IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

INVESTIGATION OF THE CAUSE OF LIQUID MALDISTRIBUTION IN VACUUM DISTILLATION UNIT

Suma T[1], Yelgaonkar V. N.[2], Gaurav Agrahari[3]

[1,2]Scholar, Sri Satya Sai University of Technology and Medical Sciences, Sehore, Madhya Pradesh, (India)

[3]Board of Radiation and Isotope Technology, Vashi, Navi Mumbai, (India)

ABSTRACT

Performance of an industrial process column and vessels depends upon its mechanical design and chemical process optimization. Any malfunctioning of the columns, depending on their size, can cause huge production losses resulting in high revenue losses. Gamma scanning technique is a very useful on-line troubleshooting tool to identify the problem as well as to assess the column/vessel hardware and its general health for chemical and petrochemical industries. The purpose of this investigation is to apply the gamma scanning technique to check the supply of liquid from distributor nozzles of a vacuum distillation unit (VDU). The results of experiments performed in a leading petrochemical complex are presented in this paper. A portion of the VDU has been scanned in six different directions. The interpretations from the graph between count-rate and height from the bottom of VDU showed the directions in which good quantity and moderate or less quantity of liquid falling from the distributor nozzles.

Keywords: Gamma Scanning Technique, VDU, Distributor Nozzles, Count-Rate.

I. INTRODUCTION

Gamma Scanning of columns, vessels and pipes is one of the major radioisotope sealed source techniques. This largely used technique is used to obtain a clear view of processing equipment, for detecting process troubleshooting without the extensive cost of a shutdown. It offers a powerful, original and reliable approach to investigation of industrial processes in all branches Gamma scanning provides a non-destructive and cost effective way of analysing problems of process columns/vessels [1]. Scan data is useful for scheduling shutdowns, estimating turnarounds, carrying out periodic maintenance & process optimisation.

Major advantage of the gamma scanning techniques is its utility without disturbing the process i.e. it is carried out online[2]. Conventional methods of troubleshooting like pressure drop studies, viscosity measurements, sampling etc. can provide rough idea about the problem in the system but they cannot pinpoint the problem area. Whereas, gamma scanning and radiotracer studies are used worldwide for effective trouble shooting and to arrive at exact problem location [3].

Disadvantage of this methods is the need of trained manpower, training for handling of radioisotopes and knowledge of radiation safety is necessary.

1.1 Safety issues

Usually radioisotope used for gamma scanning is Cobalt-60. This has half life of 5.27 years and emits gamma energies of 1.17MeV and 1.33MeV. Intensity of the source used was 200 mCi (7.5 Giga Becquerel). 200 mCi Co-60 is sufficient to scan the columns of the diameters of about 12 meters.

However, these intensities will not be as hazardous as the intensity of a radiography source which is usually more than 10Ci (370GBq). In case of radiography being carried out, the surrounding area needs to be cordoned off [4].

In general, criteria of time distance and shielding needs to be observed while handling radioisotopes. Time taken to handle the radioisotope or when in vicinity should be minimum, the radioisotope should be handled from a distance as far as possible or one should keep away from the source and the radioisotope needs to be adequately shielded for handling i.e. surface dose rate on the container should be less than 200 mR/hour [5].

All of these factors are strictly taken in to account while carrying out the gamma scanning. The radioisotopes are handled by the trained and experienced professionals. The sealed source for gamma scanning was maneuvered in the tungsten shielded collimator along VDU and it was observed that general public / refinery staff and workers do not go in the vicinity of the source.

