

INTISARI

Kelangkaan air bersih merupakan permasalahan global yang semakin mendesak akibat pertumbuhan populasi, perubahan iklim, dan keterbatasan sumber daya air konvensional. Salah satu solusi berkelanjutan yang berkembang adalah teknologi *atmospheric water harvesting* memanfaatkan uap air di atmosfer melalui proses kondensasi. Efisiensi proses kondensasi sangat dipengaruhi oleh karakteristik permukaan material serta dinamika pelepasan *droplet* dari permukaan kondensor. Penelitian ini bertujuan untuk mengkaji secara eksperimental pengaruh variasi pola biomimetik daun di permukaan pelat dan penerapan getaran mekanis terhadap laju kondensasi dan efektivitas pengumpulan air.

Penelitian dilakukan menggunakan pelat tembaga vertikal dengan beberapa variasi pola permukaan, baik hidrofilik, hidrofobik, maupun berpola sudut tertentu. Proses kondensasi berlangsung di dalam *condensation chamber* dengan kondisi lingkungan terkontrol, yaitu temperatur permukaan sekitar 5 °C dan kelembapan relatif $80 \pm 5\%$. Getaran mekanis diterapkan menggunakan *vibration speaker* dengan variasi frekuensi tanpa getaran, frekuensi resonansi, serta frekuensi sapuan pada gelombang *square*. Parameter yang diamati meliputi laju massa kondensat, fluks kalor kondensasi, dan karakteristik pelepasan *droplet*.

Hasil penelitian menunjukkan bahwa kombinasi pola permukaan dan penerapan getaran mekanis mampu mempercepat pelepasan *droplet*, meningkatkan pembaruan area aktif kondensasi, serta meningkatkan laju pengumpulan air dibandingkan kondisi tanpa getaran. Berdasarkan hasil penelitian pola permukaan sudut 60° dengan frekuensi resonansi menghasilkan jumlah perolehan air kondensat sekitar 74,42%, sedangkan getaran Sapuan frekuensi menghasilkan peningkatan jumlah perolehan air sebesar 57,14%.

Kata Kunci: kondensasi, pola permukaan, getaran mekanis, *atmospheric water harvesting*, *dropwise condensation*

ABSTRACT

Global freshwater scarcity has become a critical challenge due to population growth, climate change, and the depletion of conventional water resources. Atmospheric water harvesting has emerged as a promising sustainable solution by utilizing water vapor from ambient air through condensation processes. The efficiency of condensation-based water harvesting systems is strongly governed by surface characteristics and the dynamics of *droplet* removal from the condenser surface. This study presents an experimental investigation on the combined effects of biomimetic surface patterning and mechanical vibration on condensation performance and water collection efficiency.

The experiments were conducted using vertically oriented copper plates with various surface configurations, including hydrophilic, hydrophobic, and patterned surfaces with different inclination angles. Condensation experiments were performed inside a controlled condensation chamber with surface temperatures maintained at approximately 5 °C and relative humidity of $80 \pm 5\%$. Mechanical vibration was introduced using a vibration speaker under three conditions: no vibration, resonant frequency, and frequency *sweep* using *square* wave signals. Key performance indicators evaluated in this study include condensate mass flux, condensation heat flux, and *droplet* detachment behavior.

The results of the study indicate that the combination of surface patterns and the application of mechanical vibration can accelerate *droplet* detachment, increase the renewal of the active condensation area, and enhance the water collection rate compared to conditions without vibration. Based on the research results, a 60° surface pattern with a single-frequency vibration yielded approximately 74.42% of condensate water recovery, while sweep-frequency vibration resulted in a 57.14% increase in water recovery.

Keywords: *Atmospheric water harvesting; condensation, surface patterning; mechanical vibration; droplet dynamics.*