IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.301

Volume 3, Issue 6, May 2023

Development of Software Tool to Identify Liquid Maldistribution in Distillation Columns

Chinmay Walinjkar, Manisha Bansode, Prof. Payal Shah, P.B Walinjkar

Sardar Patel Institute of Technology, Bhabha Atomic Research Centre, Mumbai

Abstract: *This paper gives the details of the software developed for the detection of faults in distillation columns using the segmented FFT method. This software tool was tested successfully using simulated data and verified using actual data from a previous study. The software tool correctly detected unequal liquid distribution in sections of the distillation column. This result was helpful for correctly identifying the faults in the distillation columns.*

I. INTRODUCTION

A distillation column is an essential item used in the distillation of liquid mixtures to separate the mixture into its component parts, or fractions, based on the differences in volatilities. Our focus would be on packed style distillation columns specifically. A packed column consists of a cylindrical shell containing support plates and a liquid distributor. The cylindrical shell is filled with some sort of packing that rest on the support plate. The packing material offers a large interfacial area for mass transfer. Due to faults in the liquid distributor and beds, there is a high chance of liquid maldistribution which severely affects the quality of the final product. Rectifying such a fault includes opening the column which stops the production that can lead to an enormous loss of revenue to refineries. One of the online methods of identifying faults is Gamma scanning. The data from the scans is traditionally analyzed manually by comparing the graphical plots of the data. A better and faster alternative to this is to use the segmented FFT method.

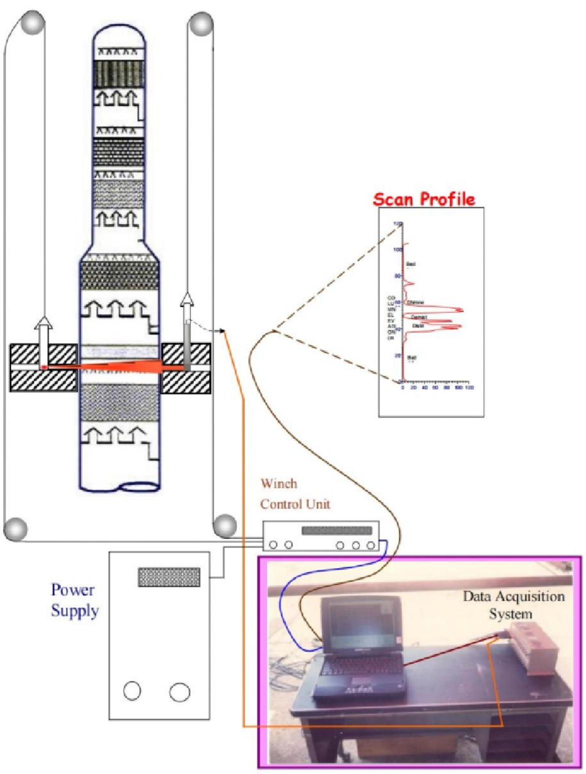

Fig. 1: Setup of the Gamma Column Scanning Equipment [1]

As time is such an important constraint in this whole process, an automated system which could process the data instantaneously and produce results could help in speed up the process of maintenance of distillation columns. Indirectly it leads to huge economic savings. Hence, an automated software for detection of liquid maldistribution was developed using segmented FFT method of data analysis at back end referring the design requirements from the published references.

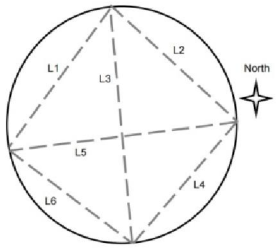

Fig. 2: Scan Line Orientations in Research Study [1].

II. SOFTWARE DEVELOPMENT

The software is developed using python environment and PySimpleGUI. We chose this due to its Open-Source nature and ease of use. Basic pipeline of the software code for data analysis is as shown in figure 3.

