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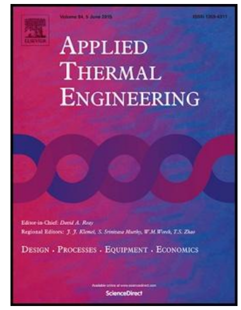

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DESIGNER FLUID PERFORMANCE AND INCLINATION ANGLE EFFECTS IN A FLAT GROOVED HEAT PIPE

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ABSTRACT

A flat heat pipe was used to study the effects of an advanced working fluid previously shown to improve the thermal performance of phase change heat transfer devices through surface augmentation of the wick. Surface structures were created by the working fluid through chemical oxidation reactions and solubility forced deposits. The modular heat pipe apparatus allowed water and the advanced working fluid to be compared in the same device. A clear viewing cover plate allowed for visual observation of the evaporating section of the heat pipe. The setup was first tested for repeatability with water and produced three sets of thermal resistance values within 5%. The advanced working fluid decreased the thermal resistance by approximately 20% and nearly tripled the capillary limit. The advanced working fluid was also tested at larger angles and was able to maintain normal operation due to the additional capillarity of the fluid deposits. This work also provides insight into the design of fluids for other wick geometries by examining the effect of increasing the concentration of the fluid and how the fluid deposits on the surface. The results indicate that concentration of the fluid was over the amount necessary for the evaporative surface area of the grooved wick.

Keywords: *Flat heat pipe, Phase change heat transfer, advanced working fluid, Inorganic aqueous solution (IAS), grooved wick*

1 INTRODUCTION

Thermal management challenges in electronic devices and systems have emanated from progressive increases in power consumption and decreases in component size. Heat produced by even consumer devices has soared past expected cooling needs requiring more advanced thermal technologies. Heat pipes and other phase change heat transfer devices have been a popular method of transferring heat for decades due to their passive and efficient nature [1].

High heat flux cooling needs has led to a variety of research devoted to development of novel heat pipe wick structures and designer fluids [2-4]. Typically a working fluid is chosen based on its dimensionless Merit number and operating temperature range limiting the possibility for performance improvement in this aspect of heat pipe design. However, several types of advanced working fluids, such as binary fluids, nanofluids, and other designer fluids offer additional mechanisms for thermal performance enhancement. The purpose of a designer fluid is to either alter the properties of the fluid or the evaporating surface. For example, binary fluids can adjust operating temperature ranges and surface tension gradients while nano-particle suspensions, known as nanofluids, leave a coating of nanoparticles on the surface of the wick while increasing the thermal conductivity of the solution. This deposited coating has been shown to increase evaporative performance in phase change heat transfer devices through the extra capillarity and wetting ability of the small coating pores [5-8].

A unique group of designer fluids has been developed from the originally patented Inorganic Aqueous Solution (IAS) created and studied at UCLA [9, 10]. These fluids create microstructures on the surface of the wick *in situ* through chemical reactions and solubility forced deposits. This surface augmentation is inherently hydrophilic and has shown to increase the performance and dry-out heat flux in a variety of wicks. To the author's knowledge, these fluids have been the first attempt at using dilute aqueous solutions for performance enhancement in phase change heat transfer devices. This type of chemically reacting working fluid is particularly promising because of the cost, and reliability associated with the inorganic constituents and coating respectively.

The chemical composition and basic transport mechanisms of the generated coating have been identified in previous research studies and are summarized below. However, several design aspects are still unaddressed and require investigation. Before the fluid constituents and concentration can be optimized, the deposition mechanisms must be examined. The goal of this work was to further develop the designer fluid design process by examining how the coating is deposited in a wick through its performance in a grooved flat heat pipe. Changes in thermal resistance and the heat transport limit as well as the nature of the fluid deposits will provide insight into further development of the advanced working fluid. A modular flat heat pipe was designed and fabricated to allow visual observation during operation and dry-out of the wick.