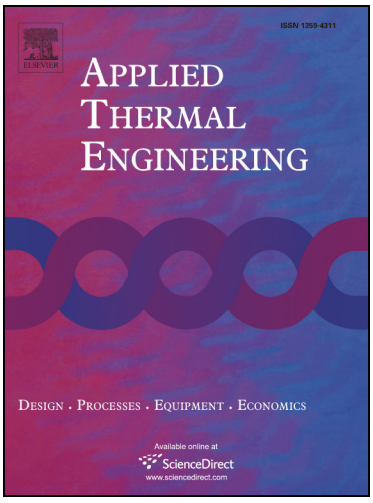

Design and evaluation of an additively manufactured aircraft heat exchanger

David Saltzman, Michael Bichnevicius, Stephen Lynch, Timothy W. Simpson, Edward W. Reutzel, Corey Dickman, Richard Martukanitz

PII: S1359-4311(17)37473-2
DOI: https://doi.org/10.1016/j.applthermaleng.2018.04.032
Reference: ATE 12029

To appear in: *Applied Thermal Engineering*

Received Date: 22 November 2017
Revised Date: 23 February 2018
Accepted Date: 6 April 2018

Please cite this article as: D. Saltzman, M. Bichnevicius, S. Lynch, T.W. Simpson, E.W. Reutzel, C. Dickman, R. Martukanitz, Design and evaluation of an additively manufactured aircraft heat exchanger, *Applied Thermal Engineering* (2018), doi: https://doi.org/10.1016/j.applthermaleng.2018.04.032

Design and Evaluation of an Additively Manufactured Aircraft Heat Exchanger

David Saltzman, Michael Bichnevicius,
Stephen Lynch, Timothy W. Simpson
Penn State University
University Park, PA 16802

Edward W. Reutzel, Corey Dickman,
Richard Martukanitz
Applied Research Lab—Penn State
University Park, PA 16802

Additive manufacturing (AM) technology has significant potential to improve heat exchanger (HX) performance through incorporation of novel geometries and materials, but there is limited understanding of AM HX functionality relative to conventionally manufactured components. This study compares the performance of conventionally-built plate-fin air-liquid crossflow heat exchangers (i.e., aircraft oil coolers) to additively manufactured heat exchangers of similar geometry. To replicate internal features, three dimensional X-ray computed tomography scans were performed on the conventionally-built heat exchanger. A baseline AM model of the conventional design was designed, as well as an AM model with additional enhancement features on the air side. The two AM heat exchanger geometries were constructed using a laser-based powder bed fusion process with AlSi10Mg aluminum-alloy powder. Visual inspection of the as-built AM HX indicated significant surface roughness and some cracks in the fin-tube joint, but only at the edges of the heat exchanger. Overall heat transfer was increased by about 10 percent for the baseline AM and by 14 percent for the enhanced AM heat exchanger when compared to the conventionally built baseline heat exchanger. Measured air-side pressure drop for the AM heat exchangers was double that of the conventionally built baseline heat exchanger. Overall, this study indicates potential for improved heat transfer and demonstrated functionality of AM HX in realistic applications.

Nomenclature

A_c	minimum flow area into a fin passage
A_s	convective surface area in a flow passage
AM	additive manufacturing
BAM	Baseline Additively Manufactured design
BTM	Baseline Traditionally Manufactured design
CAD	computer aided design
CT	computed tomography
EAM	Enhanced Additively Manufactured design
ETM	Enhanced Traditionally Manufactured design
f	friction factor
F_d	depth of fin passage in the flow direction