SCAN ABSORPTION COLUMN IN INDUSTRIAL PROCESS

Pemindaian Kolom Absorpsi pada Industri Proses

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ABSTRACT
The absorption process column in the process unit 01-K-1101 has been used for more than 45 years. The mechanical drawings of the internal structure and history of the treatments are not well documented. The main construction of bubble column consists of 35 trays with 30 bubble caps on each tray. The inlet reflux flows the liquid phase of fluid from the top through two down sponges on each tray to the bottom. A few information relating to the operational history of this column is a major problem that concerns factory management. Investigation is required with the purpose of diagnosing the internal state of the structure and fluid flow at the time of operation. Measurements using a 70 mCi Co-60 gamma source and a synthesis detector show this column is still performing well.

Keywords: radiation, gamma, nuclear, industry, petrochemical

ABSTRAK
Kolom proses absorpsi pada unit proses 01-K-1101 telah digunakan lebih dari 45 tahun. Gambar mekanik struktur internal dan riwayat perawatannya tidak terdokumentasi dengan baik. Konstruksi utama *bubble column* ini terdiri dari 35 tray dengan 30 *bubble caps* pada setiap tray. Reflux inlet mengalirkan fluida fase cair dari top melalui dua *down spon* pada setiap tray hingga bottom. Informasi yang sangat sedikit terkait riwayat operasional kolom ini adalah masalah besar yang menjadi kekhawatiran manajemen pabrik. Investigasi diperlukan dengan tujuan mendiagnosa kondisi internal struktur dan aliran fluida pada saat beroperasi. Pengukuran menggunakan sumber gamma 100 mCi Co-60 dan sebuah detektor sintilasi menunjukan kolom ini masih memiliki performa baik.

Kata kunci: radiasi, gamma, nuklir, industri, petrokimia

INTRODUCTION

For more 45 years, absorption column 01-K-1101 were used for absorbing nitrous oxide in chemical process. The plant management has no maintenance record about the tower condition in detail. The problem occurred when the column has no main hole to do the routine check, in order to maintain the optimum production process. It required a checking technique to determine the condition of each component in the column, without damaging the column structure. There are numerous process advantages that can be realized by using column scanning technique in various application [1].

The online problems of trayed or packed bed columns such as damaged tray or packing, foaming, flooding, maldistribution, weeping and entrainment etc. can be accurately determined by gamma scanning technique [2]. The online means diagnosis of the operation condition by measuring a level, distribution or flow pattern of process media in mixed phases without shutting down the process inside column [3].

Gamma scanning of distilation columns is a case in point, a widely accepted process diagnostic tool for a couple decades now [4]. Some experiments used gamma scanning to perform on-line troubleshooting, optimization and predictive maintenance of trayed or packed distillation columns, without interfering with the process or tower internals in any way. Some paper explained the effectiveness of utilizing Monte Carlo simulation to demonstrate in analyzing troubleshooting of the column [5]. For instance, the density profiles generated in scans can identify damaged trays and packing, liquid maldistribution, flowrate-related problems such as weeping or entrainment, and process problems such as fouling or foaming. Thus periodic scanning of critical equipment by using gamma-ray source can improve the efficiency and also reduce the possible down time of the plant for unidentified problem [6].

EXPERIMENTAL METHOD

Tools and Materials

The configuration of the scanner consists of a NaI(Tl) detector has a diamater 5 cm and an encapsulated source has an activity 100 mCi ^{60}Co (initially was 300 mCi) located opposite to the center of column, placed approximately 2 m apart. Radiation counting system which is integrated with computerized system. The scintillation detector is Model 44-2 Ludlum which operated in 1000 V. A 2200 ludlum ratemeter set on 2 seconds sampling time. The data obtained were visualized through Laboratory Virtual Instrument Engineering Workbench (LabVIEW) 2014 application, in order to show the measurement result of column scan profile.

The absorption column 01-K-1101 is an object to be scanned, height 1200 cm, consisting of 35 bubble trays, 2 bleacher trays, shell ID : 2300 ø x 13 mm thickness, foot shell : 964 x 2326 ø x 13 mm. as present in the figure 1 below.

