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# Image Processing Technique for Drilled Holes Inspection in Large Rectangular Plate

Deepak Sachan[1], A Sainath Chaithanya[2]
[1]*Sr. Engineer, BHEL R & D, Hyderabad, Telangana, 500093 India.*
[2]*M. Tech, VLSI System Design, Anurag Group of Institutions (autonomous), Hyderabad, Telangana-500088*
*Corresponding author: Deepak Sachan*

**ABSTRACT**
Baffle plates used in power plants as heat exchangers for the process of condensation are huge in size with large volume of holes meant for inserting and supporting the bundles of condenser tubes are transported to the site, where the tubes assembly is carried out.. Incidentally if a hole is undersized, oversized or not drilled, to rectify the same it is extremely difficult to carry out such operations at site as an oversize hole will lead to tube vibrations leading to physical damages to the condenser tubes. This leads to requirement for inspection of drilled holes in large rectangular plate. At present holes are checked by hand gauges, GO / NOGO Gauges, which is manually carried out and also time consuming. This made a way for optical inspection which offers the desirable characteristics of being non-invasive and non destructive, able to analyze real time objects in a remote sense.The present paper describes an automated method using image processing technique, for measurement of the large number of holes and its parameters for reducing the cycle time of inspection and improve the hole parameter measurement process, in tube sheet or baffle plates.
***Keywords*** Adaptive filters, Baffle plate, Connectivity, Heat Exchangers, Image processing, , Label, NX-UG (CAD tool).

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## I. INTRODUCTION

The purpose of baffle plate is to condense exhaust steam from the steam turbine by rejecting the heat of vaporization to the cooling water passing through the condenser tubes; the plate is having with its unique inlet designs to ensure high thermal efficiency where heat transmission takes place.

A sample of Tube sheet or baffle plate is as shown in Figure 1is having dimensions of 1200mm x 800mm x 25 mm, provided with 415 holes.

Holes are drilled in to the plates using mechanical means such as single or multi-spindle drilling machine for the insertion of bundles of condenser tubes are transported to the site, where the tubes assembly is carried out.

Incidentally if a hole is undersized, oversized or not drilled, to rectify the same it is extremely difficult to carry out such operations at site as an oversize hole will lead to tube vibrations leading to physical

damages to the condenser tubes This lead to drilled hole inspection in baffle plates.

Presently parameters of holes in the Baffle plates sometimes baffle plate are being checked manually, which consumes a lot of time and manpower, hence it is desired to automate the inspection process for large number of holes on plate and this made a way for optical inspection.

A number of research studies being carried out on non-contact type metrological measurement since it has many advantages over contact type measurements. Image processing [6] is one that aids for non-contact type optical measurements that allow one to enhance image features of interest while attenuating detail irrelevant to a given application and then extracts useful information about the scene from the enhanced image.

The real time capturing of plate needs a special mechanical alignment that takes time for establishment. An alternate source is provided, where a reference sample plate has been designed in NX-Unigraphics (CAD tool). An in built camera tools in NX make us to glance the appearance of plate's top view exactly when it is captured at different elevations practically.

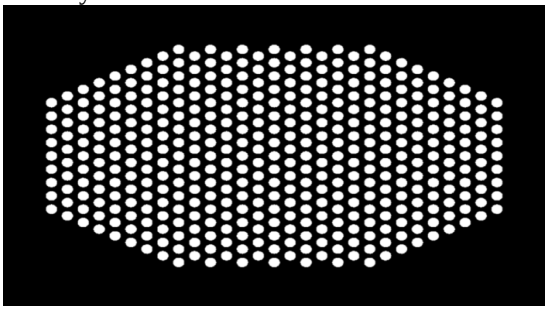

**Figure 1:** Tube sheet or Baffle plate

Finally Inspection of plate using image processing technique is employed in order to check the source image for different parameters namely hole count,

missing holes, misplaced holes, and the dimension of and to inspect whether holes are drilled at equal intervals. Height between the camera and the plate is adjusted in order to grab entire/section of plate. Parameters of the holes are estimated using image processing algorithm and checked with the reference designed plate in NX; parameter values of holes when the full/section of plate captured at various heights are noted and deviations are observed and plotted.

