Study of volume fraction in biphasic flow using nuclear technique

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This report presents a methodology for volume fractions prediction in water-gas stratified flow regime using the nuclear technique and artificial intelligence. The volume fraction is one of the most important parameters used to characterize air-liquid biphasic flows. It is a physical value which determines other parameters, such as the phase's densities and the flow rate. These parameters are important to predict the flow pattern and to determine a mathematical model for the system. They are also important to study heat transfer and pressure drop, for example. The approach is based on gamma-ray pulse height distributions pattern recognition by means of the artificial neural network [1]. The detection system uses appropriate narrow beam geometry, comprised of a (^{137}Cs) energy gamma-ray source and a NaI(Tl) detector in order measure transmitted beam whose count rates are influenced by the phases composition. The static theoretical models for stratified regime have been developed using MCNP-X code in order to provide training, test and validation data for the network. The model of stratified regime presented in Fig. 1 has been used to collect data in order to train the network. The values of the thickness (h_w) of water fluid have varied in the simulation resulting in different combinations of volume fractions.

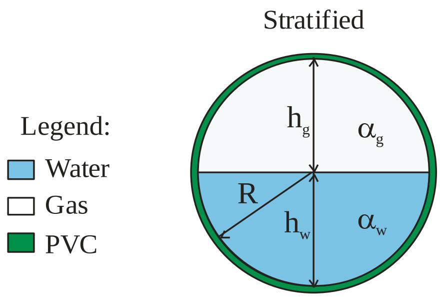

Figure 1. Stratified flow regime.

The pulse height distribution is obtained from the measured transmission beam achieved by detector which is used for network training. The gas (α_g) or water (α_w) volume fraction is obtained by taking the ratio of the circular segment area filled with each material (gas or water) and the cross sectional area of the pipe. Fig. 2 shows the correlation between the volume fractions predicted by the network and the real ones for all patterns.

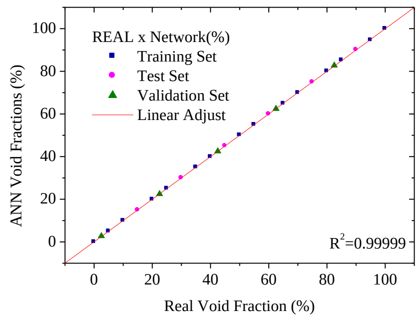

Figure 2. Volume fraction obtained for the network.

A linear model was fit into the data of Fig. 2 using a least-squares procedure and a linear correlation coefficient of 0.999 was obtained for water, demonstrating an excellent convergence of neural network. In Table 1, results obtained for the validation set of outputs network on stratified regime are presented.

Table 1. Network prediction for the production set on stratified regimes.

Data Validation	Water (α_w)(%)	
	Real	Network
1	2.5	2.7
2	22.5	22.5
3	42.5	42.5
4	62.5	62.4
5	82.5	82.7

For the investigated stratified regime, the network could satisfactorily correlate the measurements simulated by code with the volume fraction of each material of a biphasic (gas-water) system, indicating that the methodology can be applied for such purpose. The results of all the validation tests presented maximum average relative errors of 0.53% for volume fraction, demonstrating good agreement between the real and the predicted network values of volume fractions. More than 92% of all data was predicted with relative error within ±5%. The results indicate that the methodology can be used for measuring the volume fraction or the water level.

References

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