Experimental report

27/08/2018

Proposal: 1-02-230 **Council:** 4/2017

Title: Residual stress analysis in Ti64 alloy fabricated by Additive Layer Manufacturing

Research area: Materials

This proposal is a resubmission of 1-02-204

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Samples: Ti64

Instrument	Requested days	Allocated days	From	To
SALSA	5	4	22/04/2018	26/04/2018

Abstract:

Ti64 alloys are of great interest for aerospace applications respectively because of their low density, high mechanical and corrosion properties. Nevertheless large scale production is still restricted. It is therefore essential to use titanium alloys in the most efficient way in order to minimize the amount of wasted metal. Near-Net-Shape (NNS) processing means including powder metallurgy, such as additive layer manufacturing (ALM), offer the possibility to meet this need. The present project focuses on selective laser melting (SLM) fabrication process of Ti64 based components and the relationship between SLM parameters, residual stresses and microstructure. It consists in developing an experimental and numerical dialogue between process parameters, microstructural and mechanical properties. The present experiment aims at the determination of residuals stresses induced in the bulk of specimens fabricated with various strategies of SLM process (scanning direction, hatch angle).

Residual stress analysis in Ti64 alloy fabricated by Additive Layer Manufacturing

Proposal number: 1-02-230
Main proposer : Benoit MALARD (CIRIMAT, Toulouse)
Allocated days: 4
Date: 22/04/2018 to 26/04/2018

The aim of this study was to better understand the origins of residual stress in Ti64 alloy parts processed by Additive Layer Manufacturing (ALM). Many parameters are known to play a role in the building of residual stress, as geometries, orientation on the base plate or height of the sample. During this experiment, three different geometries where studied on SALSA : Bridges in order to do comparisons with previous work done using Laboratory X-Ray; walls of different heights (15mm, 30mm and 45mm); T shaped samples to enhance the effect of thermal conductivity through surface contact with the building plate (Figure 1). Bridge and walls were processed on 5mm height supports to prevent bending in order to keep residual stress within the sample. A comb was also analyzed in order to access the d_0. Samples where processed on a ProX200 machine using constructor parameters: power = 300W, laser scan velocity: 1800mm/s, powder layer thickness: 60µm, laser diameter: 70µm. The powder was reused Ti64 powder with 1000ppm of oxygen measured and the laser was a Nd:YAG laser with λ=1024nm.

