INTISARI

Peningkatan kebutuhan sistem pendinginan pada aplikasi dengan *heat flux* tinggi, seperti *data center*, mendorong pengembangan metode *spray cooling* yang memiliki kemampuan perpindahan panas tinggi. Fenomena dasar pada metode tersebut adalah *droplet impingement*, yang dipengaruhi oleh berbagai parameter, di antaranya kekasaran dan temperatur permukaan. Penelitian ini bertujuan untuk menganalisis pengaruh variasi kekasaran dan temperatur permukaan terhadap dinamika *droplet* serta penurunan temperatur pada proses *single droplet impingement* di permukaan tembaga (Cu).

Pengujian dilakukan menggunakan aquades sebagai fluida uji dengan bilangan Weber, yaitu rasio antara gaya inersia dan gaya tegangan permukaan, dipertahankan pada kisaran 55 melalui ketinggian permukaan air (*head*) yang konstan. Permukaan tembaga divariasikan menjadi tiga tingkat kekasaran, yaitu Cu 1 (Ra = 0,218 μm), Cu 2 (Ra = 1,507 μm), dan Cu 3 (Ra = 6,401 μm), sedangkan temperatur awal permukaan divariasikan pada 80, 100, 110, 130, 150, 200, dan 250°C. Dinamika *droplet* direkam menggunakan *high-speed camera* dan dianalisis melalui *image processing* menggunakan MATLAB, sedangkan perubahan temperatur permukaan diukur menggunakan *thermocouple*.perubahan temperatur permukaan diukur menggunakan *thermocouple*.

Hasil penelitian menunjukkan bahwa peningkatan temperatur permukaan mempercepat transisi dinamika *droplet* dari *spreading* menuju *bouncing* dan *splashing*. Kekasaran permukaan yang lebih tinggi meningkatkan kecenderungan terjadinya *contact line pinning* pada temperatur rendah serta memicu *splashing* pada temperatur tinggi. Secara kuantitatif, nilai *maximum spreading factor* berada pada rentang 2,4–3,6, sedangkan *contact time* menurun secara signifikan dari 80 ms menjadi sekitar 10–17 ms seiring meningkatnya temperatur permukaan hingga terjadi *bouncing*. Selain itu, spesimen Cu 3 (Ra = 6,401 μm) menghasilkan penurunan temperatur permukaan terbesar dibandingkan Cu 1 dan Cu 2, yang mengindikasikan bahwa peningkatan kekasaran permukaan berpengaruh terhadap karakteristik perpindahan panas selama proses *droplet impingement*. Hasil penelitian ini memberikan pemahaman mengenai pengaruh temperatur dan karakteristik permukaan terhadap dinamika *droplet* serta perilaku perpindahan panas pada permukaan tembaga

Kata kunci: *droplet impingement*, kekasaran permukaan, temperatur permukaan, dinamika *droplet*, perpindahan panas, tembaga.

ABSTRACT

The increasing demand for cooling systems in high heat flux applications, such as data centers, has encouraged the development of spray cooling due to its superior heat transfer capability. The fundamental phenomenon governing heat transfer in spray cooling is droplet impingement, which is influenced by various parameters, including surface roughness and surface temperature. This study aims to analyze the effects of surface roughness and surface temperature on droplet dynamics and surface temperature reduction during single water droplet impingement on copper (Cu) surfaces.

Experiments were conducted using deionized water as the working fluid, while the Weber number, defined as the ratio of inertial to surface tension forces, was maintained at approximately 55 by keeping the water head constant. Three copper specimens with different surface roughness values were tested, namely Cu 1 (Ra = 0.218 μm), Cu 2 (Ra = 1.507 μm), and Cu 3 (Ra = 6.401 μm), at initial surface temperatures of 80, 100, 110, 130, 150, 200, and 250°C. Droplet dynamics were recorded using a high-speed camera and analyzed through MATLAB-based image processing, while surface temperature variations were measured using thermocouples.

The results showed that increasing surface temperature accelerated the transition of droplet dynamics from spreading to bouncing and splashing. Higher surface roughness increased the tendency for contact line pinning at low temperatures and promoted splashing at elevated temperatures. Quantitatively, the maximum spreading factor ranged from 2.4 to 3.6, while the contact time decreased significantly from 80 ms to approximately 10–17 ms as the surface temperature increased and bouncing occurred. In addition, the Cu 3 specimen (Ra = 6.401 μm) exhibited the greatest surface temperature reduction among all specimens, indicating that increased surface roughness influences the heat transfer characteristics during droplet impingement. These findings provide a better understanding of the effects of surface temperature and surface characteristics on droplet dynamics and heat transfer behaviour over copper surfaces.

Keywords: *droplet impingement, surface roughness, surface temperature, heat transfer, copper.*