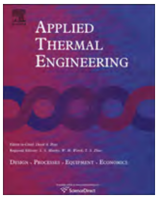
Applied Thermal Engineering 48 (2012) 194–201

Contents lists available at SciVerse ScienceDirect

Applied Thermal Engineering

journal homepage: www.elsevier.com/locate/apthermeng



Development of an adhesive-bonded counterflow microchannel heat exchanger

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HIGHLIGHTS

- ► Adhesive-bonded microchannel heat exchanger design, fabrication and testing.
- ► 50% material reduction and 20% size reduction.
- ► Higher effectiveness and greater heat load than original design.
- ► Good agreement between theoretical and experimental results.
- ► Adhesive erosion mitigated using sealing bosses.

ARTICLE INFO

Article history:
Received 15 November 2011
Accepted 2 May 2012
Available online 10 May 2012

Keywords:
Adhesive bonding
Microchannel array
Counterflow heat exchanger
Effectiveness
Pressure drop

ABSTRACT

A low-temperature liquid-to-vapor counterflow microchannel heat exchanger has been redesigned and fabricated using a scalable, low-cost adhesive bonding process. Adhesive erosion concerns are mitigated with the use of sealing bosses. Performance has been tested using water and compressed air as test fluids. Results show greater effectiveness and higher heat transfer rates than the original heat exchanger due to relaxed design constraints afforded with adhesive bonding. A maximum effectiveness of 82.5% was achieved with good agreement between theoretical and experimental values. Although thermal performance was improved, higher pressure drops were noted. Pressure drops were predicted with a maximum error of 16% between theoretical and experimental values. Much of the pressure drop was found to be in the device manifold which can be improved in subsequent designs.

1. Introduction

Microchannel process technology (MPT) is the use of microchannel arrays for the bulk processing of mass and energy. Although MPT devices can be on the order of meters in dimension, MPT devices include critical microchannel dimensions ranging from below 100 μm to several mm [1]. One of the major advantages of MPT is the high surface area to volume ratios compared to conventional fluidic technology. These ratios allow accelerated rates of heat and mass transfer within microchannels due to short diffusional distances. As a result, microchannels provide the ability to reduce the size and weight of a wide variety of energy and chemical systems including microelectronic cooling systems (Kawano et al. [2]; Little [3]), chemical reactors and separators (Cao et al. [4], Matson et al. [5]), fuel processors (Ryi et al. [6]), and heat pumps (Garimella et al. [7]) among many others.

A significant barrier to commercializing MPT has been the cost of manufacturing microchannel arrays [8–10]. Prior work has demonstrated and characterized a new approach to bonding low-temperature microchannel arrays that relies on mass production techniques for electronics assembly [11]. The new approach involves the use of surface mount adhesives to bond a stack of microchannel laminae (thin layers of material also referred to as shims) with integrated height control features or sealing bosses. The objective of this paper is to demonstrate the feasibility of using this approach in the redesign of a microchannel heat exchanger, in an effort to investigate its value.

1.1. Need for low-temperature, low-cost MPT applications

One growing area for MPT application is low-temperature thermal management, such as the cooling of consumer electronics. The peak operating temperatures for electronics cooling rarely exceeds 125 °C, limited by several factors such as thermal leakage currents, ergonomics and safety. This implies that high bond strength as a function of temperature is not needed for electronics cooling and other low temperature applications such as climate control and recuperation. Thus, it can be reasoned that

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doi:10.1016/j.applthermaleng.2012.05.001