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

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The pipelines always operate pressurized, establishing the transport of the different petroleum products, as: gasoline, diesel, kerosene. During the change of the pumped fluid, in a period, two distinct fluids are in direct contact with one another inside the duct, and the contaminations are inevitable. This process defines a region in the fluid called the interface that causes losses [1]. Thus, this work presents a methodology to evaluate the sensitivity of the transmitted gamma densitometry technique in the study of the calculation of fluid volume fractions using the MCNP-X code [2] for identify the interface region of fluids.

Volume Fractions

The method is based of transmission of a gamma ray beam through a pipe containing multiphase fluid. The recording of the signal in the detector is proportional to the emission of the gamma rays from the radioactive source. Considering the stratified flow regime with the in a pipe, knowing the dimensions and characteristics of the pipe and of the fluids, the intensity of the beam. For a measurement geometry with a pencil beam and perpendicular to the layers of fluids. The fluid volume fraction on biphasic systems using the gamma attenuation technique can be calculate using the Eq. 1 [3].

$$\alpha_1 = \frac{\ln(I/I_2)}{\ln(I_1/I_2)} \qquad (1)$$

Where:

$\alpha_{1n,m}$: volume fraction of fluid n or m;
I: gamma ray intensity recorded with pipe containing fluids 1 and 2;
I_n: intensity containing only fluid n;
$\alpha_2 = 1 - \alpha_1$

Proposed Geometry of the Detection System

The detection geometry consists of a source of ^{137}Cs, diametrically opposite, and one NaI(Tl) detector, positioned around an acrylic tube. The pipe has internal diameter of 7 cm, thickness wall of the 0.5 cm, as shown in Fig. 1. The interior of the pipe has been filled with volume fractions different, varied from 50% to 100% with 6 steps, of water (H_2O) and oil ($C_{10}H_{18}O$) fluids. The F8 tally was used to estimate the simulated Pulse High Distribution.

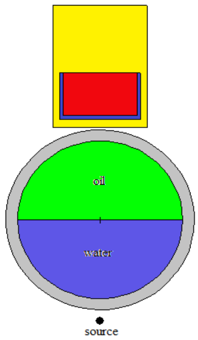

Figure 1. Simulated geometry.

The fluid volume fraction value was performed by means of the counts on the photopeak and the results can be visualized in Table 1.

Table 1 - Comparison of the results obtained using analytical solution and the code MCNP-X.

Water Volume Fraction (%)	
Analitical Equation	MCNP-X Code
50	53.26
59.06	60.66
67.94	67.70
76.42	74.79
84.29	81.65
91.24	88.10
96.83	94.12

The results for the methodology of the transmission through the photopeak indicate that it is possible to calculate volume fractions of up to 3% with relative error around ± 5%.

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