II. PROCESS DETAILS

Heated reduced crude oil (RCO) from Vacuum Heater is fed to Vacuum Column at the 'flash Zone' above stripping section trays. Flash zone pressure is maintained at 39 mmHga by either top or flash zone PC (only one on-line at a time). The liquid after entry is conveyed into rivulets which rain down to the bottom section of the column. The catching rims are vertically lined up to collect and to enhance the liquid drop down, these leas in considerably increased liquid removal efficiency. Vapour portion of the feed entering the flash zone along with the stripped light ends from the bottom rise up the column & is fractionated into 4 side stream products namely Vacuum Diesel, Light vacuum gas oil (LVGO),Heavy vacuum gas oil (HVGO) and Slops. The slop product is drawn in case of imported crude only to meet PEN value of Vacuum residue product.

There are 5 packed sections in the column. All these are structured packings. Each packed bed is separated by a Chimney tray. Below flash zone there are 6 valve trays. Demister pads are provided at the top to minimize carryover of liquid hydrocarbon to ejector section. Each of the draws including pump around are 'total' from the respective Chimney trays. The internal reflux from the bed above is sent down the bed below through a distributor. There are valve trays are provided in the vacuum Column Bottom below flash zone in stripping section. Superheated LP steam is injected into the column bottom to strip out light ends from Vacuum residue. Column top has been provided with 4 Nos. of relief valves.

Across individual packed beds there are differential pressure indications. These give the operating person a fair idea of liquid – vapour distribution across the bed or across total column height & also of any mal-distribution of liquid reflux, packing inconsistency etc. All level indications in the column are gas purged to avoid plugging of tapings.

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

Adequate numbers of pressure/ temperature indication of DCS level & local indicators are provided at various locations in vacuum ejector, condensers & hot well circuit. These can be put to excellent usage for understanding of any malfunctioning in vacuum circuit of the column. A schematic representation of vacuum distillation unit and a portion of it which has been scanned are shown in Fig.1and Fig.2 respectively.

III. EXPERIMENTAL

A collimated source and detector system is positioned in the same horizontal plane either, across the diameter or selected chords with the help of pulleys and wire ropes connected to a winch system as shown in Fig 4. After assessing the situation, a detailed study was carried out to select proper chords depending upon the orientation of cyclones. Both the source and detector are moved synchronously along the length of the reactor and the radiation intensity is recorded at desired elevations by using nucleonic scalar rate meter. The data thus generated are plotted against reactor elevation and interpreted with reference to the internal loading and hardware configuration of the reactor to derive necessary information

The transmission of γ radiation through any material is governed by the exponential equation[6]

$$\mathbf{I = I_0\, e^{-\mu x}}$$

Where:

I = Intensity of radiation transmitted through a material of thickness X cm

Io = Intensity of radiation from the γ - ray source reaching the detector in the absence of the material.

μ = Linear absorption coefficient (cm^{-1})

The scan line orientations are as shown in Fig.3.Block diagram of the scanning process and the setup of the gamma column scanning equipment is shown in Fig.4 and Fig.5 respectively.

3.1. Gamma Scanning

As seen from the block diagram of the gamma scanning equipment, the source and detector collimator is hung (Fig.6 and Fig.7) from the convenient location which could cover chimney tray below Bed 2, distributor above Bed 3, Bed 3, and chimney tray below Bed 3 (Fig.1). The arrangement of pulleys is made at predetermined suitable locations. From the drawings, details of internal mechanical hardware of the VDU are known. The process/operations engineer marked points at which the pulleys can be affixed as well as lines are marked which should be followed by the wire ropes of source and detectors.

Both source and detector collimators have ~ 4” outer diameter which are required to pass through between platform and body of the column. Wherever necessary, at some locations specific gratings were removed from the platforms to facilitate the smooth passage of the collimators. Automatic gamma scanning system consisting of source operator and detector operator was installed at a suitable location at the level near Bed 3 of VDU. The source and detector operators were controlled through a remote control unit and data of counts per 3 seconds with respect to elevation were obtained and recorded in the laptop. The graph of count-rate Vs. height is a scan line.

