

Calculation of velocity for single-phase flow based on radioactive particle tracking

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This report demonstrates the calculation of velocity of fluids by using particle tracker injection [1]. The physical properties of the tracker are identical to single phase flow therefore; the particle movement corresponds to the tracking of this phase. The required data was obtained by the MCNP-X code. The geometry setup consists of two NaI(Tl) detectors and ¹³⁷Cs was used as particle tracker in the studies. The gamma-ray densitometry has been used in mining, chemical and petrochemical processes.

Velocity measurement

The average fluid velocity “v” can be calculated using the Equation 1.

$$v = L/\tau_o \quad (1)$$

Where: τ_o - time delay and L - distance between detectors.

The analyses of $I_v(t)$ and $I_z(t)$ signals recorded from 1x1” NaI(Tl) detectors allows the calculation of the transportation time delay, see Figure 1.

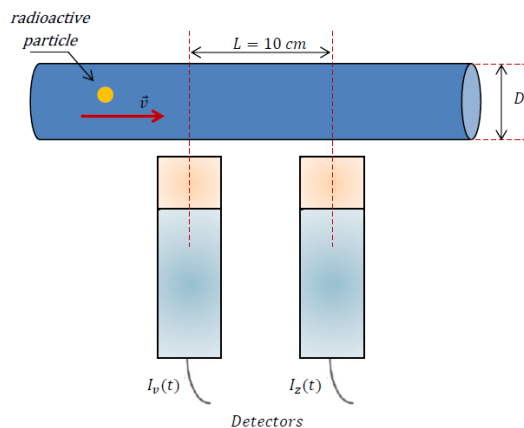


Figure 1. The schematic diagram of setup

The most classical method is based on the Cross-Correlation Function (CCF) defined from Equations 2 and 3 [2].

$$R_{vz}(\tau) = \lim_{T \rightarrow \infty} \frac{1}{T} \int_0^T v(t)z(t + \tau)dt \quad (2)$$

$$R_{vz}(\tau) = \frac{1}{N} \sum_{n=0}^{N-1} v(n)z(n + \tau) \quad (3)$$

Where: T is the averaging time, τ – time delay, $v(t)$ and $z(t)$ - continuous-time signals, N is the number of discrete values of $v(n)$ and $z(n)$ signals.

The discrete values of $v(n)$ and $z(n)$ signals were obtained by counting of pulses $I_v(t)$ and $I_z(t)$ for sampling time 0.1 second. The τ_o transportation time delay is the position of the maximum CCF for the signals received from the NaI(Tl) detectors, see Figure 2.

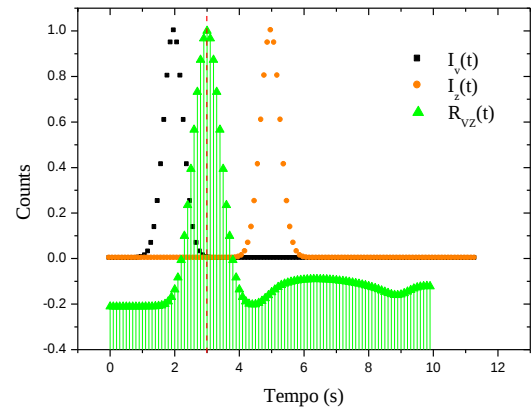


Figure 2. The Cross-Correlation Function

In the above mentioned experiment, the time delay is $\tau_o = 3$ seconds and velocity $v = 30 \text{ m.s}^{-1}$ were calculated ($L=10 \text{ cm}$). The relative combined standard uncertainty $uc(v)$ usually very low ($<0.5\%$). In this report presents a study to calculate the velocity of fluids using radioactive particle tracker. The fluid velocity was calculated using time delay estimation technique.

References

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