Proceedings of the 10th World Congress on Mechanical, Chemical, and Material Engineering (MCM'24)
Barcelona, Spain –August 22-24, 2024
Paper No. HTFF 147
DOI: 10.11159/htff24.147

A Study of the Aluminum-Ammonia Heat Pipe with Hybrid Wicks

Meng-Hao Chen[1], Ho-Chuan Lin[2], Alfandy Tansyafri[2], Van-Hoan Vu[2]
[1]Taiwan Space Agency (TASA)
8F, 9 Prosperity 1st Road, Hsinchu Science Park, Hsinchu City, Taiwan
mhchen@tasa.org.tw
[2] EW JET PRODUCTS Co., Ltd
3F-B, No.179-2, Sec-1, Datong Rd., Xizhi Dist., New Taipei City, Taiwan
edlin@ewjpro.com; alfandy@ewjpro.com; henrywu@ewjpro.com

Extended Abstract

It is well known that aluminum-ammonia heat pipe (AAHP) is an efficient two-phase heat transport device and has been widely utilized for high power satellite thermal management. The heat pipe requires a wick structure throughout to return liquid from the condenser to the evaporator. Axial grooved extruded wick is the typical type used in AAHP to provide high permeability and associated low liquid pressure drop compared with sintered or mesh wick. In addition, several studies investigated different kinds of groove shapes, including rectangular, triangular, trapezoidal, and omega shapes [1-2]. Among them, the omega-shaped groove has better heat transfer performance than the other shapes but is relatively difficult to fabricate [3].

In this study, hybrid wick AAHPs were developed based on the U-shape axial grooved configuration with novel wick-sleeve (WS) structure. The design is expected to solve the extrude aluminum wick limitation and increase overall thermal performance through enhance capillary force and release the entrainment limitation. The cylindrical WS structure is fabricated using the AlSi10Mg 3D-printing technique and then be integrated into the axial grooved wick of the heat pipe. The WS is the type of screen wire mesh with an average porosity of 53%. The length of each WS is 250 mm, about one-third of the heat pipe length. Several configurations were attempted and investigated, include the WS install locations and its external fin designs. The install locations mean the WS be installed on the evaporator, condenser or both sections of the heat pipe. The external fin designs indicate the WS has zero fin, three fins or six fins protruding radially outward. Furthermore, these fins engage with the U-shape axial grooves of heat pipe while installing the WS structure.

The experimental setup of the AAHP is placed horizontally, and 12 thermocouples are evenly arranged along the axis of the AAHP on the evaporator, adiabatic, and condenser sections. The length of each section is 250, 170, and 240 mm, respectively. Heating plate heats the evaporator section and the output power is gradually increased until it reaches 300 W. Cooling plate cools the condenser section with fixed temperature of 10°C. The transient temperature response of the AAHP is recorded with the data sampling interval of one second.

The experimental results show that the AAHP has better thermal performance with the configuration of WS be installed only on the evaporator section. The WS on the condenser section retains more working fluid, which results in higher resistance to the vapor flow and higher thermal resistance between the hot vapor and the cooling plate. Furthermore, the external fin design of WS is also a factor that affects the overall performance. The dry-out phenomenon appears earlier for the type of zero fin, whereas the types of three fins and six fins eliminates this problem.

References

[1] K. Yang, Y. Mao, Z. Cong and X. Zhang, "Experimental Research of Novel Aluminium-Ammonia Heat Pipes," *Procedia Engineering*, vol. 205, pp. 3923-3930, 2017.
[2] V. Vlassov, J. Bertoldo Jr. and N. Santos, "A Comparative Study Heat Pipes with Rectangular and Omega-Type Grooves Performance," in *Joint 19th IHPC and 13th IHPS*, Pisa, Italy, June 10-14, 2018.
[3] Y. Chen, C. Zhang, M. Shi, J. Wu and G. P. Peterson, "Study on Flow and Heat Transfer Characteristics of Heat Pipe with Axial "Ω"-Shaped Microgrooves," *Int. J. of Heat and Mass Transfer*, vol. 52, pp. 636-643, 2009.