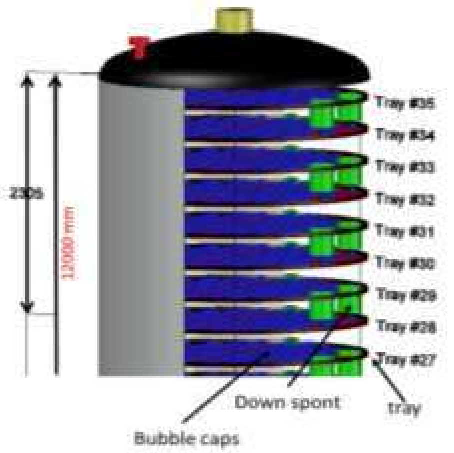

Figure 1. Configuration of bubble caps, down sponge and trays in the 01-K-1101 column.

Description in general is vertical cylinder tank with dished head and bottom, supplier Phoenix-Rheinrohr. The equipment purpose is absorption of nitrous oxide (from process gas) in water to form nitric acid. Many experimental techniques have been proposed to describe the properties of material movement [7].

Gamma counter in this experiment was Ludlum 2200 scaler ratemeter. Voltage was set in 1000 Volt, after the plateau had been found before. Scintillation detector with materials solid, liquid, gasses, produced sparks of scintillators of light when ionizing radiation passed through them [8].

Other tools which used are gamma counters, toolkits, accessories, personal safety equipment, such as helmets, shoes, glasses, earplugs. Radiation safety equipment: thermo luminescent dosimeter (TLD), radiation signs and survey meter become work standards to increase radiation protection against the environment.

Methods

Before measuring the system, safety induction preparations were carried out to prioritize safety in the activity. This experiment was done based on the standards of BAPETEN Head Regulation No.6, year 2009. Then it's required to understand mechanical drawing to determine the measurement points that represented the object's construction profile.

Table 1. Scan orientation May 2018

No	Scan Code	Source (°)	Detector (°)
1	C1	143	30
2	C2	143	330
3	C3	217	330
4	C4	217	30

Based on mechanical drawing, the measurement was done by scanning the column from bottom to top positon, and hanging the gamma source on the orientation 143°, while detector 30°. The elevation of both radiation source and detector was 58 cm under TL. This column in operation condition with a pressure input 6.5 kg/cm^2 and temperature 40-42°C, meanwhile the amount of pressure and temperature respectively is 6.1 kg/cm^2 and 37°C.

Time duration measured for two seconds for each elevation point, then both of them were raised by a distance of 2.5 cm from the previous condition. This instruction repeatedly done until reached top elevation, 1200 cm. Investigation applied four orientations, with configuration in Figure 2.

When a gamma ray undergoes a Compton interaction or pair production, and a portion of the energy escapes from the detector volume without being absorbed, the background rate in the spectrum is increased by one count [9]. This count will appear in a channel below, the channel that corresponds to the full energy of the gamma ray. Larger detector volumes reduce this effect.

