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Inclusion of AM Process Simulation within the Defect Tolerant Fatigue Design Concept of SLM Manufactured Components

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The selective laser melting (SLM) process is prone to porosity, defects arising from lack of fusion, thermal stresses (including residual stresses), and irregular surface quality. These factors have a significant combined effect on the fatigue strength of components produced with this manufacturing technique. The adjustments to the SLM process parameters and additional post-processing procedures necessary to improve the fatigue strength of the printed components also tend to increase build time and manufacturing cost [1-3]. This situation is similar to that of casting design, whereby assuming a defect-free casting in fatigue dimensioning would lead to expensive manufacture of such components. Instead, the standard practice in castings is to allow for the existence of manufacturing and material defects at e.g. low stress regions of the component and revise the design based on casting simulation and structural optimization. A similar approach can be utilized in the design of SLM components. An overview of the proposed defect tolerant fatigue design concept for the SLM process is illustrated in Figure 1.

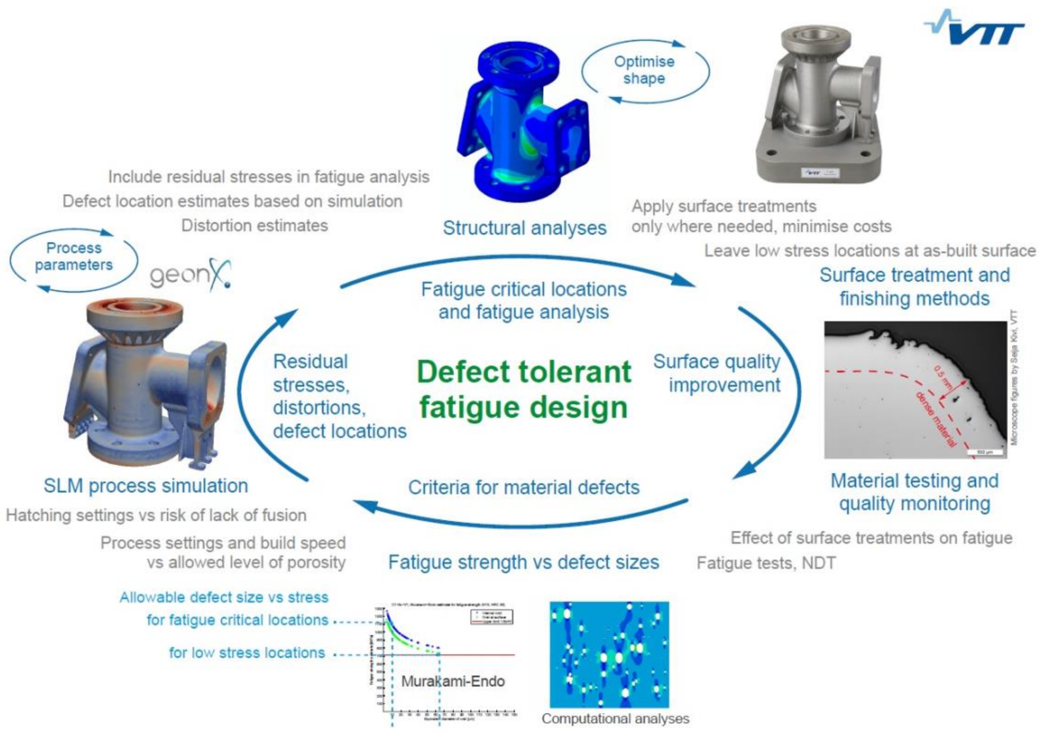

Figure 1. Defect tolerant fatigue design concept for use with SLM manufactured components [4].

The numerical simulation of the SLM process and post-treatments has been identified as a key component in the workflow. The ability to obtain estimates of the thermal stresses, distortions and defect distributions in the manufactured component early in the design phase is crucial for enabling the designer to create a part that meets all specifications and is manufacturable at a reasonable cost. The goal of the present paper is to investigate the use of commercially available SLM process simulation software for prediction of thermal build-up during printing and geometric accuracy of the final component.

