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Considerations on the construction of a Powder Bed Fusion platform for Additive Manufacturing

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Abstract

As the demand for moulds and other tools becomes increasingly specific and complex, an additive manufacturing approach to production is making its way to the industry through laser based consolidation of metal powder particles by a method known as powder bed fusion. This paper concerns a variety of design choices facilitating the development of an experimental powder bed fusion machine tool, capable of manufacturing metal parts with strength matching that of conventional manufactured parts and a complexity surpassing that of subtractive processes. To understand the different mechanisms acting within such an experimental machine tool, a fully open and customizable rig is constructed.
Emphasizing modularity in the rig, allows alternation of lasers, scanner systems, optical elements, powder deposition, layer height, temperature, atmosphere, and powder type. Through a custom-made software platform, control of the process is achieved, which extends into a graphical user interface, easing adjustment of process parameters and the job file generation.

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1. Introduction

This paper will give an overview over recent activities and considerations constructing a set-up for consolidating metal powders into objects by means of laser radiation, also known as powder bed fusion (ASTM International, 2013). Complete systems are industrially available from vendors, yet mentioned systems have the major drawback that process parameters for all sub-systems are predefined by the vendor and therefore not accessible to the end-user. Commercial systems are often limited to proprietary software and feedstock powders. From the users perspective, this is mostly fine, as it ensures process stability, but from a research point of view, it is unacceptable. The motivation for constructing an experimental powder bed fusion system is therefore to uncap the possibilities of powder bed fusion presented by modifying and optimizing subsystems, and achieve full control over job planning and scan strategies.

A general example of such a set-up can be seen in Fig 1. The set-up consists of following modules:

- Laser source
- Scanner system
- Scan window
- Powder delivery system
- Powder bed

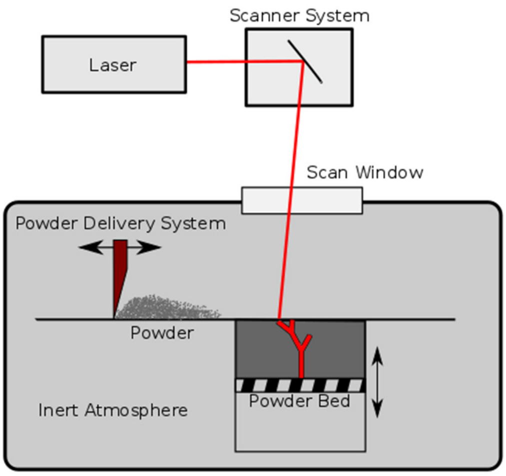

Fig 1: General functionality.

Industrial systems are equipped with one or several fiber lasers capable of delivering an output in the range 200W – 1000W. A scanner system is used to maneuver the laser beam around to selectively consolidate the particles in the powder bed. The scanner system usually consists of two galvanometric mirrors and a fθ-lens, providing scan-speeds up to 10 m/s. The powder delivery system (PDS) uses either a scraper or a roller to coat and recoat the powder bed with a uniform layer thickness and density, minimum layer thickness of 0.02 mm. The material processing takes place in a chamber with protective atmosphere.

This paper is divided into three parts focused on programming, the optical system and powder handling respectively.

2. Programming

Enveloping the entire process into a coherent software platform allows full control of the powder bed consolidation. The process is grouped into different stages, see Fig 2. Initially the computer-aided design (CAD) is stored as an STL file, being the de facto standard format used in additive manufacturing (AM). Next, the STL file is processed through a slicer software, generating a job-file in for the form of g-code, a numerical control language. Efficiency is increased