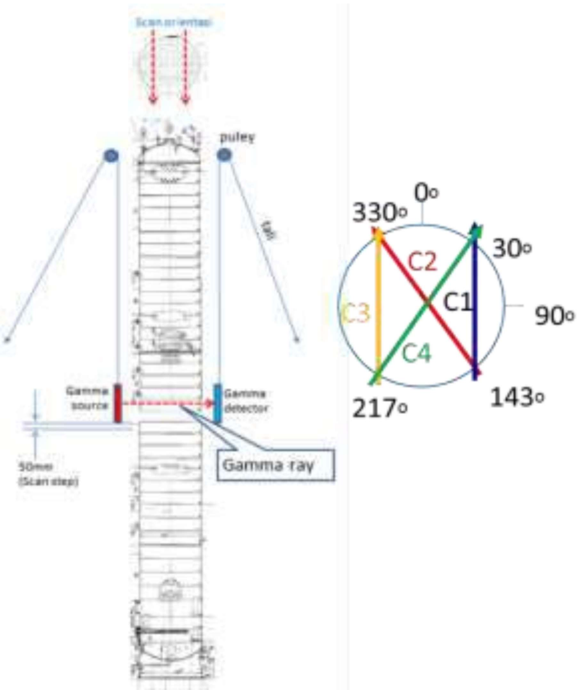

Figure 2. Scan orientation of the column

The principle of analyzing is the radiation intensity measured by detector after passing an object show in the figure 3. If a parallel beam of energetic photons gamma with intensity I_o strikes a target of thickness x, the number of photons I(x), emerging without having interacted in the target is given by this following equation [10] :

$$I_x = I_0 e^{-\mu x} \quad (1)$$

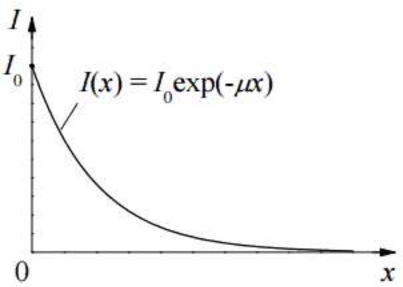

Figure 3. The intensity of the transmitted gamma ray decreases exponentially with material thickness.

where:

I(x)= Intensity of gamma rays through material (cps)

I₀ = Initial intensity of source (cps) (before passing material)

μ = The linear attenuation coefficient (m^{-1}) does depend on energy

x = Thickness of shielding material (m)

RESULTS AND DISCUSSION

The voltage pulse produced by the detector (or by the photomultiplier in a scintillation counter) is shaped by a multichannel analyzer (MCA). The multichannel analyzer takes the very small voltage signal produced by the detector.

This figure 4 provides information that C1 & C3 scans display good measurement results. From tray #15 to tray #35 were in the position corresponding to the mechanical drawing. This means that no tray has collapsed. The radiation intensity kept staying in the range of 20,000 counts, indicated that there was no flood of liquids.

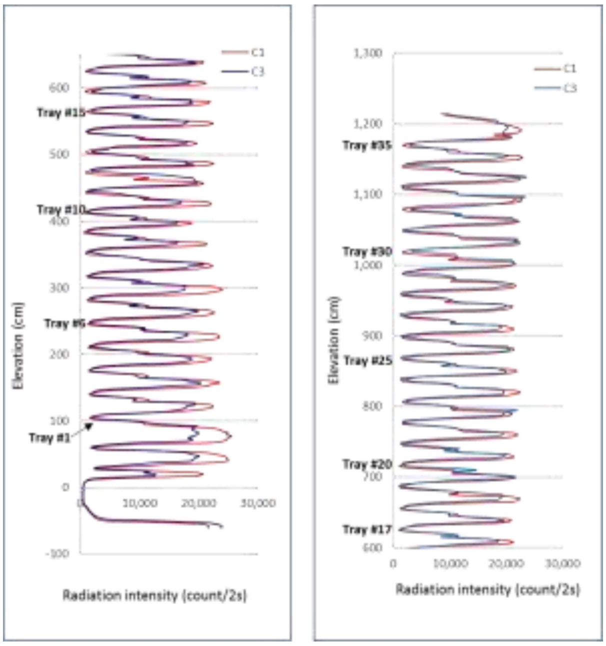

Figure 4. Scan profile of C1 and C3

According scanning results of C1 & C3 presented information that the liquid level hold up was 13 cm above TL. Unlike C1 scans that was not about the S nozzle, the C3 nozzle S scans blocked gamma ray radiation. The gas chamber under tray #10 had a smaller radiation intensity than any other, due to the injection of a production material. Therefore, it induced the difference of material density that attenuated radiation.

Scan C2 was directed through the midpoint of the column. When compared to C1 & C3 data, scan profiles on Figure 5 is identic. Tray #15 until tray #35 was in their position according to the reference drawing. Among the existing trays, observed gas chambers as an indication of no flooding happened, tray falling out, or the presence of foreign objects. Gas chamber was at the intensity of 18,000 counts.

