# Potential of the nuclear technique for study of solid-liquid flow regimes in mining industry

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This report presents a study for the identification of a possible stratification of the solid phase inside a pipeline [1]. 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. The solid phase displacement behavior depends on water flowrate, density, pipe diameter, average size of the pellet etc, which makes the flow regime knowledge essential to the appropriate operation of the system. This step is intended to analyze the response of the MCNP-X code to identify the flow regime for some simplified mathematical models. These models considered only one ore pellet arranged in three different positions (left, center or right) of a pipe filled with water as shown in Fig. 1 [1].

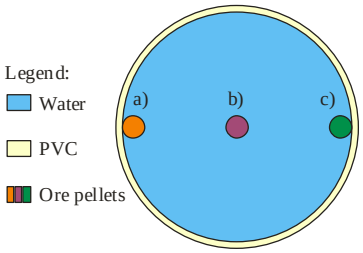


Figure 1. The models for the different ore pellets displacement: a) left; b) center; c) right.

A narrow beam geometry and one NaI(Tl) detector were used. The detector was positioned 2.5 cm from the pipe and 180º diametrically aligned to a source. Two collimated gamma-ray point sources (59.45 keV: $^{241}$Am and 662 keV: $^{137}$Cs) were also simulated in the code [1]. The ore pellets were substituted by 304 stainless steel spheres with a 7.92 g.cm$^{-2}$ density and 1 cm radius. A PolyVinyl Chloride pipe with 0.5 cm thickness and 20.0 cm of internal diameter has been used. A pulse-height distribution estimate (F8 tally), available in the code, was used to obtain the deposited energy distribution per incident photon on the considered detector volume. The distributions for the pipe filled with water and only one ore pellet in three different positions recorded at detector for both sources are shown in Fig. 2.

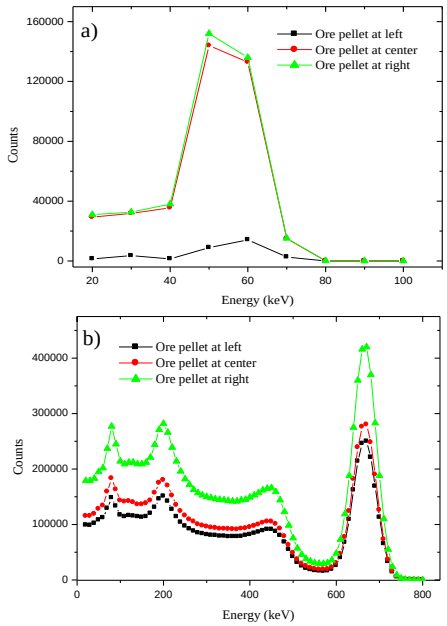


Figure 2. Distributions recorded by MCNP-X code for detector at different ore pellet positions for sources: a) $^{241}$Am; b) $^{137}$Cs.

Considering the simulated transmitted beam, the differences between the distributions for each one of the ore pellet's position (right, center or left) were registered by the detector. This first approach demonstrates that variations of the recorded signal intensity at the detector can be directly related to the flow regime [1]. In any case, the total count rate for $^{241}$Am and $^{137}$Cs sources were performed by integral method as shown in Table 1 and the results indicate that the technique can be used to identify the flow regime commonly found in hydraulic transport of ore pellets.

Table 1. Counts recorded regarding the position of the ore pellet.

| Ore pellet position | Counts | |
|---|---|---|
| | $^{241}$Am | $^{137}$Cs |
| Left | 3.07E+03 | 1.61E+08 |
| Center | 4.03E+05 | 1.88E+08 |
| Right | 9.38E+06 | 2.94E+08 |

## References

[1] SALGADO, C. M. et al. Study of solid-liquid flow regimes in mining industry using gamma radiation. In: INTERNATIONAL NUCLEAR ATLANTIC CONFERENCE, 24-29 nov., 2013, Recife, PE. **Proceedings…** Recife, PE: ABEN, 2013. ISBN: 978-85-99141-05-2.