Study of stratification level in mining industry using gamma radiation

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This report presents a study which aims at the identification of the stratification of the solid phase inside a pipeline. One of the most promising areas in the mining industry is the development of devices for measuring solid mass flowrate in pipelines, mainly in transportation of ore. A problem inherent in these systems is the stratification: if a critical velocity is reached, the ore pellets begin to sediment at the bottom of the pipe and they may block the system. The solid phase displacement behavior depends on a number of factors (water flowrate, density, pipe diameter, average size of the pellet), which proves that knowledge of the flow regime is essential to the appropriate operation of the system. An apparatus to evaluate the stratification level through ore pellets spatial distributions inside the pipe is important because it increases the safety conditions of pumping and solid phase transport. The simulated detection system uses gamma-ray source and four NaI(Tl) detectors. The proposed geometry combines the transmitted (I_T) from D1 (aligned to the source: 180°) and scattered (I_S) from D_2 (at 135°), D_3 (at 90º) and D_4 (at 45º) beam measurements (dual-mode densitometry) [1]. The ore pellet was substituted by 304 stainless steel spheres with a 7.92 g.cm^{-2} density and 1.0 cm radius. The measurement system simulation is shown in Fig. 1.

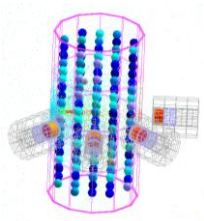

Figure 1: Simulated Geometry.

Eight different models were developed using MCNP-X code: homogeneous (H_1, H_2, H_3 and H_4 - simulates a blocked pipe) and stratified (S_1, S_2, S_3 and S_4). For each one of these regimes, calculating the relative counts I_T and I_S beams, there is a variation of the volume fractions of solid phase (ore pellets), which range from 2.1% to 39.8%, in relation to the liquid phase (water). A single window of channels was selected and the accumulated counts were performed by integral method for ^{241}Am source. The proposed method is based on I_T and I_S beam ratio of count rate recorded at D_1 and D_2, using this method, it was possible to establish a pattern for both regimes as shown in Fig. 2.

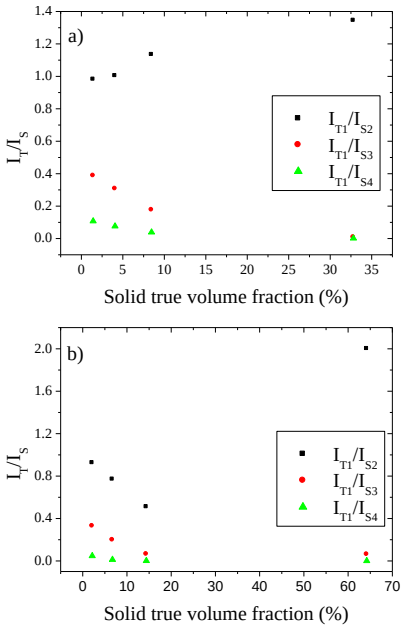

Figure 2: The I_T and I_S beams ratio on flow regime: a) stratified; b) homogeneous.

The graphics for the stratified (rising curve) and homogeneous (falling curve) flow regimes indicate the possibility of identifying flow regimes. Due to the water layer above of the pellets, the I_{T1}/I_{S2} incident beam ratio becomes much higher, which makes the curve rise when the solid volume fraction increases, as shown in Fig. 2a, while in Fig. 2b, the opposite occurs for the homogeneous regime. It is also possible to note that the H_4 flow regime has a well characterized value. The results are encouraging and suggest that the methodology can be used for the identification of the stratification level. Unfortunately, the ^{137}Cs source, which is frequently used in industry, it was not possible to establish any difference between the regimes, thus, further studies must be carried out using artificial neural network.

References

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