Study of density prediction for petroleum and derivatives using gamma-ray attenuation

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This report presents a study of density prediction for petroleum and derivatives aiming at product monitoring. The detection system uses appropriate narrow beam geometry, comprising a collimated ^{137}Cs gamma-ray source and a NaI(Tl) detector diametrically positioned on the other side of the pipe, in order to measure the transmitted beam (I_T). Theoretical models for different materials have been developed using the MCNP-X code. The method presented in this work is based on gamma-ray attenuation measurements presenting high sensitivity to the effective atomic number of the petroleum derivatives, mainly at low energy gamma-ray [1]. The attenuation coefficient for photoelectric effect at a given photon energy is highly dependent on both the atomic number of the absorbing material and the density of the absorber. A Polyvinyl Chloride tube with 0.3175 cm thickness and 250 mm of maximum outside diameter composes this test section. The measurement system simulation has been used on previous papers as shown in Fig. 1.

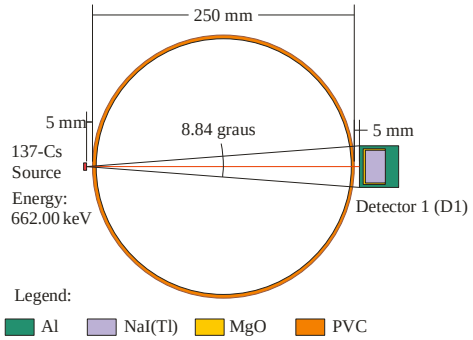

Figure 1. Simulated system.

The mass attenuation coefficient for the different petroleum materials and energies can be determined by the transmission of collimated mono-energetic beam by Beer–Lambert's law. When a wide beam is used, a factor which further complicates the exponential-attenuation process is the build-up effect. Regarding the material type and the gamma rays energy, the coefficient can be determined, once the attenuation depends on density and on the beam path length covered through the absorber, thus, the methodology focuses on these two variables. In order to demonstrate the expected results for two different materials for the same geometry, glycerin and gasoline - both in a pipe of 24 cm diameter and 0.32 cm wall thickness - were calculated by code (tally card F8) and are presented in Fig. 2(a). Fig. 2(b), on the other hand, presents the results for the case of the same material: glycerin, but using a different pipe diameter – 4 cm and 24 cm.

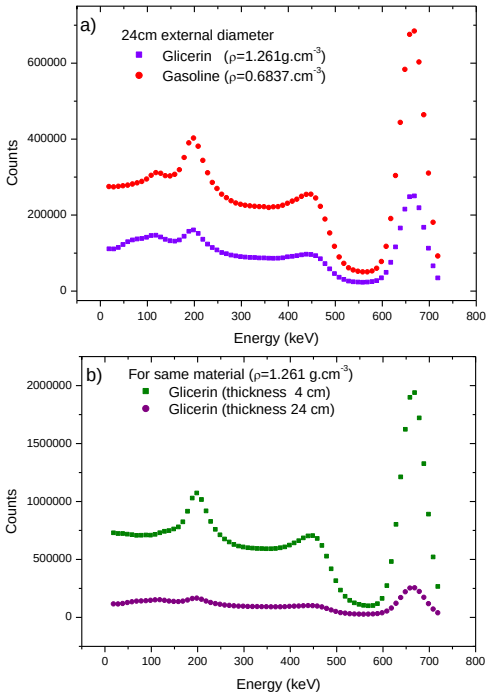

Figure 2. The PHD for: a) two different materials for the same thickness absorber; b) two different thickness of absorber for the same materials.

Due to the differences (behavior) found between the PHD for each one of the densities, it is possible to design an artificial neural network to predict the density the derivates from products' monitoring application without a prior knowledge of the actual material composition.

References

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