# Effect of thin porous copper coating on the performance of wickless heat pipe with R134a as working fluid

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**Abstract**

The heat transfer characteristics of a thin porous copper-coated wickless heat pipe using R134a as a working fluid is investigated and is compared for its performance with uncoated wickless heat pipe using the same working fluid. An electroplating process was utilized to form a porous structure of copper over the inner surface of the wickless heat pipe. The experiments were carried out in the heat input range between 50 and 250 W. The thermal resistance of heat pipe at three different inclination angles such as 0°, 45° and 90° with horizontal are investigated. The results showed that 45° inclination has the lowest resistance with significant improvement in heat transfer characteristics. The coated wickless heat pipe exhibited a low thermal resistance when compared to uncoated wickless heat pipe. The condenser and evaporator heat transfer coefficients of a coated wickless heat pipe were found to be higher by about 11% and 25%, respectively, when compared to uncoated heat pipe for a heat flux of 10 kW $m^{-2}$ and inclination of 45°. The magnitudes of dimensionless numbers (such as, *Bo*, *We*, *Ku* and *Co*) on coated and uncoated wickless heat pipes are also found.

**Keywords** R134a · Electroplating · Copper coating · Heat transfer performance · WHP

**List of symbols**

| | |
|---|---|
| $A$ | Area ($m^2$) |
| $Bo$ | Bond number |
| $Co$ | Condensation number |
| $D$ | Diameter (m) |
| $g$ | Acceleration due to gravity (m $s^{-2}$) |
| $h$ | Heat transfer coefficient (W $m^{-2}$ $K^{-1}$) |
| $h_{fg}$ | Heat of vaporization (J $kg^{-1}$ $K^{-1}$) |
| $k$ | Thermal conductivity (W $m^{-1}$ $K^{-1}$) |
| $Ku$ | Kutateladze number |
| $L$ | Length (m) |
| $Q$ | Heat input (W) |
| $q$ | Heat flux (W $m^{-2}$) |
| $R_t$ | Total thermal resistance (°C $W^{-1}$) |
| $r$ | Radius (m) |
| $T$ | Temperature (°C) |
| $We$ | Weber number |

**Subscripts**

| | |
|---|---|
| c | Condenser |
| e | Evaporator |
| v | Vapour |
| l | Liquid |

**Greek symbols**

| | |
|---|---|
| $\Delta x$ | Change in any parameter "x" |
| $\mu$ | Viscosity (N s $m^{-2}$) |
| $\rho$ | Density (kg $m^{-3}$) |
| $\sigma$ | Surface tension (N $m^{-1}$) |

## Introduction

Heat pipe is a passive heat transfer device that works on the principle of phase change heat transfer processes of boiling and condensation process. It comprises a cylindrical enclosure lined with a liquid saturated wick structure.

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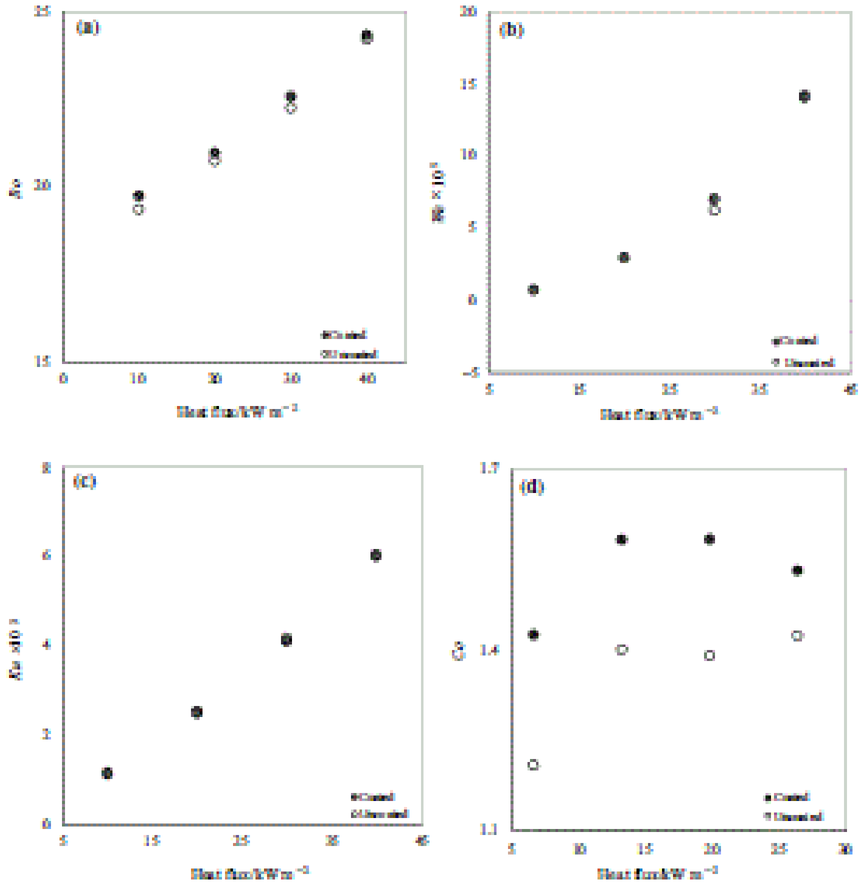


Fig. 10 Effect of heat flux on the dimensionless numbers, a Bond b Webber, c Kutateladze and d Condensation numbers

Therefore, the coated wickless heat pipes are potential alternative for traditional wickless heat pipes in the field of electronic cooling and other fields of heat transfer applications.

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