## II. LITERATURE REVIEW AND RESEARCH DEVELOPMENT

In field of image processing applications in metrology, many researchers have done many research works. Some of the distinguished ones, which are relevant and carry basic information for this paper have been highlighted briefly.

An automated visual printed circuit board (PCB) inspection for Defect classification operation is employed in order to identify the source for four types of defects namely, missing hole, pin hole, short-circuit, and open-circuit [1].

Determination of misplaced drills on printed circuit board, the algorithm proposed in this paper uses image processing techniques for automated optical inspection and does not requires the original image of the PCB (original mask) [2].

Bloom diameter are measured using vernier caliper and number of blooms in a bunch is counted manually which may leads to mismatch. The work deals with image processing approach to estimate bloom parameters and total number of blooms in a bunch. To estimate these parameters gradient based circular Hough transformation technique is implemented using MATLAB [3].

Measuring the roundness and roughness of a work piece is essential for the engineering industries which are measured using one of the internationally defined methods of Minimum Zone Circles. This parameter was measured and studied using video measuring machine and image processing technology through Matlab [4].

With the aid of the above references, the current task of **'**Image processing technique for drilled hole inspection in large rectangular plate' had been made easier and laid a way for developing an algorithm for the inspection of baffle plate using image processing techniques in Matlab.

## III. METHODOLOGY

**Approach for task**

As the real image of the plate are captured by an MP (Mega pixel) camera, which requires specialized mechanical equipment that needs time for collection and establishment. In order to replicate the process an alternate method of is developed where tube sheet is designed in CAD Drawing of UG-NX. By capturing the plate at various positions and heights holes like area, centroid, perimeter, radius, roundness by camera tool, Inspection of plate images are carried out

**NX-Unigraphics:**

The input image for processing is taken from NX Unigraphics [8] which is an advanced high end CAD/CAM software package. This is one of the key function in computer aided design engineering drawing, which conveys all critical information like geometry, dimensions before manufacturing a design unit. The capturing view of plate in NX is shown if Figure 2.

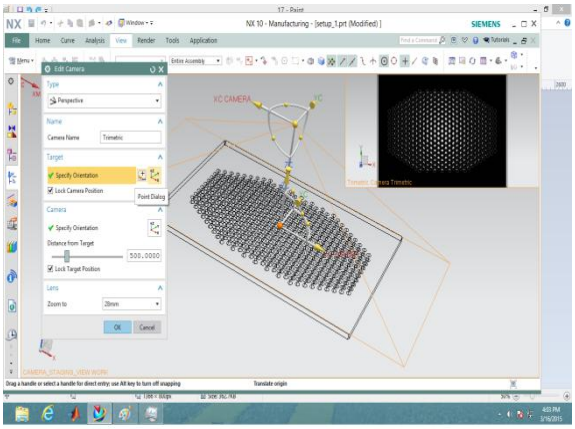

**Figure 2:** Capturing view of plate by camera in NX

In this study of hole inspection the plate image is inspected by using connectivity and labeling [5], its algorithm is shown in Figure 3.

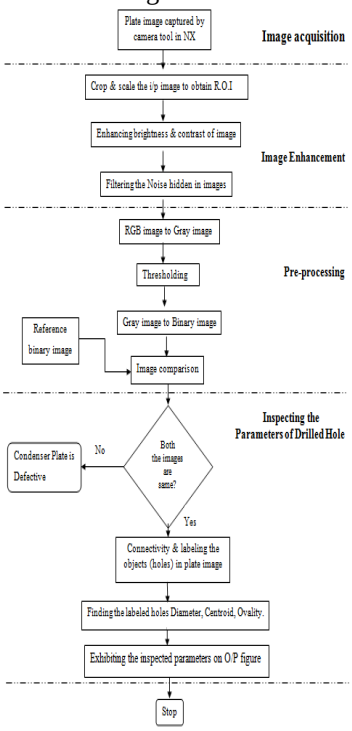


**Figure 3:** Flow Chart

## IV. EMPIRICAL TESTS AND RESULT ANALYSIS

**Test 1: Diameter Inspection of holes**

The top view of Tube sheet / baffle Plate that has been designed in NX and its diameter values of holes obtained from program are depicted in figure 4 (a, b). appearance of full plate when captured at height of 3000mm and hole diameter values obtained from program are depicted in figures 4(c, d)