IV. RESULTS AND DISCUSSIONS

4.1. Interpretations from scan lines taken as chords L1, L2, L4 and L6 show the following.

Scan Line L-1: Distributor is supplying proper liquid flow in this direction. In bed no. 3, presence of good amount of liquid is observed. However upper half shows lesser liquid than the lower half. Chimney tray and nozzle below show large quantity of liquid accumulation (Fig.9).

Scan Line L-2: Less liquid is seen falling from this direction from the distributor. Upper half of bed no. 3 is deprived of sufficient quantity of liquid. However some quantity of liquid is seen in the lower half of the bed. Good quantity of liquid seen in the chimney tray & nozzle below (Fig.10).

Scan Line L-4: In this direction, very less quantity of liquid is seen falling from the distributor. Upper half of the bed shows much less liquid. However in the lower half of the bed no. 3, good quantity of liquid is seen. Good amount of liquid is seen in the chimney tray up to the nozzle (Fig.11).

Scan Line L-6: Good quantity of liquid is seen falling from the distributor in this direction. Upper half of the bed no. 3, uneven liquid distribution is observed. In the lower half of the bed, good amount of liquid is observed. In the chimney tray, from nozzle to top of the chimney, liquid is seen (Fig.12).

4.2. Interpretations from diagonal scan lines L3 and L5

Scan Line L-3 & L-5: Less liquid is seen falling from distributor in the direction of diagonal L-3 whereas good quantity of liquid is seen falling from the distributor in direction L-5. In both L-3 and L-5 direction, good quantity of liquid is observed in bed no. 3 (Fig.13 and Fig.14).

4.3. Interpretations from superimposed scan lines of the chords

Comparison of L-1 & L-2: Less liquid is seen falling from the distributor in the direction of L-2 as compared to L-1.First half of the bed no. 3, in the direction of L-2, much less liquid is observed then the direction of L-1. However in the lower half of the bed, even liquid distribution was seen (Fig.15).

Comparison of L-4 & L-6: Very low quantity of liquid was seen falling from the distributor in the direction of L-4 & good quantity of liquid was seen falling from L-6 direction. Upper half of the bed no. 3 in the direction of L-4 shows slightly better liquid than L-2 but less liquid than L-6. However in the lower half of the bed, liquid distribution is even throughout (Fig.16).

