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Analysis on the Drum Performance of the Washer-dryer Based on Heat and Mass Transfer Rate

Hongsik Park[1], Soonbum Kwon[1], Dongchan Lee[2], kanghun Lee[3], Yongchan Kim[1*]
[1]Department of Mechanical Engineering, Korea University
145, Anam-ro, Sungbuk-gu, Seoul, 02841, Republic of Korea
hspark201@korea.ac.kr; bum8891@korea.ac.kr; yongckim@korea.ac.kr
[2]School of Mechanical and Information Engineering, University of Seoul
163, Seoulsiripdae-ro, Dongdaemun-gu, Seoul, 02054, Republic of Korea
dclee.uos@gmail.com
[3]Home Appliance Solution R&D Lab, LG Electronics
kanghun15.lee@lge.com
[*] Corresponding author

Extended Abstract

Currently, the dryer market is experiencing growing demand for products with superior performance and efficiency [1]. According to Global Market Insights, the compound annual growth rate of the dryer market is projected to reach approximately 5.6% by 2032, which represents a significant share of the home appliance market. Additionally, the market value of tumble dryers is expected to reach around 32.1 billion USD by 2032 [2]. Recently, washer-dryer units that enable both washing and drying in a single drum have been introduced, receiving significant attention from consumers owing to their convenience and space-saving advantages.

The drum structure of washer-dryers differs from that of conventional dryers. Drainage holes for washing are located on the side of the drum, resulting in a dual-layer structure comprising an inner and outer drum. Owing to this structural difference, the heated air in washer-dryers experiences limited heat and mass exchange with the fabrics, as a portion of the airflow escapes through the side holes of the drum. This leads to reduced drying effectiveness and degrades the overall performance of the system. Consequently, this structural difference is expected to cause distinct heat and mass transfer mechanisms compared to conventional dryers. However, studies examining the heat and mass transfer characteristics and performance parameters of washer-dryer drums are limited.

In this study, an experimental setup of a heat pump washer-dryer drum was constructed. By varying operating parameters such as temperature, humidity, initial airflow rate, and load, the outlet air conditions were measured to evaluate the heat and mass transfer performance of the washer-dryer drum. The temperature was set at 40, 60, 80 °C, the absolute humidity at 0.03, and 0.05 kg kgda-1, the volume flow rate at 1.7, and 2.7 CMM, the load at 3, 5, and 9 kg. The parametric experiment was conducted under fixed inlet air condition (60 °C, 0.03 kg kgda-1, 2.7 CMM, 3 kg) varying one parameter at a time as described above. As a result, the heat and mass transfer rates selected as performance indicators showed significant enhancement with both the temperature and the inlet air flow rate. Specifically, compared to 40 °C, the rates improved by 346%, and 406% at 60 °C and compared to 60 °C, 45.5%, and 31.7% improvement is shown at 80 °C respectively. At 2.7 CMM, the rates showed 45.4% and 76.8% improvement compared to those at 1.7 CMM. This study provides the fundamentals on the drum performance of washer-dryers, and these results serve as base data for the optimization of the washer-dryer structure.

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