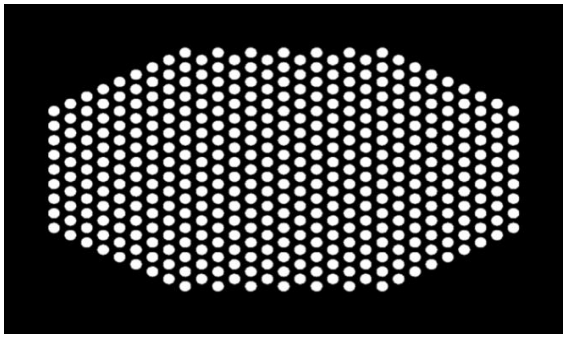

**Figure 4 (a):** Appearance of baffle plate in NX

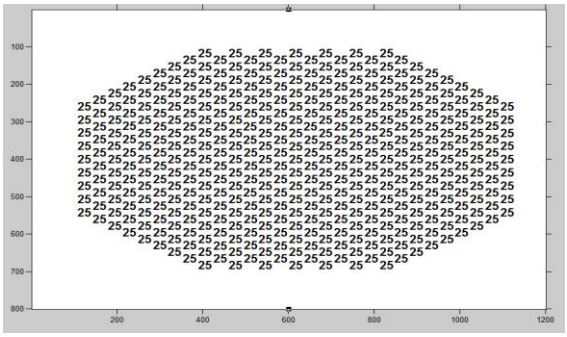

**Figure 4 (b):** Diameter values of holes obtained from program

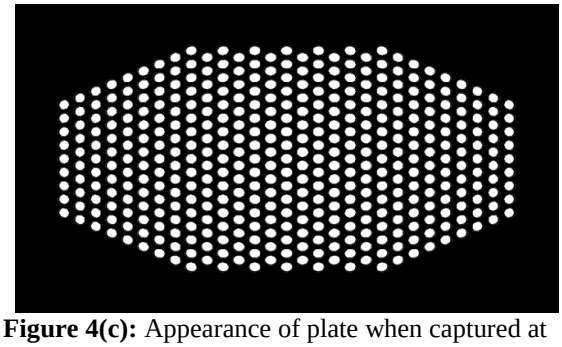

**Figure 4(c):** Appearance of plate when captured at 3000mm distance

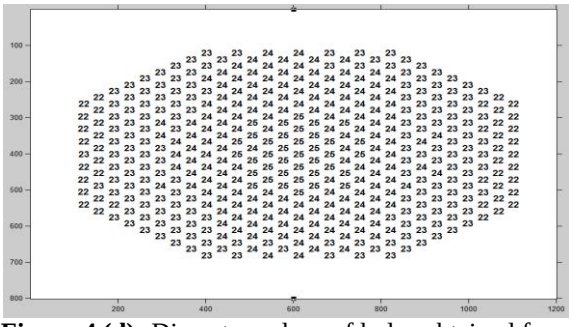

**Figure 4 (d):** Diameter values of holes obtained from program

As we go on increasing the height of camera tool the inner edges of holes disappear gradually. It is expedient to take camera at 3000mm height to capture plate as it exhibits a minimum diameter of 22pixels (mm) existing at border holes of plate, which is taken as a good consideration from the expected diameter of where the remaining heights like 1000mm shows 16mm of minimum diameter for border holes. We can't exceed the height of camera as the maximum permissible height of camera is 3000mm.

A graph is plotted with hole number to the diameter values obtained from program at various heights along with hole number to its deviation from expected diameter(=25 mm) which are depicted in figures 4 (e, f).

