Study of gamma-ray scanning technique for troubleshooting analysis of column distillation

C. Raitz, C. M. Salgado[1], L.E.B. Brandão[1]
e-mail: craitzj@hotmail.com, otero@ien.gov.br
brandao@ien.gov.br

[1]*DIRA, IEN*

Keywords: gamma-ray scanning, profiling, distillation column, artificial neural networks.

Industrial equipment, such as distillation columns, suffer from usage and, with time, problems may arise which decrease their efficiency. In many cases, it is desirable to test the equipment without stopping the production. The gamma-ray scanning (GRS) technique offers a noninvasive method that can be used for troubleshooting equipment. It is also a safe method, since sealed radioactive sources are sufficient to get a good signal/noise ratio. The idea behind GRS is very simple: a collimated gamma-ray source and a radiation detector are placed on opposite sides of a column. Their position is then incremented by small steps along the column axis. The recorded intensity depends on the material within the gamma-ray beam path. Denser/thicker materials attenuate more photons, which drops the recorded intensity, while lighter/thinner materials interact less with the photons, generating a high intensity. The generated intensity per position plot is a profile of the column interior. The comparison of this profile with the one for the same column operating on normal conditions should reveal technical problems that reduce the process efficiency. Fig.1(a), for example, shows the sketch of a normally operating column, together with its measured GRS profile in Fig.1(b). Notice the presence of absorption peaks whenever the source/detector passes through a column tray, due to a higher material density. This profile is to be compared with the one in Fig.1(c), which presents two common problems in distillation columns: weeping and flooding. They arise because of insufficient pressure difference between the trays, or lower/higher than normal vapor rates [1]. In fact, GRS service is already commercially available from companies such as QUANTUM Technical Services and TowerScan. In addition, it is not necessary to measure the profile of the column operating on normal conditions. With the column's technical features, it is possible to simulate the profile measurement using the Monte Carlo method [2], for normal operation, and with several known issues. A few of these are foaming, damaged or collapsed trays, and entrainment. In comparison with the measured GRS profile, the simulated profiles may serve as a basis to detect problems in the column.

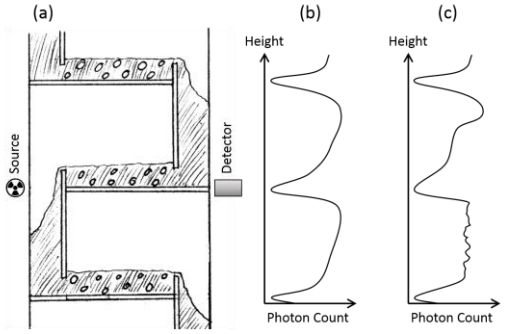

Figure 1. (a) A sketch of a normally operating column together with (b) its GRS profile. (c) A GRS profile indicating equipment malfunction.

The *Aplicação de Técnicas Nucleares* (ATN) group of the *Instituto de Engenharia Nuclear* has been developing a new tool for profile analysis based on Artificial Neural Networks (ANN). ANNs can be trained to recognize patterns much like the human brain does [3]. As far as we know, GRS profiles are still analyzed with the naked eye. We expect this new tool to provide a reliable impartial analysis method. The ATN group used the MCNP code (Monte Carlo N-Particle Transport) to simulate the GRS profile measurement of a distillation column. We plan to simulate the profile measurement of a column operating with several known issues. These profiles will be fed into an ANN as training and validation sets. Thereafter, the ANN can be used to detect equipment malfunction within a given accuracy range. Our results will be published in a forthcoming paper.

References

[1] BUCKLEY, P. S.; LUYBEN, W. L.; SHUNTA, J. P. **Design of distillation column control systems**. [S. l.]: Butterworth-Heinemann, 1985.

[2] SHAHABINEJAD, H.; FEGHHI, S.A.H.; KHORSANDI, M. Structural inspection and troubleshooting analysis of a lab-scale distillation column using gamma scanning technique in comparison with Monte Carlo simulations. **Measurement**, [S. l.], v. 55, p. 375–381, 2014.

[3] SALGADO, C. M. et al. Flow regime identification and volume fraction prediction in multiphase flows by means of gamma-ray attenuation and artificial neural networks. **Progress in Nuclear Energy**, Oxford, v. 67, p. 555–562, 2010.