Proceedings of the 10th World Congress on Momentum, Heat and Mass Transfer (MHMT 2025)
Barcelona, Spain - April 2025
Paper No. ICMFHT 129
DOI: 10.11159/icmfht25.129

Investigation of Fog Harvesting Efficiency of a Multilayer Fog Collector Using Particle Shadow Velocimetry

Sohom Goswami[1], Pranav Joshi[1], K. Muralidhar[1]
[1]Indian Institute of Technology, Kanpur
Kalyanpur, Kanpur, 208016 India
sohom20@iitk.ac.in; jpranavr@iitk.ac.in; kmurli@iitk.ac.in

Extended Abstract

Fog harvesting has attracted significant attention from researchers in recent years as a potential source of clean water to combat the global problem of acute water scarcity. This technique primarily involves the capture of atmospheric water droplets by inertial capture on a porous structure placed in the path of fog-laden airflow. The physics involved is multiscale, governed at the device scale by the aerodynamics of flow past porous bluff bodies [1]. At the pore scale, it is governed by flow past individual fibers and droplet dynamics involving forces arising from surface tension, gravity, and aerodynamic drag. A novel approach to enhance efficiency at the device scale involves using three-dimensional porous structures with appropriate geometric properties to ensure high efficiency of droplet capture [2], [3]. These structures have been shown to deliver an order-of-magnitude greater improvement in fog harvesting performance as compared to traditional surface engineering techniques. While the feasibility of using such a strategy has been demonstrated using proof-of-concept experiments, a detailed understanding of the roles of geometric parameters in governing the physics of fog flow past multilayer fog collectors (MFCs) has received little attention. Theoretical predictions, obtained under several idealizations, have been described in the literature. The fog collection efficiency of MFCs depends on two effects: (i) the deviation of the fog flow path around the mesh due to pressure drop, quantified by the filtered fraction, ϕ and (ii) the probability of droplets being captured by one of the n layers of the mesh, quantified by the incident fraction, χ. The product of these two fractions gives the total efficiency of an MFC. Thus, experimental studies are required to delineate how the geometric parameters affect these two fractions. Experimental parameters include the porosity of the mesh (ϵ), the number of layers (n), and interlayer spacing (b). Initial experiments by the authors on fog water collection (FWC) measurements with multilayer SS meshes reveal that all three parameters play an important role in governing the performance of MFCs. In the present work, the authors experimentally investigate the effect of each parameter on the two above-mentioned fractions. This is achieved by combining particle shadow velocimetry (PSV) and fog water collection (FWC) measurements on MFCs composed of multiple layers of SS meshes separated by SS spacer rings of thickness b, the desired interlayer spacing. Both PSV and FWC experiments are performed inside a wind tunnel custom-made for the present study. The PSV technique is a variant of the conventional Particle Image Velocimetry (PIV) technique. It uses an inline volumetric illumination of the flow field, where the shadows of seeding particles are captured as opposed to scattered light in conventional PIV measurements [4], [5]. Experimental results enable a better understanding of the relative importance of design parameters in determining the overall fog capture performance of MFCs, while their comparison with theoretical predictions ascertains their range of validity, yielding an improved model for real-life applications.

References

[1] J. de D. Rivera, "Aerodynamic collection efficiency of fog water collectors," *Atmos. Res.*, vol. 102, no. 3, pp. 335–342, 2011.
[2] M. Azeem, A. Guérin, T. Dumais, L. Caminos, R. E. Goldstein, A. I. Pesci, J. de D. Rivera, M. J. Torres, J. Wiener, J. L. Campos, and J. Dumais*., "Optimal Design of Multilayer Fog Collectors," *ACS Appl. Mater. Interfaces*, vol. 12, no. 6, pp. 7736–7743, 2020.
[3] C. M. Regalado and A. Ritter, "The design of an optimal fog water collector: A theoretical analysis," *Atmos.*

Res., vol. 178–179, pp. 45–54, 2016.
[4] J. Estevadeordal and L. Goss, “PIV with LED: Particle shadow velocimetry (PSV),” *43rd AIAA Aerosp. Sci. Meet. Exhib. - Meet. Pap.*, no. January, pp. 12355–12364, 2005.
[5] H. Hessenkemper and T. Ziegenhein, “Particle Shadow Velocimetry (PSV) in bubbly flows,” *Int. J. Multiph. Flow*, vol. 106, pp. 268–279, 2018.