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ScienceDirect

Procedia Manufacturing 21 (2018) 117–124

Procedia MANUFACTURING

www.elsevier.com/locate/procedia

15th Global Conference on Sustainable Manufacturing

3D printing of biodegradable parts using renewable biobased materials

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Abstract

The paper presents ways of utilising the additive manufacturing process 3D-printing using renewable biobased materials, with a focus on adapted packaging for sensitive components. This application provides an attractive scenario for sustainable production and the re- or upcycling of waste material such as wood flour, rice husk or miscanthus fibre. Packaging of prototypes with sensitive or filigree structures or made of fragile materials is currently difficult, because standardized packages are often not suitable and cost for adapted packages are high. Within this study, CAD-data based adapted packaging made of renewable raw materials is addressed. The 3D-printing process was modified for using conditioned biobased fibre and a special binder. Furthermore, a software tool was developed to create adapted packaging designs by using the individual part geometry.
In this way and in combination with AM processes, sustainable and biodegradable packaging for complex components can be generated within a short time. The manufactured packaging is conform to the demands of packaging for fragile goods and can be produced just-in-time.

Peer-review under responsibility of the scientific committee of the 15th Global Conference on Sustainable Manufacturing (GCSM).

Keywords: Additive Manufacturing; 3D Printing; Binder Jetting; Renewable Materials; Biodegradable Materials;

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2351-9789
Peer-review under responsibility of the scientific committee of the 15th Global Conference on Sustainable Manufacturing (GCSM).
10.1016/j.promfg.2018.02.101

1. Introduction

Additive manufacturing (AM), also called 3D printing by the wider public, is a group of manufacturing technologies that can, and already has, change the way parts and products are being made [1]. Contrary to the established subtractive technologies such as milling or grinding, AM builds up material to form a part, stepwise and layer by layer. It allows for new designs to be realised which were unthinkable of using only subtractive processes, such as structures inspired by biological growth or internal cavities. While much research and development has been conducted using metallic and polymer materials for AM, some material sectors are so far not being addressed. This study works towards closing this gap and focuses on bio-based materials and their application in 3D printing.

2. 3D Printing

3D printing (3DP) in its original terminology is a process within the group of Additive Manufacturing. In 3DP, also named Binder Jetting, an inkjet print head is used to inject a liquid (mostly a binder substance) into the top layer of a powder bed, causing fusion or agglomeration of the particles. By lowering the platform and raking a new defined layer of fresh, unfused powder on top, the process can be repeated (Fig. 1, a). This enables the generation of three dimensional parts in a powder bed. Because of the bed's stabilisation mechanism, there is no need for support structures as they are required for example in resin-based processes such as SLA. Furthermore, the process is fast compared to the polymer-melt based FDM/FFF processes which are colloquially coined '3D Printing'. With state-of-the-art printers, around 20 mm of build height are possible per hour on a full platform of the size of 300 x 200 mm.

Fig. 1: (a) 3D printing process principle [2], (b) multi-coloured 3D printing example part [3]

After the part has been printed, it is taken out of the powder bed and blown clean of the unused powder. Mostly, the part is then infiltrated or at least (spray) coated to enhance its mechanical properties and add water proof features. Commonly used powder materials include gypsum, starch and ceramic materials (which need to be sintered after 3DP). Because the process is based on desktop inkjet print head technology, multi-coloured parts are possible. Its application was first to be found in the prototyping/design sectors where the visual properties were more important than industrial-grade mechanical strength (Fig. 1, b).

3. Biodegradable materials

3.1. Motivation

While many parts aim for maximum lifetime, for some applications a very defined lifetime is more beneficial. Packaging, for example, needs to protect the goods until they have reached their final destination; afterwards its use has ended and it needs to be disposed of. Similar boundary conditions exist for visual aids or decorative parts such as theater stage or film set props, architectural models or event equipment. For most of these applications, the volume of material used is high, as is the amount of waste generated. Commonly used materials are polymers in solid or foamed state, which degrade very slowly or need to be incinerated in a controlled environment. From a