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Impact of build envelope on the properties of additive manufactured parts from AlSi10Mg

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HIGHLIGHTS

- Use of a modified metal laser melting system X LINE 2000R; alloy AlSi10Mg.
- The influence of the angle of incidence on the properties (surface roughness, porosity, mechanical properties).
- Differences between the properties of specimens manufactured by laser 1 and laser 2.
- Impact of preheating on tensile strength and elongation at break in x/y.
- Large scattering of the measured values (influence of the enlarged build envelope).

ARTICLE INFO

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ABSTRACT

The selective laser melting (SLM) process is well established in the construction of prototypes and in the low volume production. With increasing build-up rates the next step to serial production is possible. Multi laser systems and larger build envelopes make the process cost-efficient. Enlarged systems enable not only the manufacturing of numerous smaller parts in one build job but also bigger parts for the automotive and aerospace industry. A modified metal laser melting machine X LINE 2000R equipped with a dual laser system and an enlarged build envelope is used to investigate the position-dependent properties of parts made from AlSi10Mg. The impact on porosity and mechanical properties is shown for different spatial directions. The results are an important contribution to process design, component layout and further improvements of larger SLM machines.

1. Introduction

The selective laser melting (SLM) is a layer by layer process in which a defined powder thickness is melted by the laser [10,5,11,3,8]. Due to the repeating steps of powder coating and powder melting for several thousands of layers, complex shaped and 3-dimensional parts can be produced [16,11,8]. For printing large-scaled parts in automotive and aerospace, the selective laser melting process provides a fast and efficient way to create low volume parts of any length and height (Fig. 1). Especially in case of prototyping, additive manufacturing enhances the flexibility of aircraft and automotive manufacturer in design iterations [5]. Additive manufacturing (AM) overcomes the disadvantage of modifying casting molds (time consuming and cost-intensive) when the component design is changing [4]. Further, Kempen et al. [8] and Tang et al. [13] observed that selective laser melted AlSi10Mg samples display similar properties to parts from the conventional die casting process. However the microstructure and mechanical properties of additive manufactured parts can show anisotropy and position-depending properties [8,9,15,4,13].

For large-scaled SLM machines the position–depending changes in microstructure and mechanical properties are more pronounced as compared to SLM machines with reduced build volume. The machine development trends towards increased build envelopes (Fig. 2) such as X LINE 2000R (Concept Laser GmbH), SLM 800 (SLM Solutions Group AG) or A.T.L.A.S. (Concept Laser GmbH and General Electric) in order to fabricate large-scale parts. The present investigation displays the influence of an enlarged build envelope on porosity, roughness and mechanical properties of AlSi10Mg samples in detail.

2. Experimental methodology

2.1. Machine and powder

The AlSi10Mg specimens used for the investigation were produced

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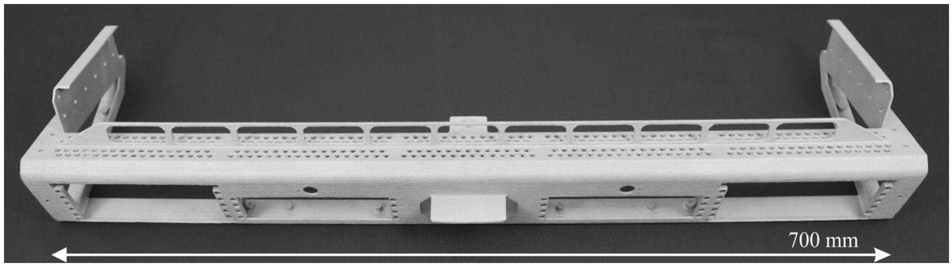

Fig. 1. Additive manufactured part for aerospace application.

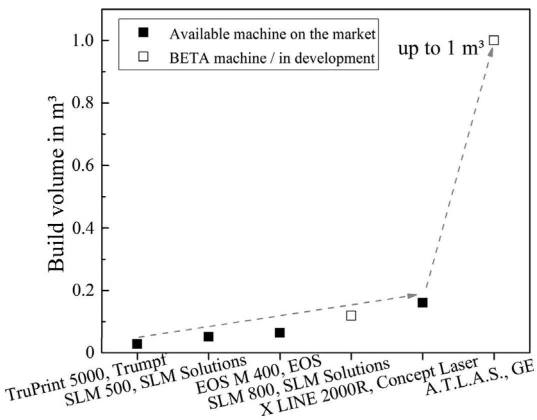

Fig. 2. Build volume of different powder bed metal laser melting machines and manufacturers.