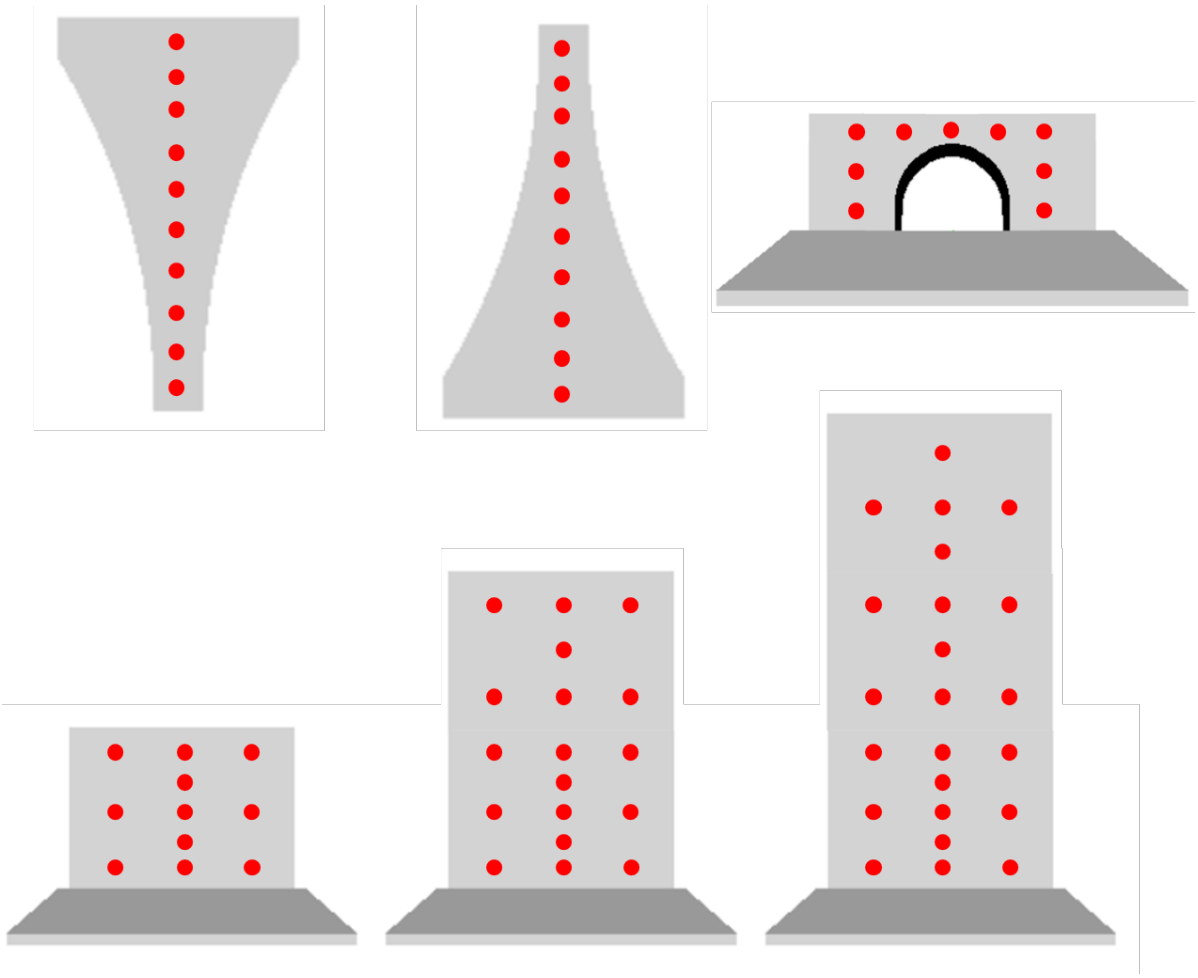

Figure 1 – Samples studied and measured points in red.

On SALSA, the gauge volume was defined by the radial collimators and fixed to 2 x 2 x 2 mm^3. The neutron wavelength was set to 1.62 A°, inducing a 2θ = 75.13° for the (103) reflection. Because of the 2θ not being equal to 90°, the gauge volume was slightly elongated with a longer horizontal diagonal. Diffraction patterns where then acquired during 15mm for every positions defined, in the three principal directions. Positions measured on each samples are shown on figure 1 by red dots.

Experimental data were treated using LAMP to access the strain and then residual stress tensors. Residual stress tensors are shown in figure 2 for the 15mm height wall sample in principal directions.

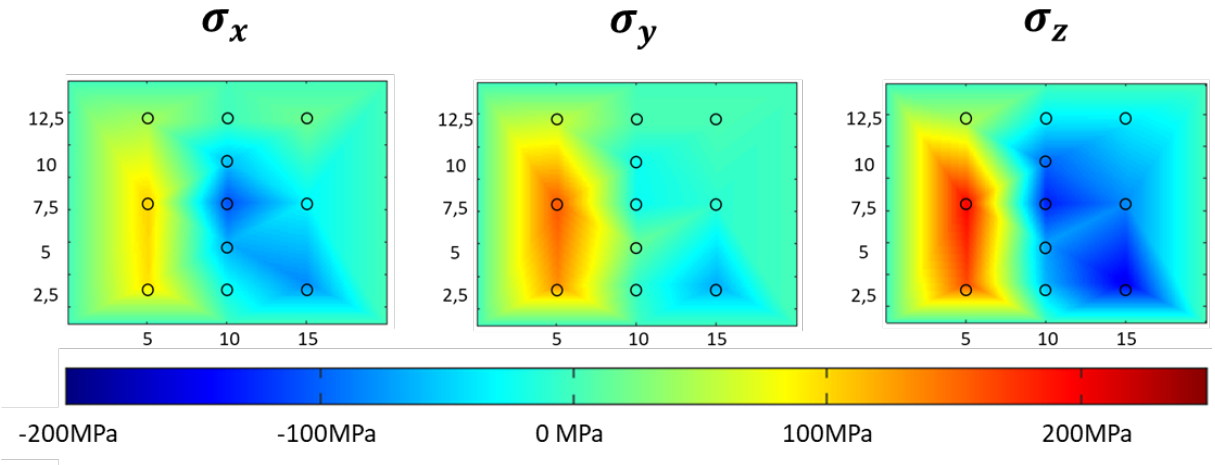

Figure 2 – Stress tensors in the 15mm height wall sample

In figure 2 one can see that residual stress state is not the same in the two sides of the samples. This suggest that the laser pattern or the pressing roll that dispenses the powder could have a role to play on the origins of residual stress. It could also be noticed that residual stress tensors reach higher extremes on the z direction, inducing a preferential orientation for the residual stress tensor.

In conclusion, this time on SALSA allowed us to collect a lot of experimental data, giving insight on residual stress building through fabricated parts. Differences in geometry and height of samples have been investigated. Residual stress state in a bridge have been studied in order to compare this result with laboratory X-Ray measurements. Even if there is still work to be done to understand experimental data, the 4 days experiment gave a lot of interesting results.