Available online at www.sciencedirect.com

ScienceDirect

Procedia Manufacturing 7 (2017) 127 – 130

Procedia MANUFACTURING

International Conference on Sustainable Materials Processing and Manufacturing, SMPM 2017, 23-25 January 2017, Kruger National Park

Finite Element Simulation to Support Sustainable Production by Additive Manufacturing

Andreas Lundbäck*, Lars-Erik Lindgren

Luleå University of Technology, 971 87 Luleå, Sweden

Abstract

Additive manufacturing (AM) has been identified as a disruptive manufacturing process having the potential to provide a number of sustainability advantages. Functional products with high added value and a high degree of customization can be produced. AM is particularly suited for industries in which mass customization, light weighting of parts and shortening of the supply chain are valuable. Its applications can typically be found in fields such as the medical, dental, and aerospace industries. One of the advantages with AM is that little or no scrap is generated during the process. The additive nature of the process is less wasteful than traditional subtractive methods of production. The capability to optimize the geometry to create lightweight components can reduce the material use in manufacturing. One of the challenges is for designers to start using the power of AM. To support the designers and manufacturing, there is a need for computational models to predicting the final shape, deformations and residual stresses. This paper summarizes the advantages of AM in a sustainability perspective. Some examples of application of simulation models for AM are also given.

Peer-review under responsibility of the organizing committee of SMPM 2017

Keywords: Additive manufacturing; Finite element; Simulation

1. Introduction

Additive manufacturing (AM) is a manufacturing process where material is added layer-by-layer. AM is said to mimic nature as nature in general is additive and not subtractive. In the ISO/ASTM 52900 standard [1], AM is

* Corresponding author. Tel.: +46-920-492856.
E-mail address: andreas.lundback@ltu.se

Peer-review under responsibility of the organizing committee of SMPM 2017
doi:10.1016/j.promfg.2016.12.033

defined as: *“process of joining materials to make parts from 3D model data, usually layer upon layer”*. In Fig. 1, the principle of conventional subtractive manufacturing (upper route) and additive manufacturing (lower route) is shown. With the conventional manufacturing route, we start with some bulk material and e.g. machine it until wanted shape is obtained. The process leaves us not only with the component but also a lot of scrap material is produced. With additive manufacturing on the other hand, we start with powder as raw material and build the component by adding material selectively. When the process is finished we have a component of net-shape and very little scrap material.

Additive manufacturing is ideal to use as a direct manufacturing approach when building complex shapes, customized parts, low volume or high-value products. Direct production from 3D CAD models means that no tools or molds are required and small batch sizes can be more economically attractive relative to traditional manufacturing. AM is still an emerging technology but has shown promise in a number of different fields. Examples are biomedical implants, jewelry and various applications within the aerospace and automotive industry. As the technology matures and production performance improves it is expected that new applications are found. Although AM is typically suited for manufacturing of components with complex shape in small volumes, it can still support mass production. By reducing the lead time and enabling more complex internal shapes when making tools and dies the cost for mass production can be reduced.

For the above mentioned applications there are mainly two methods used, powder bed fusion (PBF) and directed energy deposition (DED). PBF is a method for building new components from scratch. A thin layer of powder is evenly distributed with a rake and a heat source selectively fuses regions of the powder bed. The heat source is either an electron beam or a laser beam. With DED a component can be built from scratch but it is more commonly used for building features on existing parts or even performing a repair or refurbish of a component. The heat sources used for DED are arc, laser beam and electron beam and the material can be added as powder or wire. The build rate is usually much higher in DED owing to that a thicker layer can be added for each pass. This in turn means that a higher heat input per time unit is applied which can cause larger deformations and residual stresses. The build volume is restricted to the size of the build chamber. The build chamber for PBF systems is usually much smaller than for DED. It is due to the possibility to fit large components in the chamber and the way the material is added that DED is suitable for repair of existing components.

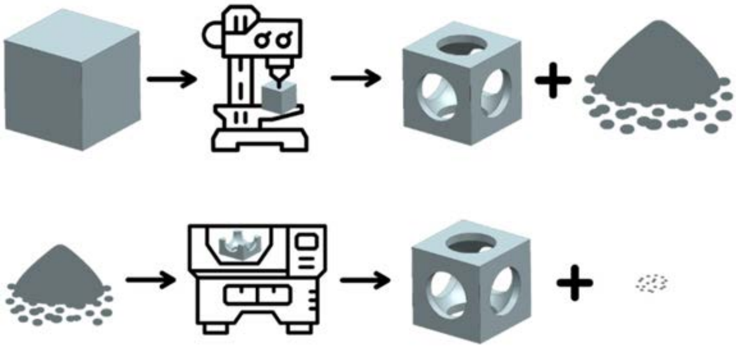

Fig. 1. Illustration of conventional subtractive production (upper part) and production with additive manufacturing (lower part).

The sustainability aspects of AM may offer advantages for industry to embrace the technology. Additive manufacturing is inherently less wasteful than traditional subtractive methods of production. The adoption of AM and other advanced manufacturing technologies can contribute to making value chains shorter and more localized and offer significant sustainability benefits [2]. Changes in lifecycle costs, energy and CO_2 emissions globally by 2025 are also expected. There is quite a bit of research going on in the field of AM in a sustainability perspective e.g. [3-5], but still there are gaps to fill [3].

A good example where the adoption of AM can make a difference is within the aerospace industry. In aeroengines, buy-to-fly material ratios of 4:1 with conventional production methods are typical, but up to 20:1 are