Calculation of volume fractions on biphasic stratified regime using gamma ray scattering

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In the oil industries, interconnected pipelines are used to transport large quantities of petroleum and its byproducts. The same pipeline is used to carry more than one type of product. In the operation of this system, there is a sequence of products to be transported and during the exchange of the product, there are still fractions of the previous product and this generates contaminations. It is therefore important to identify precisely this region in order to reduce the costs of reprocessing and treatment of discarded products. In this way, this work presents a methodology to evaluate the sensitivity of gamma scattering beam technique for fluid volume fractions (FVF) calculate using the MCNP-X code [1].

Detection System and Volume Fractions

The probability of Compton scattering is directly proportional to the photon energy and inversely to the atomic number. The number of scattered photons can be obtained using Klein-Nishina[2]. The counting rate strongly depends on the density of the material examined. For measurement geometry with a pencil beam, the calculation of the FVF on biphasic systems on the stratified flow regime using the gamma scattering beam can be obtained using the Beer-Lambert law. The detection geometry consists of a source of ^{137}Cs and a NaI(Tl) detector, positioned at 60° around an acrylic tube, to measure the scattered beam, see Fig. 1.

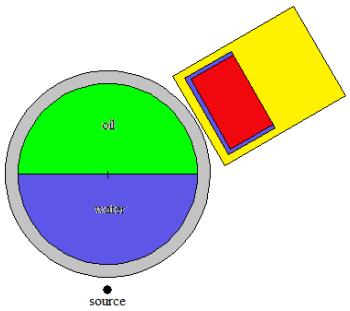

Figure 1. Simulated geometry.

The F8 tally was used to estimate the simulated PHD classified since 40 to 800 keV. The fluids used are water (H_2O) and oil ($C_{10}H_{18}O$). The FVF were varied from 50% to 100% with 6 steps. For the study of the region of the spectrum to be analyzed were simulated cases with only one fluid (Oil) with different void fractions (0%, 25%, 50%, 75% and 100%), the spectra obtained can be shown in Fig. 2.

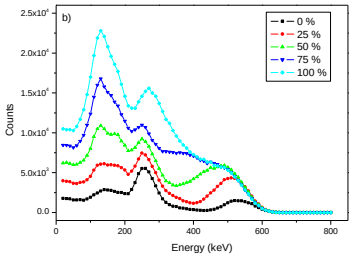

Figure 2. Spectra obtained considering the FVF for scattering beam.

In order to calculate the FVF, the first chosen peak (peak CC) in 132 keV and the all spectrum were regions that presented smaller errors. The results can be visualized in Table 1.

Table 1 - FVF results

Water Volume Fraction (%)		
Analytical Equation	MCNP-X Code	
	All spectrum	CC Peak
50	52.94	44.70
59.06	60.83	53.54
67.94	67.37	61.44
76.42	73.80	69.11
84.29	80.14	76.26
91.24	87.16	84.74
96.83	94.14	92.31

For the all scattered spectrum, the relative errors are around 5%, while for the CC peak, the errors are to 10%. The results for the methodology of entire scattering spectrum indicate that it is possible to calculate FVF of up to 3%.

References

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