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

V. FIGURES

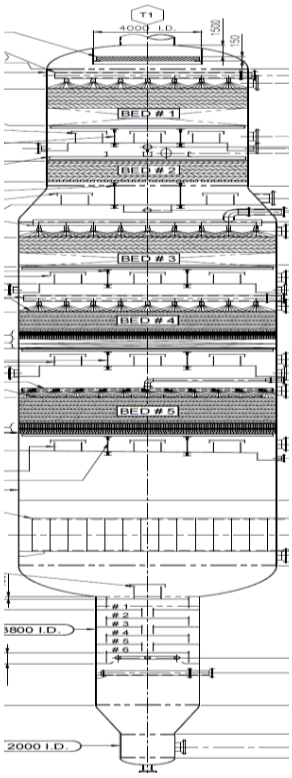

Fig.1 Vacuum Distillation Unit

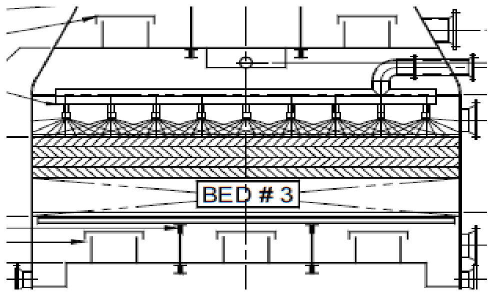

Fig 2: Portion of VDU scanned

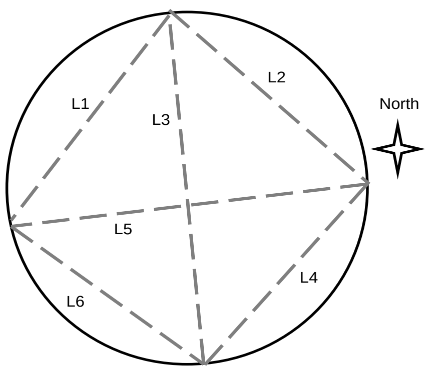

Fig.3: Scan line Orientations

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

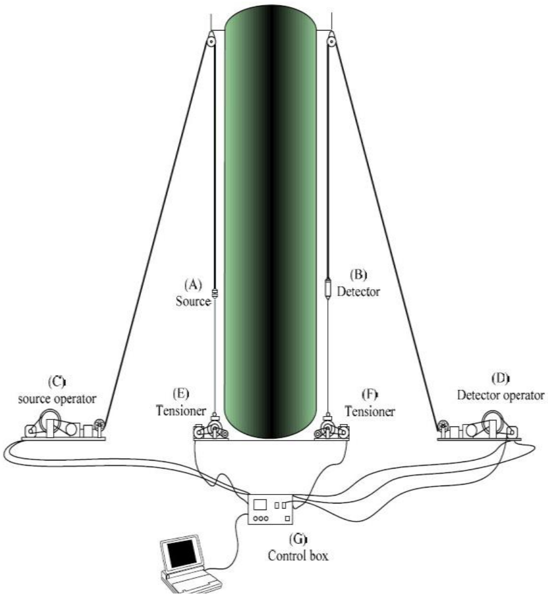

Fig 4 : Block diagram of the scanning process

