Application of nuclear techniques and artificial neural networks for identification and volume fractions in multiphase flows

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Introduction

Multiphase flow measurement is a very important issue about offshore petroleum industries. The use of techniques for determination volume fractions of oil-water-gas flows with adequate precision is required. Commonly, such techniques are invasive, and involve a high cost associated to installation and maintenance. On the other hand, non-invasive techniques tend to be less accurate. Due to this fact, many investigations on non-invasive techniques are found in literature with the aim of improving accuracy and reducing costs. By using gamma-ray sources it is possible to perform these measurements without modifying the operational conditions, allowing accomplishment of the entire monitoring process. However, volume fraction prediction by using gamma-ray measurements generally depends on the correct identification of the flow regime to increase the precision in prediction. The flow regime information in the liquid-gas flows is usually obtained by individual interpretation and subjective evaluations based on visual observations. The major difficulty in visual observation, even when using high-speed photography, is that the picture is often confused and difficult to interpret, especially when dealing with high velocity flows. In addition, there are systems that are opaque, so they do not allow the flow visualization. Likewise those systems do not allow that the method develops analysis. Therefore, it is a great contribution of the non-invasive system that can provide material volume fraction predictions regardless of the priori knowledge of the flow regime, without subjective evaluation.

Together with the detection system, artificial neural networks (ANNs) [1] have been used in order to interpret the pulse height distributions (PHDs) obtained by gamma-ray radiation detectors to identify the flow regime and predict the material volume fractions [2]. ANNs are mathematical models inspired in the human brain. The main characteristic of this technique is the ability of learning by means of examples. ANN are able to discover behaviors and patterns from a finite set of data (called the ‘‘training set’’ of the ANN). If an adequate training set is provided, the ANN is able to generalize the knowledge acquired during training process and the ANN may respond adequately to new situations (not comprised in the training set).

The ideal and static theoretical models for annular, stratified and homogeneous regimes have been developed using MCNP-X code [3], which was used to provide training, test and validation data for the ANNs.

Results and Conclusions

- A compact detection system, with two detectors, could be developed in order to provide adequate measurements for identifications and predictions. The use of non-parameterized pulse height distributions, probably contributed to this, providing more complete information about measured spectra. The ANNs architecture allow volume fractions to be predicted without knowledge about the flow regime. It has been possible due to the accuracy obtained for ANN1 (responsible to regime identification), which was able to correctly identify 100% of the actual regimes (among the possible ones).Volume fraction predictions, by ANN2 (annular), ANN3 (stratified) and ANN4 (homogeneous), presented very good results, with maximum relative errors bellow 3.5% [2].
- In summary, the proposed methodology demonstrated to contribute to the state-of-art in multiphase flow regime characterization, improving the following points: i) detection system is more compact; ii) the accuracy of ANN is improved; iii) the volume fractions can be automatically predicted without a priori knowledge of the actual flow regime. The proposed methodology demonstrated to be quite promised one [2].

References

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