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Preliminary Investigation on Life Cycle Inventory of Powder Bed Fusion of Stainless Steel.

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Abstract

Manufacturing of work pieces from stainless steel with laser additive manufacturing, known also as laser sintering or 3D printing may increase energy and material efficiency. The use of powder bed fusion offers advantages to make parts for dynamic applications of light weight and near-net-shape products. Due to these advantages among others, PBF may also reduce emissions and operational cost in various applications. However, there are only few life cycle assessment studies examining this subject despite its prospect to business opportunity. The application of Life Cycle Inventory (LCI) in Powder Bed Fusion (PBF) provides a distinct evaluation of material and energy consumption. LCI offers a possibility to improve knowledge of process efficiency. This study investigates effect of process sustainability in terms of raw material, energy and time consumption with PBF and CNC machining. The results of the experimental study indicated lower energy efficiency in the production process with PBF. This study revealed that specific energy consumption in PBF decreased when several components are built simultaneously than if they would be built individually. This is due to fact that energy consumption per part is lower. On the contrary, amount of energy needed to machine on part in case of CNC machining is lower when parts are done separately.

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Keywords: energy efficiency; life cycle assessment; sustainability; specific energy consumption

1. Introduction

Additive manufacturing (AM), known commonly also as 3D printing, is nowadays coming more popular way of fabricating products as development of the technology from building prototype parts to functional parts has increased remarkably in 2000s. AM consist of seven different subcategories of different technologies. One of these technologies is powder bed fusion (PBF) of metallic materials. This technique is used to manufacture parts out of

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metal powder layer by layer by melting metallic powder by laser beam. Metal additive manufacturing has become popular in the aerospace, automotive, defense and medical industries according to Cooper et al. (2012) and Song et al. (2015) due to its many advantages over traditional manufacturing techniques, such as casting and stamping. Additive manufacturing allows automatized rapid prototyping and small series production of complex geometries and shapes. Additive manufacturing enables also the manufacturing of light weight components, which may include e.g. lattice structures. The manufacturing parameters in the additive manufacturing process can also be easily modified which allows rapid design changes as discussed by Santorinaios et al. (2006) and Yap et al. (2015).

However, there are only few studies published about the sustainability of the metallic AM process as most of the studies available have concentrated on polymeric materials. Due to aforementioned reasons this study is concentrating on measuring and analyzing of energy and material consumption in powder bed fusion of metallic materials. Main method in this study is life cycle inventory (LCI).

Nomenclature

AISI	American Iron and Steel Institute
AM	Additive manufacturing
ASTM	American Society for Testing and Materials
CO2PE!	Cooperative Effort on Process Emissions
ISO	International Organization for Standardization
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
PBF	Powder Bed Fusion
SEC	Specific energy consumption
STL	Standard tessellation language