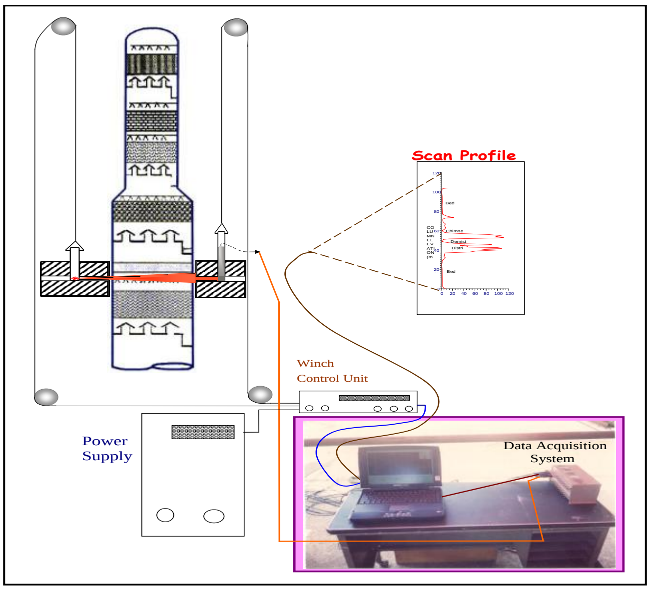

Fig 5 :Setup of the gamma column scanning equipment

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

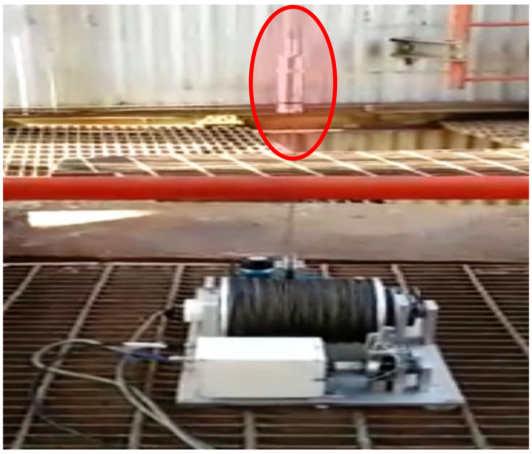

Fig 6: Detector collimator

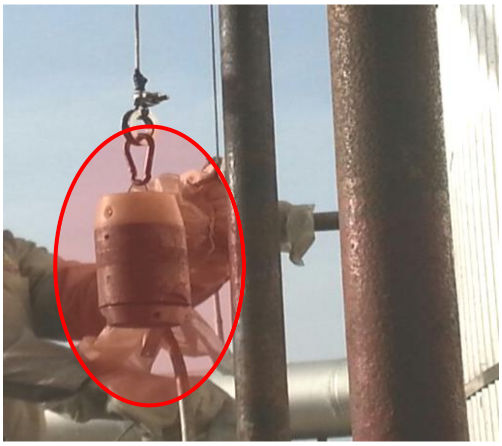

Fig 7: Source collimator

Fig 8: control unit and data aquisition

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

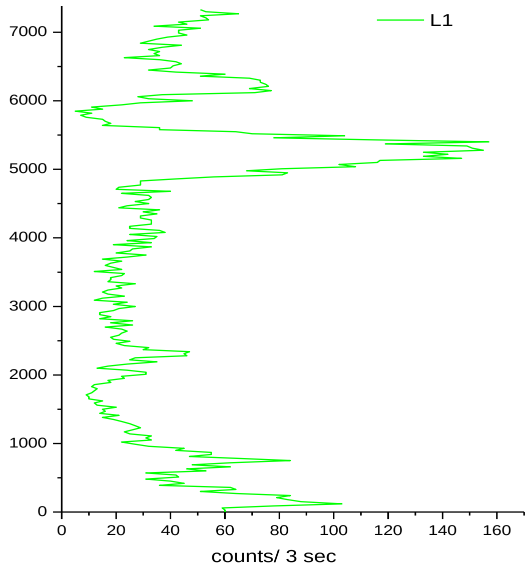