A challenging geometry was chosen for study (Figure 2) that includes design features suitable for SLM (e.g. self-supporting elliptic cross section of horizontal pipes, added ribs and local details to make overhanging members self-supporting), and features such as thick sections and overhangs that are challenging to manufacture due to thermal distortions [4]. The component was manufactured using optimized process parameters for the materials used. During manufacturing, time-lapse video and thermal imaging were recorded, and after printing a FARO laser scanner was used to determine the geometric accuracy of the printed components as compared to the CAD model. Commercially available AM process simulation software was used to predict thermal build-up of the part during printing, predict cases where build failure would occur, and determine the geometric accuracy of the built component before and after post-processing procedures. Simulated and measured results are compared and discussed, along with plans for uptake of these methods within the defect tolerant fatigue design concept.

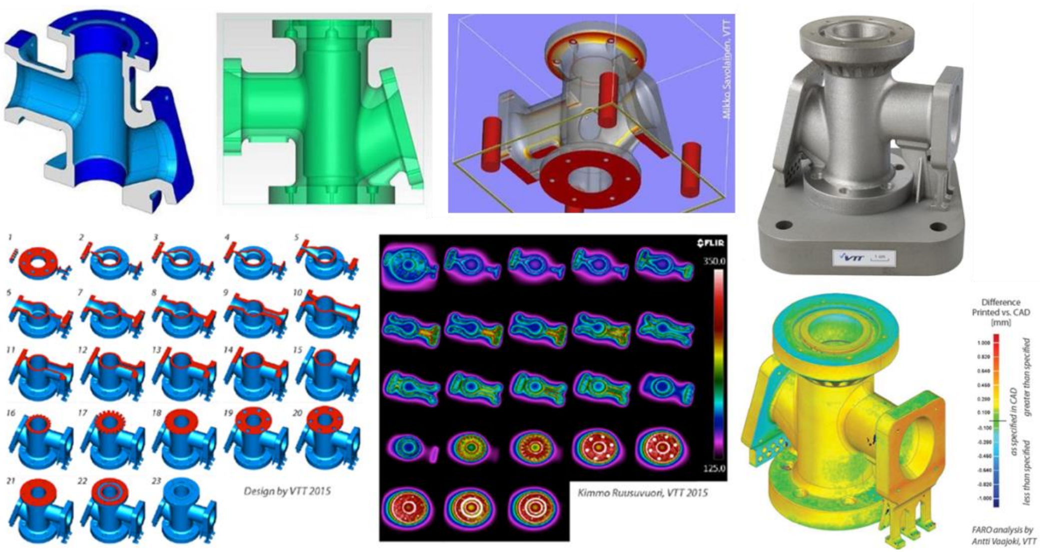

Figure 2. Images of test component CAD geometry, thermal imaging during printing, final printed component, and FARO geometric accuracy measurement.

References

[1] A. Riemera, S. Leudersa, M. Thönea, H.A. Richarda, T. Tröstera, and T. Niendorfd. On the fatigue crack growth behavior in 316L stainless steel manufactured by selective laser melting. *Engineering Fracture Mechanics*,120:15-25, 2014.

[2] E.O. Olakanmi, R.F. Cochrane, and K.W. Dalgarno. A review on selective laser sintering/melting (SLS/SLM) of aluminium alloy powders: Processing, microstructure, and properties. *Progress in Materials Science*, 74:401-477, 2015.

[3] M.L. Pace, A. Guarnaccio, P. Dolcea, D. Mollica, G.P. Parisi, A. Lettino, L. Medici, V. Summa, R. Ciancio, and A. Santagata. 3D additive manufactured 316L components microstructural features and changes induced by working life cycles. *Applied Surface Science*, 2017.

[4] P. Kokkonen, L. Salonen, J. Virta, B. Hemming, P. Laukkanen, M. Savolainen, E. Komi, K. Ruusuvuori, S. Varjus, A. Vaajoki, S. Kivi and J. Welling. Design guide for additive manufacturing of metal components by SLM process. *VTT Research Report*, VTT-R-03160-16, 2016.