Fretting Fatigue behaviour of Press-Fit Joints of AM Parts by Digital Image Correlation and micro-Computed Tomography

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Introduction

The failure mechanism of additive manufactured parts is strongly influenced by the surface roughness from which cracks may initiate. Moreover, sub-surface pores can accelerate crack initiation from the surface micro-notches as well as the damage evolution. Both mechanisms also play a crucial role for press-fit assemblies. The aim of this study is to characterize the damage behavior of additive manufactured parts under vibratory relative motion inducing fretting fatigue. Therefore, a steel cylinder made by Selective Laser Melting was press-fitted into a fatigue specimen that is conventionally manufactured, and analyzed via X-Ray tomography and Digital Image Correlation during cyclic loading.

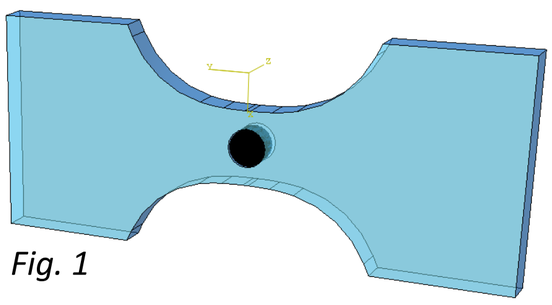


Fig. 1

Materials and experiments

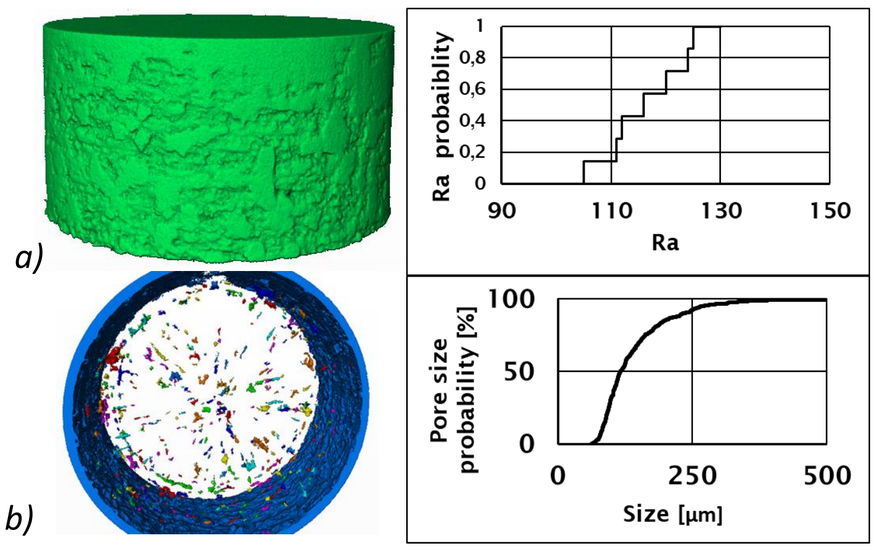
Cylinders of 3.4mm diameter were produced in axial direction by Selective Laser Melting. Two different materials, namely AISI 316L and 16MnCr5 were processed. The cylinders were pressed into a drilled hole in a conventionally manufactured fatigue specimen (Fig. 1). Sample surfaces were ground and sprayed with SiC particles to generate a reference pattern for DIC.

The 3D pin geometry, alongside internal pores, was acquired via µ-CT (Fig. 2) and imported into FE-software to simulate the stress distribution (Fig 4). Simulations were then compared it with idealized geometries (Fig 5).

