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SUMMARY OF INITIAL FEASIBILITY STUDIES ON THE USE OF LASER POWDER BED FUSION IN NOZZLE EXTENSION APPLICATIONS

Abstract

Future rocket engines and their components require innovative and cost efficient design and manufacturing solutions in order to be competitive. The European Space Agency (ESA) has identified additive manufacturing (AM) as a key technology for new space systems, where for example the Prometheus rocket engine is foreseen to rely on AM processes. GKN Aerospace is building on its legacy of in-house technologies for cooled rocket engine nozzle extension (NE) design and manufacturing, and is currently developing and maturing different AM processes. Laser Powder Bed Fusion (LPBF) is one such process that shows promise in terms of design complexity, function and shortened manufacturing lead-time. NEs developed by GKN Aerospace are in the meter(s) size range and hence current LPBF systems have limitations on what is practically feasible to manufacture. To prepare for future LPBF systems, GKN Aerospace is performing development activities to understand process capabilities in order to explore potentials and restrictions when applied to cooled NEs. This paper presents the results from a study that focused on i) exploring different material alloys, ii) material testing, iii) the integrity of thin walls and iv) manufacturability of NE inlet manifolds. Five different LPBF materials were investigated, including Ni-, Al- and stainless steel alloys. Each of these materials were characterised through material testing (tensile) and component tests. The component tests consisted of burst tests on thin wall channels with different wall thickness and build directions. Manufacturability of NE manifolds was evaluated by measurement of dimensions and surface roughness, non-destructive and destructive inspection, and possibilities to remove loose powder. All five materials were successfully built, tested, inspected and evaluated. The study concludes that LPBF is a feasible manufacturing process to use for NEs or their sub-components. The built components were proven mechanically very strong, even for thin walled designs. The results show on possibilities for optimising NE designs for AM in general and LPBF in particular. Design potentials include consolidation of parts and purposely designed wall shape and thickness. For a closed cycle NE, the different channels for main cooling and return flows could be optimised to improve functionality. The outcome of the study is valuable input for future maturation activities for NEs that will utilise both the design and manufacturing opportunities that come with AM.