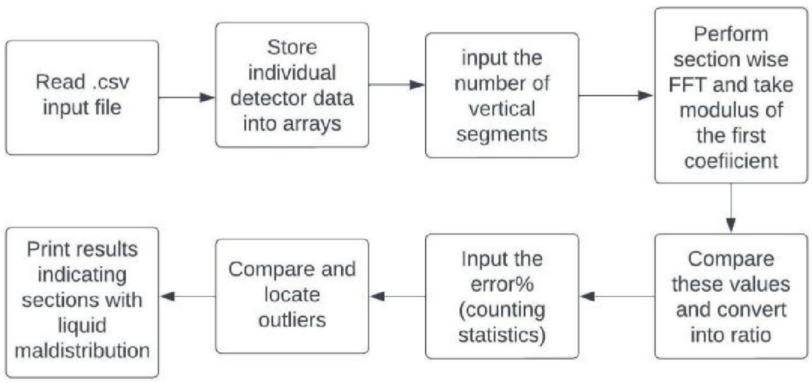

Fig. 3: Basic Pipeline of the Software Code for Data Analysis in Fault Detection.

The first step is cleaning the raw data and making it usable for analysis. The raw text data obtained from the data acquisition system (MIDAS) is converted to a suitable format(.csv). Appropriate column names are given, and the null values are dropped. This file is later used as a data frame for analysis.The file is opened using the “Open File” button provided on GUI as shown in Fig. 4.

The GUI is divided into 4 parts, the first part consists of a button provided to open the data file. The second part helps set default input values of percentage error and number of section of distillations column. Both these parts are act as input data to the software. The third and fourth parts are for output. The third part displays the results and the fourth part of GUI is reserved for plotting the graph for visual inspection. The default value of expected error% is set to 30 and option is provided in GUI for user to change it using up/down arrows as per the requirement. Similarly, the default value of the number of vertical sections along the elevation of the distillation column is kept 4 by default and an option is provided to change it as per requirement.

Taking the value of number of vertical sections as input, the dataset is divided into equal number of segments. Each segment is then transformed into frequency domain using FFT algorithm and the magnitude value of the first coefficient of each segment of each scan [2] is calculated and recorded, as shown in Table I.

These values are then converted into ratio and the error% is used to locate outliers as shown in Table II. The outliners in each segment determines the unequal distribution of liquid in the respective section of the column. The outcome is displayed on the text box provided in GUI. A plot button is given to plot the graph of the data and clear button is provided to clear all data.

After the successful testing of the software using simulated data, it is checked using actual data of the gamma scanning study conducted previously to identify liquid maldistribution in the VDU.

TABLE I: FIRST COEFFICIENT VALUES

X[1]	L1 SW	L2 NW	L6 SE	L4 SW
S1(section 1)	2803	3223	3996	9381
S2	991	2754	785	2307
S3	654	780	699	897
S4	785	1136	555	1067

TABLE II: RATIO COMPARISON OF FIRST COEFFICIENT VALUES

X[1]	L2/L1 NW/SW	L4/L6 NE/SE	L2/L4 NW/NE	L1/L6 SW/SE	Prediction
S1(section 1)	1.15	2.35	0.34	0.7	Less liquid on the northeast side(L4), more liquid on the west side (L2, L1)
S2	2.78	2.94	1.19	1.26	Less liquid on the northern side (L2, L4)
S3	1.19	1.28	0.87	0.94	Even liquid distribution
S4	2.45	1.92	1.06	1.41	Less liquid on the northern side (L2, L4)

III. RESULT AND DISCUSSION

Table I shows the magnitude values of first coefficient of the four-scan line namely L1, L2, L4 and L6 data after FFT transformation. This data is stored internally in an array. Table II shows the ratio values obtained for each segment of the data. When the liquid is equally distributed the value of ratio is 1. So, considering the %error of 30%, the ratio value between 0.7 and 1.3 indicates equal distribution of liquid and considered as normal range. Thus, the ratio values above and below this normal range of values are considered outliers.

When the ratio value is higher than normal range, it indicates less liquid in that region and when the value is lower than 0.7, it indicates more liquid. Based on this theory the results are predicted as shown in Table II, and displayed in the output box on the GUI as shown in Figure 4. It also shows the plot of the actual data. If the outbox displays no message means there is equal liquid distribution in each section of the column.