Results

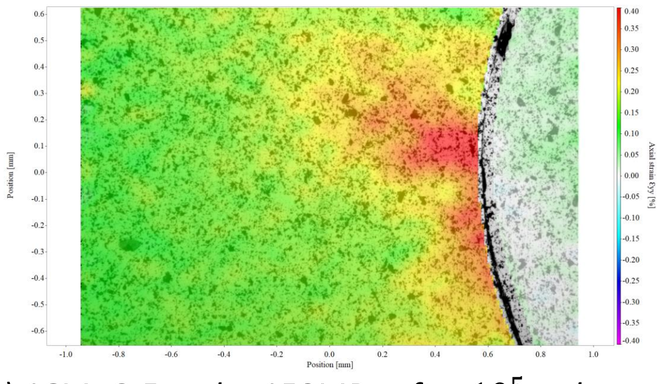
Pin characterization

Fig. 2

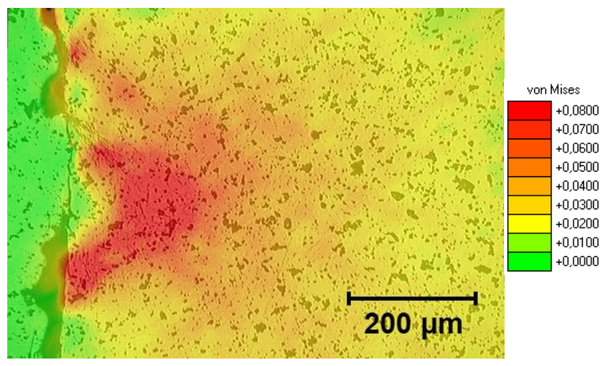


Deformation measurement

Fig. 3



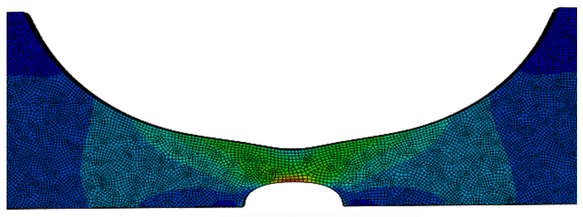
a) 16MnCr5 under 150MPa after 10^5 cycles



b) 316L under 170 MPa

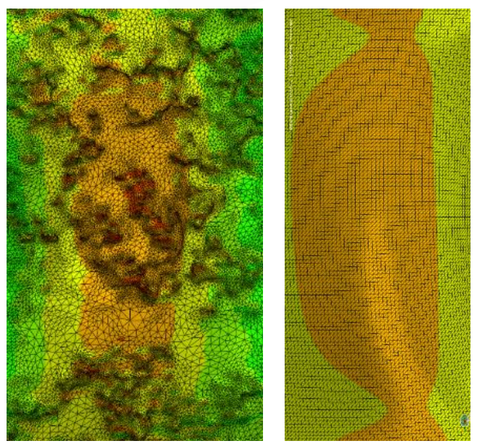
Simulation

Fig. 4



Eccentric fit

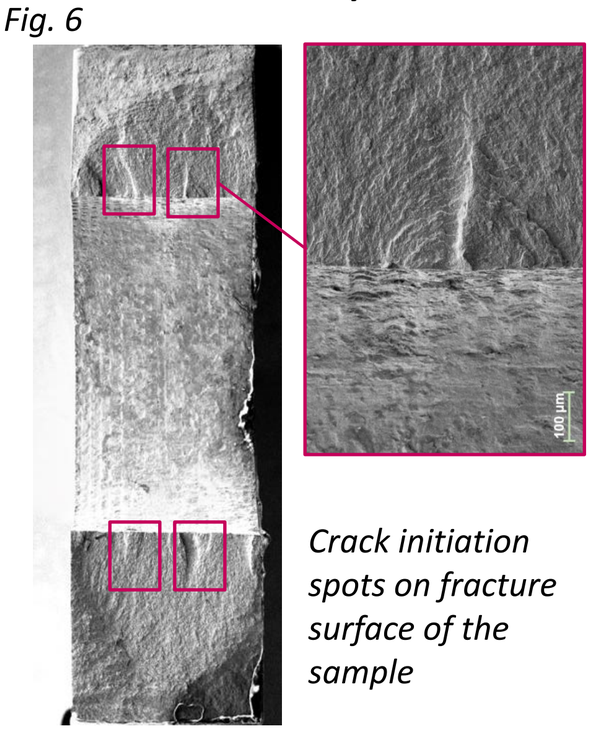
Fig. 5



a) Rough surface *b) idealized*

SEM analysis

Fig. 6



Crack initiation spots on fracture surface of the sample

Conclusions

CT-scans of the pin geometry revealed a considerable plastic deformation. Therefore simulation of the pressing process and comparative µ-CT scans will be considered in further research. Simulation with an idealized pin (Fig. 4a and 5.b) underlined the suitability of the sample geometry to induce strain onto the pin surface. For not perfectly aligned pins, a certain eccentricity is observed leading to four stress peaks, which coincided with crack initiation spots in SEM micrographs (Fig. 6). Therein, shear induced crack initiation can be identified, which is typical for fretting fatigue. Digital Image Correlation during cyclic loading displays high strain concentrations on the sample surface (Fig 3.), that can be correlated with the roughness tips of the pin.

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