Proceedings of the 10th World Congress on Mechanical, Chemical, and Material Engineering (MCM'24)
Barcelona, Spain –August 22-24, 2024
Paper No. HTFF 121
DOI: 10.11159/htff24.121

Drying Performance of Clothes with Different Fabric Types in Tumble Drum Dryers

Haerang Jo[1], Yongju Lee[1], Dongchan Lee[2], Yongchan Kim[1,*]
[1]School of Mechanical Engineering, Korea University
145, Anam-ro, Sungbuk-gu, Seoul, 02841, Republic of Korea
chr0328@korea.ac.kr; yongju40_lee@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
* Corresponding author

Extended Abstract

With the growth of the clothes dryer market, the use of clothes dryers in households is gradually increasing [1]. Numerous studies have been conducted to predict the drying performance of tumble drum dryer. However, predicting the drying performance of tumble drum dryers is challenging owing to complicated motion of clothes inside a tumble drum. While studies using the Lewis number method and empirical correlations have been conducted [2,3], the drying performance was predicted within limited range of variables. On the other hand, Lee et al. [4] confirmed the correlation between inlet air conditions and heat and mass transfer rate in the tumble drum. A prediction model for the heat and mass transfer rates of heat pump dryers was developed using Artificial Neural Network (ANN). The prediction model demonstrated high accuracy; however, it was constrained to International Electrotechnical Commission (IEC) load.

In this study, the drying performance in terms of load types, such as IEC, Practical Clothes (PC), and Department of Energy (DOE), was experimentally analyzed for various inlet air conditions. Mass of each load was set according to respective test standard. Inlet air conditions included temperature, absolute humidity, and airflow rate. The temperature was set at 40, 60, and 80 °C, absolute humidity at 0.01, 0.03, and 0.05 kg kg_{da}^{-1}, and airflow at 1.5, 3.0, and 4.5 CMM. In all fabric types, the drying performance increased with an increase in the inlet air temperature and airflow rate, and it increased with a decrease in absolute humidity. After confirming the evaporation tendencies for each fabric type, experiments were conducted under fixed inlet air conditions (60 °C, 0.03 kg kg_{da}^{-1}, 3.0 CMM) and identical mass condition (5.4 kg) to analyze the drying performance among the different fabric types. The drying performance was the highest for the DOE, followed by IEC and PC in sequence owing to the characteristics of the fabric type. Sensible heat transfer rate and mass transfer rate of the DOE load were 11.0% and 24.4%, respectively, higher than those of the IEC load at a moisture content of 0.2. Additionally, the sensible heat transfer rate and mass transfer rate of the PC load were 6.8% and 8.2%, respectively, lower than those of the IEC load. Especially, the hydrophobic characteristics of the DOE and fabric structure of the PC were the main reasons for these results. This phenomenon was notably evident within the region below the critical moisture content. This study provides fundamentals in drying performance of clothes with different fabric types in the tumble drum dryer, and the results of this study can be used to optimize the performance of tumble drum dryers for clothes.

References

[1] Energy Information Agency. (2015, August). Residential energy consumption survey [Online]. Available: https://www.eia.gov/consumption/residential/data/2015/#appliances
[2] V. Yadav and C. G. Moon, "Fabric-drying process in domestic dryers," Appl. Energy, vol. 85, no. 2–3, pp. 143–158, 2008.
[3] L. Novak, P. Gatarić, and B. Širok, "Influence of drum inlet air conditions on drying process in a domestic tumble dryer," Dry. Technol., vol. 37, no. 6, pp. 781–792, 2019.
[4] D. Lee, M. Lee, M. H. Park, and Y. Kim, "Experimental evaluation and prediction model development on the heat and mass transfer characteristics of tumble drum in clothes dryers," Appl. Therm. Eng., vol. 202, p. 117900, 2022.