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Measurement of Void Fraction for Fluid Flow Using Gamma Ray

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ABSTRACT

In this work the void fraction for oil-water mixture are measured by using radiation source ^{137}Cs with activity of 0.636 µCi. The plastic-tube contain the mixture are putting interior beaker and subjected into radiation to measure the void fraction. There are many applications industries, such as, oil and gas pipelines, heat exchangers etc.

Introduction

The void fraction it is the ratio of the volume of oil to the volume of oil-water mixture in a finite length of the pipeline. This quantity is useful in measuring and predicting the density average, pressure drop, flow pattern, etc, of a flowing two-phase flow mixture in pipes [1].

The radiation attenuation methods are used for determining the void fraction in two-phase flow by many authors. In this job is to measure the void fraction of oil-water mixture, i.e. to measure the average volume fraction of oil mixed with water experimentally using the radiation source beam [1, 3].

Experimental apparatus and measurement

The arrangement of void fraction measurement apparatus based on subject beams of Gamma ray to penetrate cross section of the pipe [4,5,6]. The Gamma ray is positioned a parallel on the opposite side of the detector as shown in photographic figure (1).

Fig. 1: Experimental arrangement for void fraction measuring equipment

The photons beam traverse the medium oil-water through thickness t without interaction is:

$$I(t) = I(o) e^{-\mu t}$$

$$I = I_o \exp[2\mu_w x + \mu_T t]$$

where:

I = Intensity of the radiation passing without interaction with the medium (cm-2. sec-1).

I_o = Intensity of the radiation incident on the medium (cm-2. sec-1).

μ_w = The linear attenuation coefficient of the material of the pipe wall (cm-1).

x = Thickness of the pipe wall (cm).

μ_T = Total linear attenuation coefficient of the oil-water mixture (cm-1).

The total linear attenuation coefficient of the radiation interaction with the oil-water mixture is:

$$\mu_T = \alpha \mu_{oil} + (1-\alpha)\mu_f$$

where:

α = void fraction.

μ_{oil} = linear attenuation coefficient of oil (cm-1).

μ_f = linear attenuation coefficient of water (cm-1).

The dematerialized water filled the pyrex tube (I. D. 8.3cm & 1.5mm thickness). Small diameter (0.6cm), empty plastic tube were used for void simulation by inserting then into the pyrex tube (an arrangement of relevance to droplet flow). I_{oil}, I_f and I detector readings were taken with the empty plastic tubes immersed in the water filled pyrex tube. This was done for every time a certain number of plastic tube were used get the actual value of volume fraction from the mockup arrangement. The extreme case of droplet flow was also simulated by filling the plastic tubes with water and putting them into the empty pyrex tube. This method ensures that the thickness of the plastic tubes was canceled.

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The experimental apparatus consists of a 137Cs-Gamma source with 0.636 µCi activity and NaI(Tl) detector 7.62cm O. D. 7.62cm active length. The sensitivity of this counter was counts/sec per photon/cm2.sec.

Results and Discussions

Fig.(2) shows the count rate changed with volume of the oil-water mixture. Which are the pyrex tube filed with the crude oil and the small plastic tubes filled with the water. The count rate was decreasing with increasing the volume fraction of the oil-water mixture.

Fig.(3) is the same as fig.(2) but the pyrex tube filled with water and the small plastic tubes filled with the crude oil, it shows increasing of count rate with increasing the volume fraction.

Conclusions:

The use of radiation source for void fraction measurement offers the following advantages [2]:

1-The electromagnetic photons can easily traverse thick walled steel pipes.

2-Relatively good accuracy.

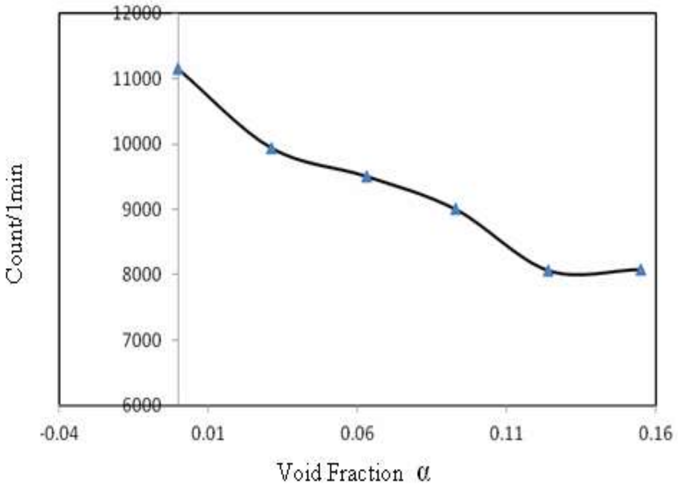

Fig 2: Experimental results of void fraction of oil-water mixture with Gamma ray count./1min. Which is the pyrex tube filed with the crude oil and the small plastic tubes filled with the water

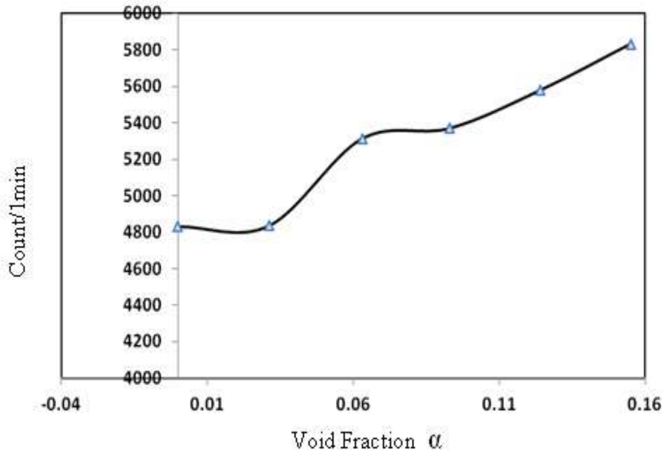

Fig 3: Experimental results of void fraction of oil-water mixture with Gamma ray count./1min. Which is the pyrex tube filed with the water and the small plastic tubes filled with the crude oil

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