mass production dynamic and it is consumed totally separately. The counterpart to this is the casing called “Grow” that could be labeled as hand-crafted and is consumed almost simultaneously; in between are examples of casings that to some extent is a result of co-production and co-design.

Figure 4. Examples of different level of customer interactions, from mass produced to crafted one-of cell phone casing, and the fuzzy area in-between where the consumer, the designer and the producer interact on different levels. Model by William Semb Kempton and Steinar Killi

However, there are few iterations in this process: there is either a matter of choosing, and then the object is produced, or more closed where the designer, producer and consumer is the same party. Could one imagine a deeper, more profoundly co-designing process? A short example might shed some light on this. Consider the following scenario. A mouse pad is designed and manufactured, using a personal 3D printer. A picture of the printed mouse in use and the generic solidworks file (or other mainstream cad software) is then uploaded on an open source server where someone picks it up, downloads the file, does some adjustments and then uploads the file to the server. This could in theory go on indefinitely; if the first designer downloads the mouse pad file, it's now adjusted n times! Figure 5 shows the first step of this experiment.

Figure 5. Development of a mouse pad design, first iteration, $n=1$, could be downloaded and produced as is, or changed to a version $n=2$, which could be uploaded, and so on. Visualizations: William Semb Kempton and Steinar Killi

If we now make a third iteration of the model of the design process it might look something like Figure 6. Here the creative, validation, manufacturing and market are symbiotic processes and there is no end to the dynamic.

Figure 6. A Loop Based Model in AM Design: Killi-Capjon-Øxseth approach for a design process based on the AICE approach. Visualizations: Emilie Strømmen Olsen and Steinar Killi

The model targets both the emerging Additive Manufacturing technologies and the possibility to perform real co-value production through the growing domain and practices of social media. In this case we are challenging Archer's three step model and sandwich metaphor in that there is no end part to development, there is a starting point and then there is an infinite loop. Of course, the loop could be broken and the last iteration could be mass produced, either conventionally with tools or with AM technology, depending on the complexity of the product and the sale potential. If this was the intention from the beginning, the previous model (Figure 3) would be the appropriate description of the design process, again following Archer's three step model.

DISCUSSION AND CONCLUSION

Additive Manufacturing technology evolves rapidly and the expectations as to its impact are surging. Companies involved in production of physical objects are surveying both the technology and the processes involved. Although there are some good cases as evidence and several of the big companies are testing out AM (NIKE, Ittala etc), there is mainly a “wait and see” attitude. The design process discussed in this paper raises several questions, the two biggest being how to make money if both the design and production happens outside of the company, and, closely linked to this, are legal issues. How is one to maintain ownership to something that’s become public domain? Talk about the next industrial revolution is not just about the technology; new business-models have to be developed too. The description of the emerging design process in this short paper will hopefully give some insight to those who set out to develop these business-models.

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