with a modified metal laser melting machine X LINE 2000R (Concept Laser GmbH). The machine is equipped with two 1 kW laser systems. The process parameters used for additive manufacturing of test specimens are related to 50 µm layer thickness, 40 J/mm^3 volume energy, nitrogen atmosphere and island scanning strategy. Island scanning strategy means that the area of exposure is separated into squares with an edge length of 10 mm. Each island is hatched by bidirectional scanning strategy. Further, the islands are rotated (α = 90°) and moved (s = 1 mm) for layer n to layer n + 1 to reduce misconnections and anisotropy (Fig. 3).

For single track experiments only the contour of a small rectangle was molten (Fig. 13(a)). The width of the single tracks were measured by using a light microscope.

The powder morphology of AlSi10Mg is shown in Fig. 4. The scanning electron microscope pictures were taken with a Helios NanoLab 600i FIB Workstation (FEI Company). The particle size distribution was analysed by laser diffraction (Mastersizer 3000, Malvern Panalytical GmbH). The D10, D50 and D90 values are about 46 µm, 65 µm and 88 µm. The internal gas porosity of about 0.4% was measured on the basis of microscope pictures. The total oxygen content of the fresh powder is about 0.07–0.09% (Horiba oxygen nitrogen analyzer EMGA-620 W, Horiba Scientific). The company Concept Laser GmbH is the powder supplier of the AlSi10Mg (CL 32Al) powder. The chemical composition is related to DIN EN 1706.

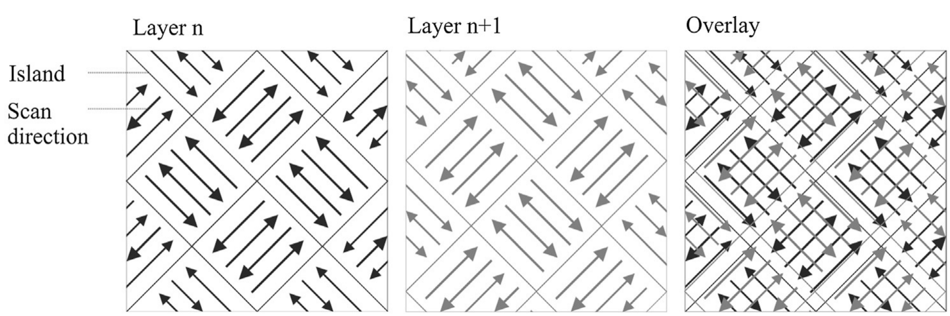

Fig. 3. Island scanning strategy (edge length 10 mm). Each island is hatched by a bidirectional scanning strategy. The islands are rotated (α = 90°) and moved (s = 1 mm) for layer n and layer n + 1.

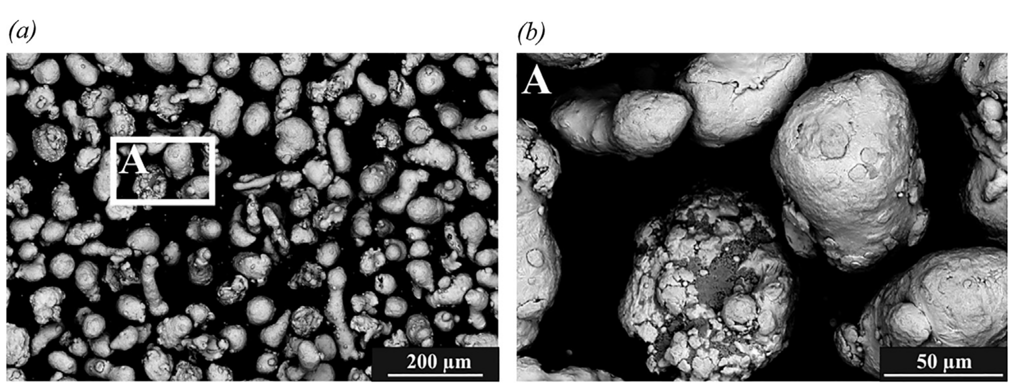

Fig. 4. Scanning electron microscope pictures of AlSi10Mg powder (CL 32Al) in different resolutions (a and b).

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