Available online at www.sciencedirect.com

ScienceDirect

Procedia Manufacturing 19 (2018) 135–142

Procedia MANUFACTURING

www.elsevier.com/locate/procedia

6th International Conference on Through-life Engineering Services, TESConf 2017, 7-8 November 2017, Bremen, Germany

Lifecycle design and management of additive manufacturing technologies

Jakob R. Müller[a,]*, Massimo Panarotto[a], Johan Malmqvist[a], Ola Isaksson[a]

[a]*Chalmers University of Technology, SE-41296 Göteborg, Sweden*

Abstract

Additive manufacturing (AM) is being proposed as a revolutionary manufacturing technology, promising significant advantages both from a design and production perspective. One challenge is the disruptive nature of AM and its impact on all life cycle phases.

This paper reports from a demonstrator project highlighting digitalization and process implications. A demonstrator tool was developed able to collectively capture and visualize different life cycle implications of AM products. Market expectations, technology characteristics and life cycle constraints were met in the demonstrator tool. Each individual part collected its own traceable data set, from design over manufacturing up to postproduction services. Key aspects demonstrated were 1) the need to represent any manufacturing and life cycle constraint already in design, 2) the need to integrate unique identifiers that build a digital twin and 3) the need to automate links between life cycle engineering steps.

Peer-review under responsibility of the scientific committee of the 6th International Conference on Through-life Engineering Services.

Keywords: Manufacturing system; Product Development; Lifecycle

* Corresponding author. Tel.: +46 31 772 13 21
E-mail address: jakob.muller@chalmers.se

2351-9789
Peer-review under responsibility of the scientific committee of the 6th International Conference on Through-life Engineering Services.
10.1016/j.promfg.2018.01.019

1. Introduction

The benefits offered by Additive Manufacturing (AM) technologies are attracting interest within the manufacturing industry. Among other benefits, AM allows to create complex internal geometries, improving both functionality and enabling new levels of topology optimization [1]. Furthermore, AM allows to create sophisticated features that improve aesthetics and can be customized to suit individual customer preferences [2]. These benefits make AM an interesting technology especially for through-life engineering service providers [3]. One example is by "Contracting for Availability" (CfA) within the UK defence industry. AM has the potential to delocalize manufacturing that can occur anywhere within a port, a support ship or an aircraft carrier. Moreover, having manufacturing capability on-board allows the manufacturer to rapidly recover the product structure during repair [4].

While AM opens up new dimensions of the design space for product development, it comes with new sets of constraints and requirements that have yet to be explored. Such constraints are very different than conventional "design for X" (DfX) guidelines adopted today by engineers, which take into account lifecycle aspects already in the design activity. For example, established manufacturing methods and their limitations and implications such as injection moulding or machining lose their relevance [5]. At the same time, the freedom of AM reduces the need for Design for Assembly (DfA) [2]. Furthermore, because AM also allows for new and innovative maintenance and remanufacturing solutions such as the repair of turbine blades [6], it is considered to bring a major change in design paradigms [7]. In safety-critical industries, such as aerospace, this change requires the certification by authorities. These premises suggest the need for engineers to rethink their conceptual barriers, which are often tacit in many cases [8], when considering lifecycle aspects in the design of products for AM. These needs have to be translated into "Design for Additive Manufacturing" (DfAM) knowledge, tools, rules, processes, and methodologies [9]. In fact, insufficient understanding of DfAM is advocated to be one of the factors limiting the uptake of AM in industry.

This study explores the challenges related to lifecycle design and management of AM technologies. The major finding is related to the need for designers to easily access information about lessons learned during the lifecycle design of AM components. In this way, a new knowledge base can rapidly be built inside the organization. For this purpose, a product lifecycle data management system is proposed in cooperation with industry partners. A functional prototype [10], the *DINA Demonstrator*, was developed to illustrate and analyse the correlations between design choices, process parameters, product life and use for all relevant stakeholders.

2. Research Method

The results of this study come from the cross-analysis between literature and the empirical findings derived from a Swedish research project conducted in collaboration with industrial partners and research institutes. The study was organized around the following research questions:

RQ1: *How can the uncertainties and unknowns about expected product behaviour for AM in the design phase be reduced?*

RQ2: *How can the relevant stakeholders access the information they need to reduce those uncertainties?*

Literature was first reviewed with the objective to find recognized needs for the lifecycle design of AM products. Articles were retrieved from the SCOPUS database through searching for specific sets of keywords such as: *key("lifecycle design*" OR "design for") AND key("additive manufacturing" OR "3d printing")*. This list of needs was further explored and refined by the interaction with industrial practitioners participating in the research project. The participants were industrial experts working in roles that relate to the management of AM technologies inside the organization, ranging from technology managers to design engineers and manufacturing specialists. The outcome of this phase was a condensed list of three needs to be addressed by methodological support. This was developed as a functional prototype [10]. The results were then presented to a consortium of stakeholders from industry and society, where feedback was gathered through interaction of the participants with the prototype. The development of the functional prototype was done following Action Research [11] and Design Thinking [10] approaches: repetitive versions of the prototype were presented to the practitioners in small groups under guidance. This prototype-based approach was chosen as it allows to collect feedback considering also the users' emotional state, as well as their stated