IJARSCT

ISSN (Online) 2581-9429

International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)

International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal

Impact Factor: 7.301

Volume 3, Issue 6, May 2023

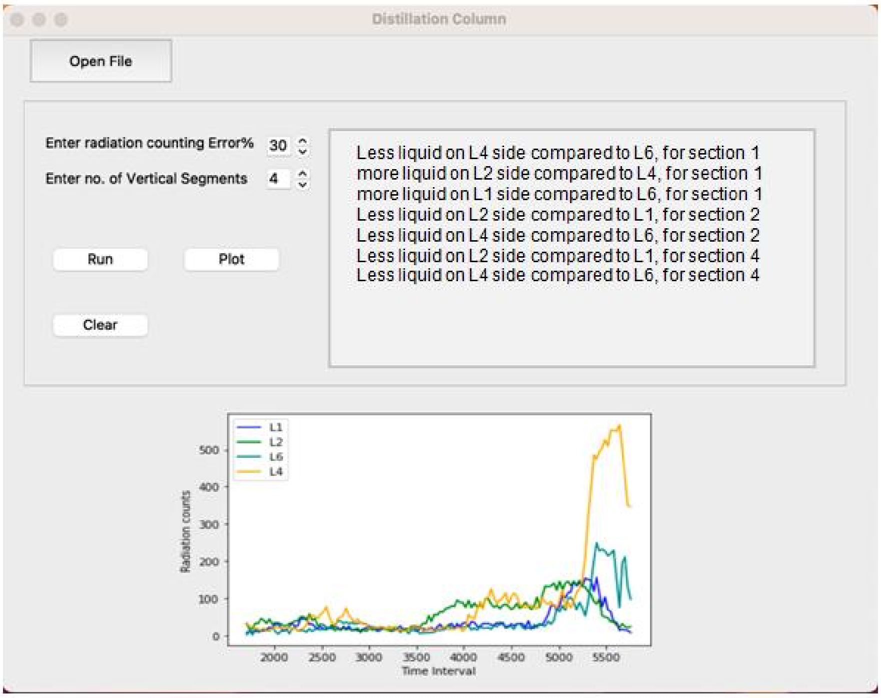

Fig. 4: Results Showing the Liquid Maldistribution in Actual Data Used[1]

IV. CONCLUSION

It is found that the results obtained for the actual data inputted to the software tool match with the previous results of the study [1]. This validates the application of the software tool to analyze the gamma scan data to detect liquid maldistributions in distillation columns. The software development has met the objectives. It has automated the process of reporting the regions of fault. The software tool has simplified the analysis of gamma scan data.

ACKNOWLEDGMENT

The authors gratefully acknowledge Director, RC&IG, BARC, and Head, RPhD, BARC for giving the opportunity to carry out the project work in BARC. Thanks, are also due to IAS, BRIT for sharing study data for validation of the software. The authors thank Prof (Dr.) B.N Chaudhari, Principal, SPIT, Prof Reena Sonkusare, HOD, SPIT for providing support and motivation to carry out the developmental work.

REFERENCES

[1] Suma T1, Yelgaonkar V. N.2, Gaurav Agrahari3," Investigation of the cause of liquid maldistribution in vacuum distillation unit", IJARSE, September 2016.

[2] V N Yelgaonkar, Parag Walinjkar, "Gamma Scan Data Analysis using Segmented FFT Method to Verify Liquid Maldistribution in Distillation Column of VDU", Indian Journal of Pure & Applied Physics Vol. 60, February 2022.

[3] J. Clerk Maxwell, A Treatise on Electricity and Magnetism, 3rd ed., vol. 2. Oxford: Clarendon, 1892, pp.68–73. "Radiotracer Methods for Leak Detection in Heat Exchangers," in Leak detection in heat exchangers and underground pipelines using radiotracers, Vienna: IAEA, 2009.

[4] A. M. Razali, N. H. Yusoff, R. Yahya, R. M. Zain, H. Ithnin, and M. F. A. Rahman 'Numerical approach to data processing for gamma scans: A case study of naphtha splitter column', 06 January 2017.