Prediction of Two-phase Pressure Drop for Air-water Flow through U-bends using the Artificial Neural Network (ANN)

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Abstract

Pipe fittings, like valves, bends, elbows, orifices etc. are essential part of any piping system. The flows through bends are more complex than that through straight tubes. The mechanism of flow in the former case is not clearly defined, as there is an existence of skin friction and loss due to the change in flow direction. The centrifugal forces also play an important role. As flow enters the curve portion the centrifugal force on the fluid acts outward from the center of curvature and generates a secondary flow. The gas-liquid flow through bends is more complex as it is always developing in nature. Due to centrifugal force the liquid moves away from the center of curvature and air flows towards the center of curvature. Literature review suggests that the pressure drop across the bend is substantially higher than that in the single phase liquid flow. The aim of the study was to assess the applicability of ANN modeling in two-phase gas-liquid flow system.

Experimental investigation has been carried out to evaluate the frictional pressure drop for air-water flow through 4 different U-bends of pipe diameter 0.01905 m.

For ANN study the input parameters are liquid flow rate, air flow rate, radius of the bend and length of the bend. The other parameters like density, viscosity of both fluids, surface tension of water, diameter of the tube and acceleration due to gravity are constant and hence, are ineffective as input parameters for ANN programming. The output parameter is the two-phase frictional pressure drop. Three different algorithms, viz., Multilayer Perceptron (MLP), i.e., back propagation, Levenberg-Marquardt and Scaled Conjugate Gradient with a single hidden layer were used. For each algorithm 4 different transfer functions were used. The total number of data points was 241. These data were initially randomized; 60% of data points were used for training, 20% for cross-validation, 10% for testing and rest used for prediction. For each case, the performance of network was checked by calculating various statistical parameters like mean square error (MSE), average absolute relative error (AARE), standard deviation (σ), cross correlation coefficient (R) and chi-square (χ^2) test.

The best network is the transfer function, $f(x) = \frac{1}{1+e^{-\beta x}}$, with 16 processing elements using the Levenberg-Marquardt algorithm. The statistical parameters are listed as MSE : 0.443640, AARE : 0.090976, σ : 0.096067, R : 0.968621, χ^2 : 1.596716.

Keywords: *Pipe fittings, Gas-liquid flow, Pressure drop, ANN prediction, Multilayer Perceptron (MLP) with back-propagation algorithm, Levenberg-Marquardt algorithm*