Proceedings of the 1st international Symposium on AI and Fluid Mechanics
Abstract No S11 A7

Predicting Coefficient of Restitution of Ice Particles Impacting Surfaces: A Machine Learning-Based Approach

Ehsan Khoshbakhtnejad[*] and Hossein Sojoudi[**]

Department of Mechanical, Industrial, and Manufacturing Engineering (MIME), University of Toledo, Toledo, OH

*** ehsan.khoshabkhtnejad@utoledo.edu**

**** hossein.sojoudi@utoledo.edu**

Understanding dynamics of ice particles impacting various surfaces is critical when assessing risks associated with atmospheric icing and/or developing mitigation strategies, with applications in aerospace, automotive, and energy industries.. In particular, accurately predicting coefficient of restitution (COR) is important as it provides critical insights into the dynamics of collisions involving ice.. This research leverages machine learning models to better predict COR values, utilizing a dataset of 4,800 data points collected from five experimental sources. The dataset encompasses a wide range of impact conditions, including impact velocities ranging from 0.050 mm/s to 10 m/s, particle sizes from 1.4 to 200 mm in diameter, and masses between 0.01 gr and 31 kg. The experiments were conducted on surfaces such as solid ice, frosted ice, sublimated ice, glass, and polymers under controlled and non-controlled temperature conditions. Four machine learning models—XGBoost, Random Forest, Gradient Boosting, and Artificial Neural Networks (ANN)—with dimensionless input parameters Re, St, Fr, Pec, Ga and combinations of these, were developed and evaluated. Among these, XGBoost was identified as the best-performing model, achieving a Mean Absolute Error (MAE) of 6.10% during testing. These results demonstrate the robust predictive capabilities of XGBoost in capturing the intricate dependencies within the dataset. Machine learning models excel in predicting COR by handling complex datasets and uncovering physical phenomena through dimensionless numbers, surpassing traditional methods. This study demonstrates potential of machine-based prediction approach to enhance transportation safety and energy efficiency and to design surfaces for preventing and minimizing ice formation.