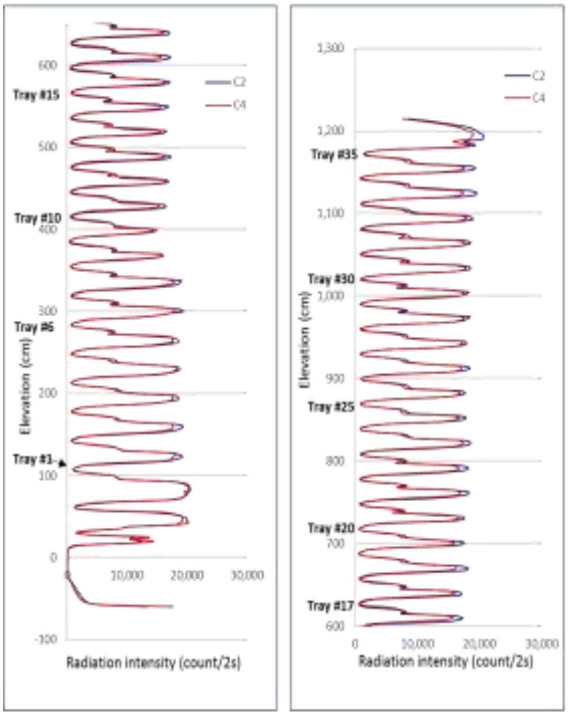

Figure 5. Scan profile of C2 and C4

Figure 6 showed us scan profile from the bottom head to tray # 15. Liquid level was observed 13 cm above TL. Nozzle S blocked gamma rays so that the radiation intensity at this position was 12,500 counts. Tray # 1b until tray # 15 was observed in their position according to mechanical drawing. High intensity observed above each tray explained that no situation of damaging or falling trays, flooding or any foreign objects. The same results with C1 measurement, position under tray #10 presented the intensity curve is lower than the others.

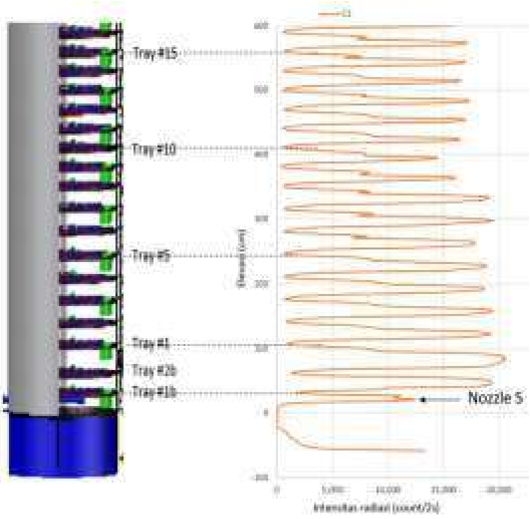

Figure 6. Scan profile C2 pada segmen bawah kolom

CONCLUSION

Column scanning technology is the most suitable technique to diagnose the various malfunction problems in industrial equipment. This technique was successfully applied for detecting the location of trays, level liquid inside, general condition of the column. Based on the results of measurements C1 to C4 can be concluded the following things:

- Tray # 1b until tray # 35 is in their respective positions according to the existing mechanical drawing.
- Liquid level was observed at a height of 13 cm above TL.
- Nozzle S with 2700 orientation was observed on measurements C2, C3 and C4 located under tray # 1b.
- There was no indication of damaged tray or packing, foaming, flooding, and the presence of foreign objects.
- This report can be a scan reference for next maintenance schedule and problem investigation.

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PERTANYAAN SAAT PRESENTASI

1. Pertanyaan (Fajar (PAIR, BATAN)):

1) Apakah perbedaannya dengan *computed tomography*?
2) Tower industri jenis apa penerapan teknologi ini?

Jawaban :

1) Scan memindai objek untuk mendapatkan profil dalam bentuk kurva proyeksi densitas. Sedangkan *computed tomography* memindai (scan) berkali-kali untuk mendapatkan citra distribusi densitas objek.
2) Secara umum bisa diaplikasikan pada tower-tower di industri proses.