Fig 9: Scan line of the Chord L1

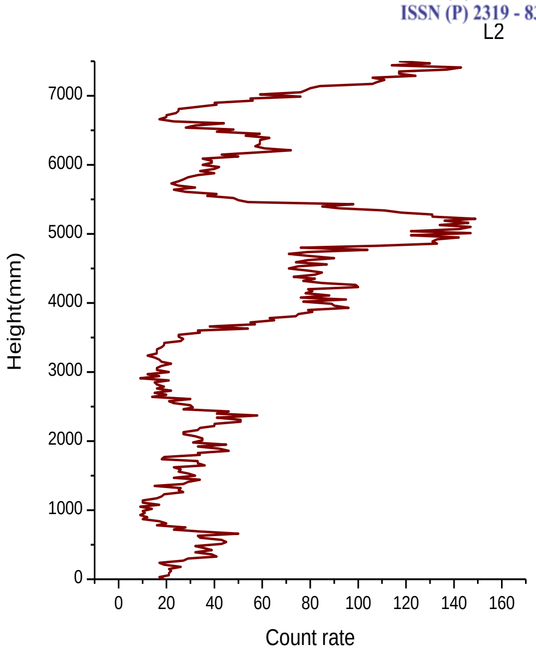

Fig 10: Scan line of the Chord L2

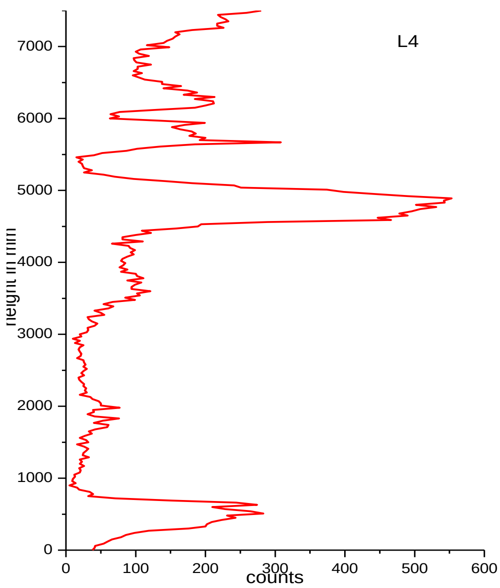

Fig 11: Scan line of the Chord L4

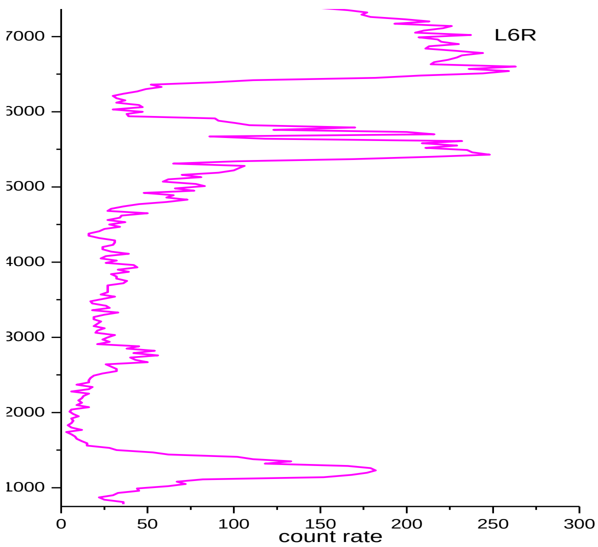

Fig 12: Scan line of the Chord L6

International Journal of Advance Research in Science and Engineering
Vol. No.5, Issue No. 09 , September 2016
www.ijarse.com
IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

