Study of different radioactive particle trajectories in a single-phase flow using MCNPX code

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This report consists of using the radioactive particle tracking technique and analyzing what happens in the flow if parameters such as distance between detectors, shielding and particle size are changed in the model studied. This model consists of a PVC duct with 100 cm of length and 0.635 cm of wall thickness, containing salt water (H_2O + 4% NaCl, density = 1.0466 g / cm³) as a fluid [1]. The radioactive particle is a ^{137}Cs (662 keV) isotropic radiation source, sealed with glass. In the configuration, there are two 1 1/4 × ¾″ NaI(Tl) detectors (D1, D2), used to calculate the velocity of the radioactive particle, which are positioned on the same axis and separated 10 cm from each other, as shown in Figure 1. Simulations were performed using the code MCNPX [2], whose response is normalized to one event per second. The proposed methodology uses values related to the total counts recorded in the detectors.

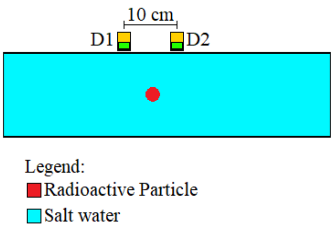

Figure 1. Simulated geometry

Three different particle trajectories were analyzed. In the first one, the radioactive particle moves in a straight line in different positions along the duct, in the second it makes disordered oscillatory movements with different amplitudes and in the third it makes triangular waves in different amplitudes. In the disordered oscillatory movement, each point of the z coordinate corresponded to a point of the y coordinate according to the equation $y = A \cdot \sin(z)$ where A corresponded to values 1, 5 and 10, in order to create movements with different amplitudes. For straight and parallel trajectories to the detectors, results showed that the distance (in cm) between two count peaks recorded in the detectors to calculate the velocity is the same distance that separates these detectors. In Figure 2, the results for disordered oscillatory movement of smaller amplitude and the triangular oscillatory movement (smaller amplitude and greater wavelength) are presented.

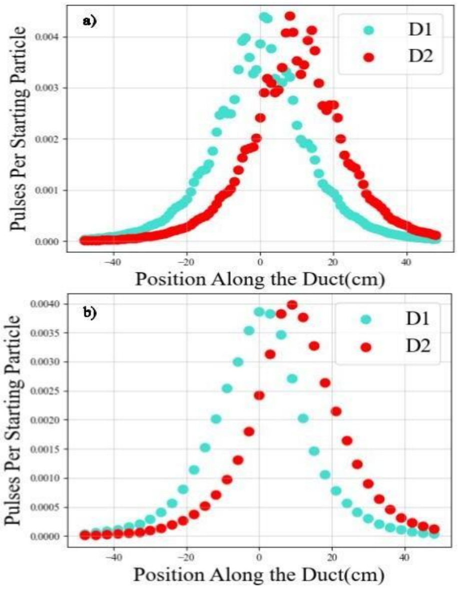

Figure 2. Oscillatory movement: a) disordered; b) triangular

The results on oscillatory trajectories do not present a well-defined curve as seen in rectilinear movements. Therefore, it is more complicated to see the distance (in cm) between two count peaks, which are misaligned. However, for oscillations with small amplitudes and longer wavelengths, the curve is very close to the shape of a Gaussian. The next steps of this study will be to calculate the radioactive particle velocity, therefore the fluid velocity, for each movement.

References

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