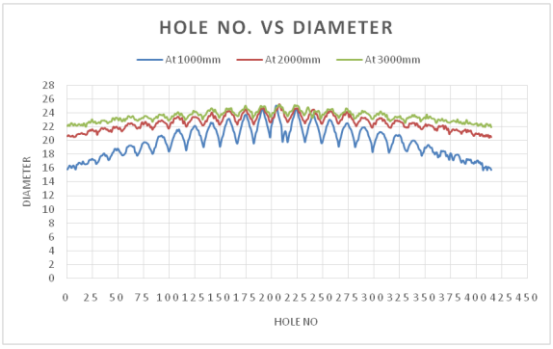


**Figure 4 (e):** Hole no. vs. obtained diameter from program

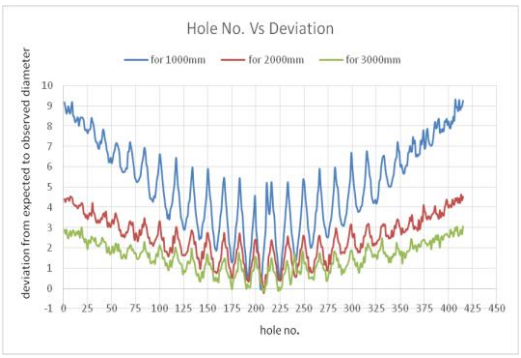


**Figure 4 (f):** Hole no. vs. observed deviation from program

**Test 2: Inspection of distance between vertical holes using Centroid**

Difference between the centers coordinates of adjacent row holes infers whether all vertical holes are equally spaced.

The below output figures 5 (a,b) show the centroid values which are arranged in regular order as that of holes in tube sheet or baffle plate.

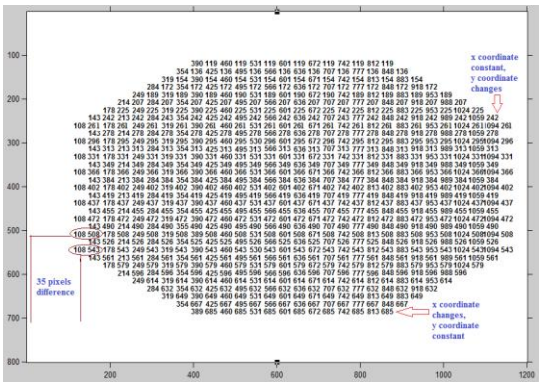


**Figure 5(a):** Centroid of holes in actual plate obtained by program

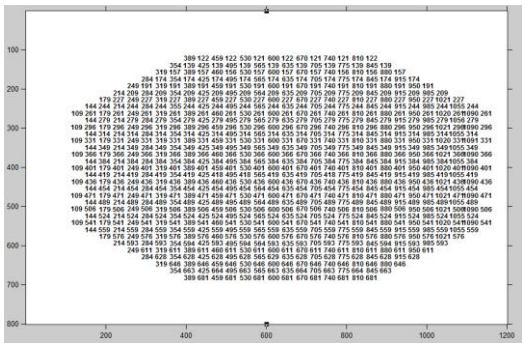

**Figure 5 (b):** Centroid of holes obtained from program at 3000mm

As the holes are arranged in random, while inspecting if it is detected the hole as the last hole in its column of holes, for which its distance of hole to succeeding hole that comes in next column is ignored which tends to a total of 386 distances for 415 holes.

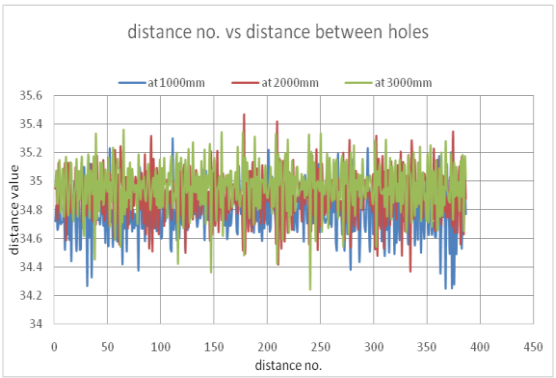


**Figure 5 (c):** Distance no. vs. hole to hole distance value

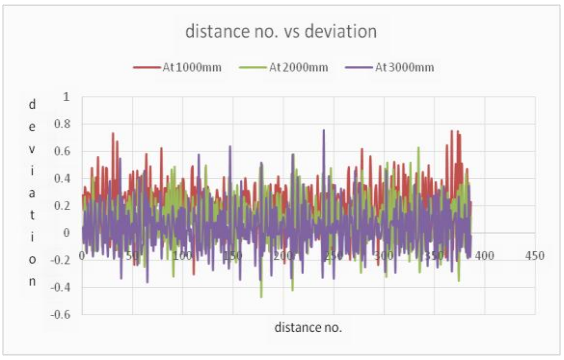


**Figure 5 (d):** Distance no. vs. Deviation from expected distance

A graph is plotted with distance number to the hole-hole distance values obtained from program at various heights along with distance number to its deviation from expected distance(=35mm) which is depicted in figures 5 (c, d).