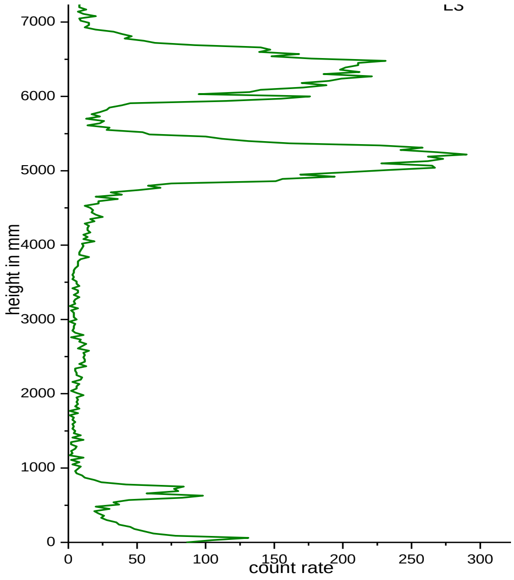

Fig 13: Scan line of the Diagonal L3

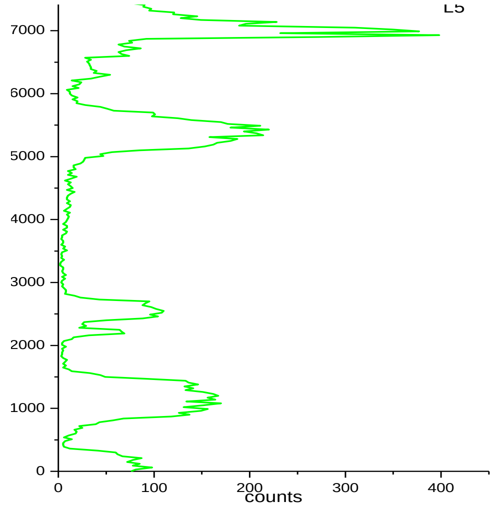

Fig 14: Scan line of the Diagonal L5

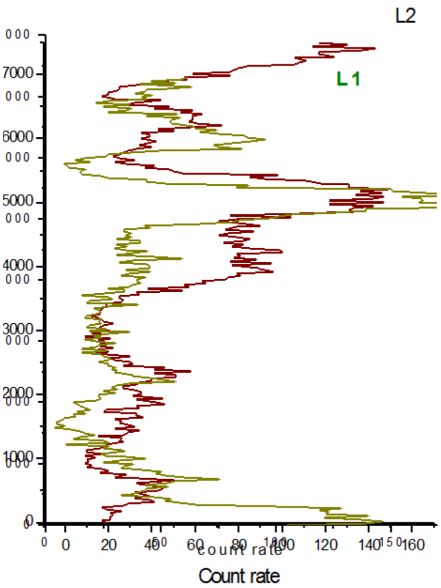

Fig 15: Comparison of Scan lines the Chords L1 and L2

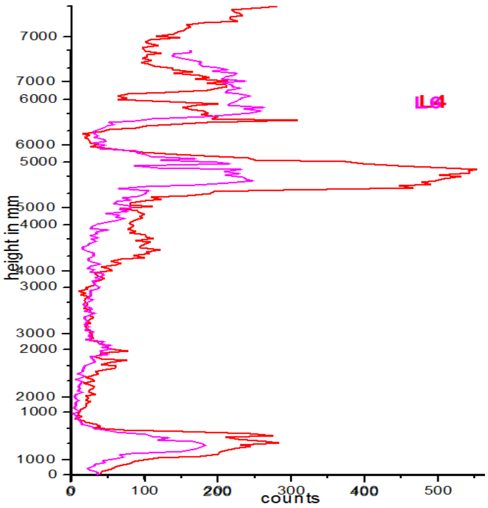

Fig 16: Comparison of Scan lines the Chords L4 and L6

IJARSE
ISSN (O) 2319 - 8354
ISSN (P) 2319 - 8346

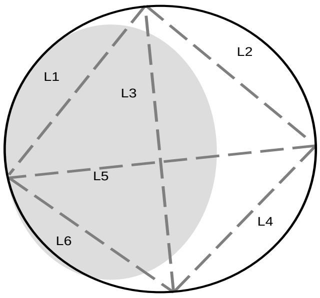

Fig.17. conceptual picture of liquid distribution

VI. CONCLUSION

From all the above scan lines and interpretations derived from them a conceptual picture (Fig.17) of liquid distribution in the upper half of the bed no. 3 is developed. In the direction of L1, L5, L6 good quantity of liquid is observed falling from the distributor nozzles on the bed no.3.In the direction of L2, L3, L4 moderate or less quantity of liquid is observed falling from the distributor nozzles on the bed no.3.Since bed receives less liquid in the south and eastern directions upper half of bed no. 3 is deprived of liquid falling from the nozzles. However, even liquid distribution is observed in lower half of the bed. Scan lines in east and south direction show that even though upper portion of the bed receives less liquid there is no bearing on the attenuation implying much coking is not observed in this portion of the bed. Based on the above results it is concluded that there is no flow from distributor in the north and east portion of the column on the bed 3.The distributor is positioned horizontally, there is no significant coking in the packed bed 3 and no channeling is observed.The corrective actions can be taken for achieving the healthy operating conditions.

VII. ACKNOWLEDGEMENT

Authors would like to acknowledge the co-operation and support of Shri Vikrant Dhakar, Shri C.B. Tiwari from BRIT, the engineering support from the refinery engineers and guidance from the management of the refinery.

REFERENCES

[1] CHARLTON, J.S; (Ed), 1986, "Radioisotope Techniques for Problem-Solving in Industrial Process Plants".

[2] IAEA, 1990, "Guidebook on Radioisotope Tracers in Industry", Tech. Report Series No 316, Vienna.

[3] IAEA 2004, “Radiotracer applications in industry – Guidebook”, Technical Report Series No. 423, Vienna, June2004.

[4] IAEA, 2004, “Radiotracer techniques, Brochure, Vienna, March 2004

[5] BROCHURE, Process Vision Services, “Fluid tracing technology”, Tracer technology company, Brussels, Belgium, 1997.

[6] BROCHURE. Process diagnostic services Tru-Tec Services, Process Diagnostic Division, Texas, USA, 2000.