ABSTRACT

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Current non-intrusive flow measurement techniques still need improvements as they have disadvantages small diameter applications. This work proposes to develop a non-intrusive thermal flow meter that uses machine learning algorithms to obtain the smallest full-scale deflection possible in low liquid flows. The meter uses a copper duct with an internal diameter of 22mm, six commercial k-type thermocouples, a microtubular heating resistance, and an artificial intelligence to infer the flow rate from the thermal distribution on the duct surface. The sensors and the heater layout was calculated based on the theoretical temperature spread obtained in the modeling done using the COMSOL Multiphysics software. To evaluate the meter, a test bench was built to control the flow rate and temperature of the heating resistor. The test bench is equipped with an electromagnetic flowmeter calibrated and certified in an external laboratory, which is used for reference and comparison, according to the ABNT guidelines and the good practices used in the industries and calibration laboratories. In the experiment, the resistance was activated so that the temperature in the central region of the duct remained at 70 ° C and the thermal distribution data was collected with flow rates between 0.05 and 0.6 m^3/h with intermediate increases of 0.01 m^3/h. The collected data provided by the experiment were used to train the following models: linear regression, K-Nearest Neighbor (K-NN), Decision Tree, Random Forests and Gradient Boosting. Besides, Multilayer Perceptron and Deep Learning models were also trained. The best result was obtained with the Dropout technique, which demonstrated that the built prototype can infer the flow with a full scale deflection equal to 1.8%. The experiment demonstrated that the use of machine learning algorithms could be used to improve non-intrusive flow measurement systems.

Keywords: Flow Measurement; Neural Network; Machine Learning; Thermal Flow; Calorimetry; Smart Sensor; Non Intrusive.