**Test3: Ovality Inspection of holes in full Plate at different heights**

The ovality of circle infers us how round the object is. For ideal case the ovality of perfect circle is 1, in practice it ranges in [0.95 1], the ovality of holes in full plate for ideal case and when captured at 3000mm height is shown in figures 6 (a, b).

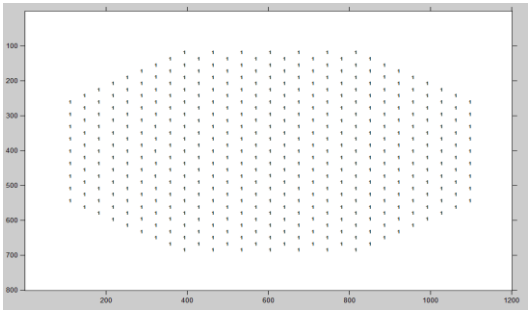

**Figure 6 (a):** Ovality of holes obtained from program for actual plate

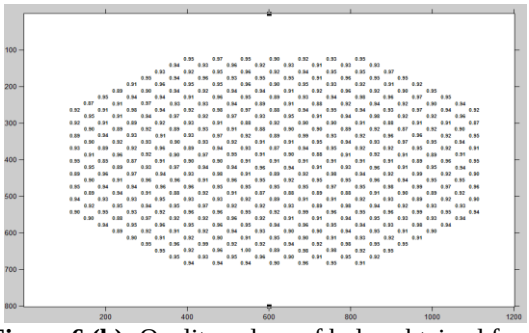

**Figure 6 (b):** Ovality values of holes obtained from program at 3000mm height

A graph is plotted with hole number to its ovality values obtained from program at various heights along with hole number to its deviation from expected ovality which is depicted in figures 6 (c,d).

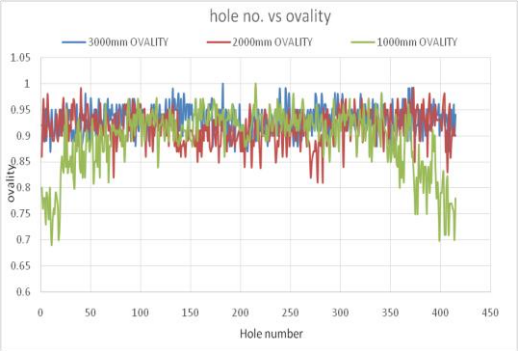


**Figure 6 (c):** Hole number vs. Obtained ovality

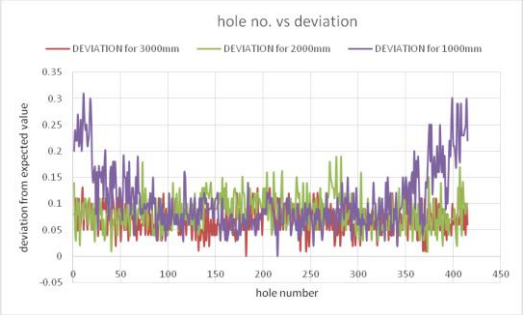


**Figure 6 (d):** Hole number vs. Deviation from expected ovality

From the Diameter, Centroid for distances between vertical holes, Ovality inspections, the results obtained by capturing the plate at 3000mm are satisfactory and in tolerable deviations when compared to the remaining heights of capturing full plate. We can't increase the camera height beyond 3000mm as 3000mm is maximum permissible height for capturing the full plate.

