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Fluka Monte Carlo simulation of gamma photon transport through a distillation column, designed using ChemSep software

ABSTRACT
ChemSep software was used to simulate and design a distillation column prototype for separating a binary mixture of water and methanol. The behaviour of the distillation column was modelled using MESH equations, which in this work have been solved through ChemSep in order to study the effect of different parameters. The desired methanol recovery was 97%, and in the simulation this was achieved using a total of 9 stages and the feed supplied at tray number 7. As the number of trays is kept constant and the feed tray position is moved down the column, the top composition becomes richer in the more volatile component. The interaction and transport of 60Co gamma photons with the distillation column and its contents, methanol-water solution as well as energy spectrum from 60Co were simulated using Fluka Monte Carlo software package. The results of the interaction and transport of gamma photons are presented as energy deposition on the column and its contents. More energy is deposited on the column walls and plates as compared to the energy deposited in the region between the trays, where there is mostly vapour space.

INTRODUCTION
Monte Carlo simulation of radiation transport and interaction with matter is the most reliable way of predicting the effects of gamma rays [1]. The interaction of gamma photons with matter follows well established laws. Gamma photons can either be absorbed due to the photoelectric effect, scattered by an atom, or converted into an electron–positron during pair production in the field of an atom. The effects of a beam of gamma photon passing through a medium are as a result of many individual interactions because a photon can interact many times before it is absorbed or escapes from the medium [2]. The above processes release kinetic energy to electrons, which escape the atom and also interact with the medium as the secondary particles [3].
The approach to this project was to design a laboratory scale prototype distillation column which will be used to simulate all possible malfunctions that arises in industries during distillation processes. The diameter, height of the distillation column, number of trays and tray separation needed to achieve the degree of separation were determined using ChemSep software, a program which performs multi-component separation process calculations [4]. The prototype distillation column with seven trays was designed using ChemSep, and was modelled in Fluka geometry. A beam of 60Co gamma photons was simulated and incident on the model distillation column. Fluka is a particle physics Monte Carlo software package for simulation of radiation transport [5]. These photons were tracked right from birth and during interaction with the distillation column until their energy falls below minimum threshold or when they escape the region of interest.
Fluka Simulation results
The result is represented as energy deposition on the column in the form of a color map. The simulation results shows that attenuation of gamma photon energy is more pronounced at tray position while there is less attenuation in regions between the trays.

Conclusions and recommendations
The result of the Monte Carlo simulation of gamma photon transport through the distillation column, agrees well with literature. The color map result suggest that if a radiation detector was to be moved along the length of the distillation column, at tray positions it will record less intensity and more intensity at region between trays. Thus energy deposition on the distillation column can be easily converted and represented in the form of a density profile which is distillation column elevation against transmitted intensity. Simulation of all possible malfunctions will be done on the distillation column while running the process and scanned and corresponding interpretations of the density profile will be made.
KEYWORDS

gamma photons, distillation column, simulation, prototype, density profile

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Primary author: Mr CHIRUME, Witness (National University of Science and Technology)

Co-authors: Dr BARICHOLO, Peter (National University of Science and Technology); Dr ALAMI, Rachad (Instrumentation and industrial applications, National Centre of Nuclear Energy, Sciences and Techniques (CNESTEN), Morocco); Mr MUDONO, Stanford (National University of Science and Technology(NUST))

Presenter: Mr CHIRUME, Witness (National University of Science and Technology)

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