Barium sulfate scale thickness prediction using the MCNPX code and an artificial neural network

A. C. L., Carvalho[1], C. M., Salgado[2]
E-mail:
anacarolinalcarvalho@hotmail.com,
otero@ien.gov.br

[1] CENS, IEN; [2]DIRA, CNEN

Keywords: artificial neural network, barium sulfate scale, gamma densitometry, MCNPX code, oil pipelines.

This report presents a method to predict the barium sulfate scales ($BaSO_4$) thickness in pipelines of multiphase systems (oil, gas and water) found in the petroleum industry. The technique is based in gamma-ray densitometry which uses a transmission measurement of gamma-ray beam to determine the density of the materials. In this study, an artificial neural network (ANN) is training to solve problems related with the measurement's conditions from this technique [1]. The data to training, test and validation of the ANN was obtained through the Monte Carlo N-Particle 6 (MCNP6) code, as shown by Figure 1. The simulated geometry consists of three (1 ¼ × ¾″) NaI(Tl) scintillators detectors spaced at 120º angle from each other around the AISI 316L pipeline, with the multiphase annular flow and the barium sulfate scale. The radioactive source is Cs-137 (662 keV) and the divergence angle from a point source is 8º.

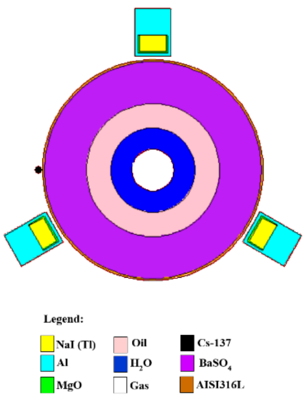

Figure 1. Geometry simulated with MCNP6 code

The pulse height distributions (PHDs) of all detectors and the thickness of the scale fed a 3-layer feedforward ANN with a backpropagation algorithm. Given the positive results, in which the convergence of the ANN was observed, the next step involved a new simulation. However, the position of the multiphase flow was changed to simulate the eccentric deposition of the $BaSO_4$, inside the pipeline. This position was varied every 15º. Thus, was possible to get 960 PHDs to the phases of training, test and validation of the ANN, so that it would be able to predict the thickness of scale independent of the position inside the pipeline. The results obtained by ANN for the maximum thickness of the scale are shown in Figure 2.

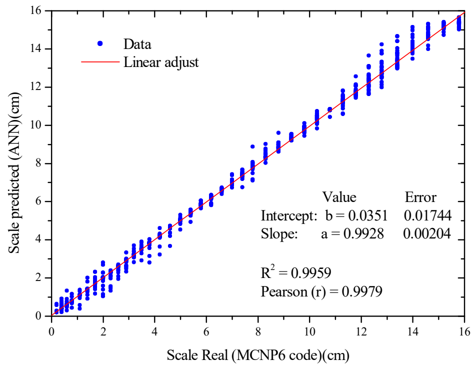

Figure 2. Comparison of the results obtained with ANN and MCNP6 code

On Table 1, are expressed all the results obtained by the ANN associated with the relative errors and the correlation coefficient (R^2).

Table 1 - Summary of the recognition of the patterns for the prediction of the network.

Relative Error	**Eccentric Cases**
<5%	82.708
5% - 10%	9.063
10 – 20%	3.229
20 – 30%	1.563
>30%	3.438
R^2	0.9959

All results shown in this report indicates that the ANN can be used to predict scales thickness from PHDs, independent of the position and without any adjustment or data.

References

[1] SALGADO, W.L.; DAM, R.S.F.; TEIXEIRA, T.P.; CONTI, C.C.; SALGADO, C.M., 2020. Application of artificial intelligence in scale thickness prediction on offshore petroleum using a gamma-ray densitometer, Radiation Physics and Chemistry, 2020, v. 168.