**Inspections of plate as various Sections at 3000mm height**

As per the requirement all the holes in plate should exhibit 25 pixels as diameter which is not satisfying with the complete plate (maximum section) by capturing at 3000mm height. The tube sheet / baffle plate on which lines are drawn with specific colors as shown in figure 7 depicts sections of plate

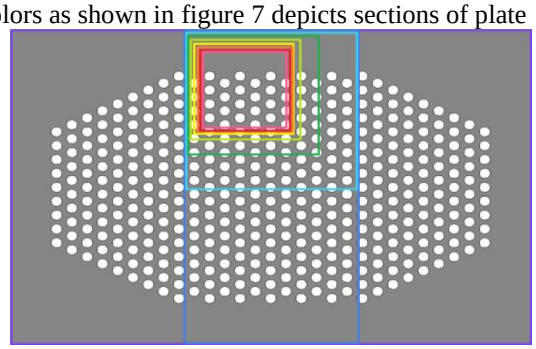

**Figure 7:** various sections in plate

**Table 1:** Color identity for various sections with % of holes showing 25mm

| Sl no. | color | Dimension of section(mm) | Area of section(mm^2) | % of holes exhibiting 25pixels as diameter |
|---|---|---|---|---|
| 1 | Violet | 800*1200 | 960000 | 5.9 |
| 2 | Indigo | 800*400 | 320000 | 6.8 |
| 3 | Blue | 400*400 | 160000 | 8.0 |
| 4 | Green | 300*300 | 90000 | 23.0 |
| 5 | Yellow green | 250*250 | 62500 | 29.0 |
| 6 | Yellow | 225*225 | 50625 | 73.0 |
| 7 | orange | 220*220 | 48400 | 80.0 |
| 8 | Red | 210*210 | 44100 | 100.0 |

diameter Analyzing the maximum section in to subsections the count of holes having 22 pixels diameter vanishes gradually. By further visualizing in to subsections the count of holes showing 25 pixels as diameter increases and there by 23, 24 pixels hole diameter disappears slowly. The observation of section dimensions (area) to the percentage of holes displaying 25 pixels diameter is depicted in table. By investigations, it is observed that the maximum section dimensions needed for all the holes to exhibit 25 pixels diameter is 210*210 for camera taken at 3000mm height where the lens of camera focuses on center of section. Extraction of 210*210 sections is shown in figure 8.

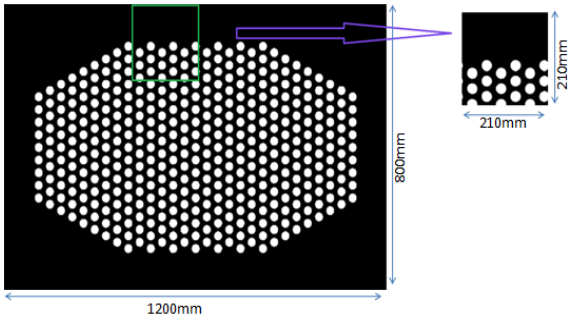


**Figure 8:** Extracting a 210*210 section from plate

Section appearance and diameter values at 3000mm height are depicted in figure 9(a, b) .

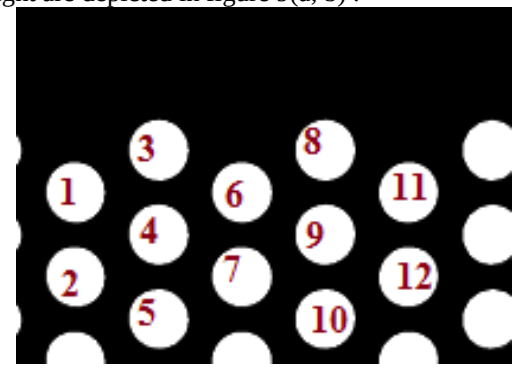


**Figure 9 (a):** Top view and numbering of section in plate captured at 3000mm height

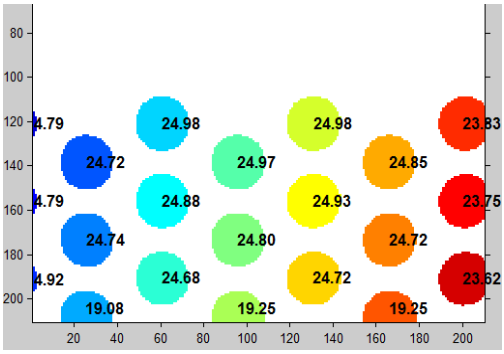


**Figure 9 (b):** Diameter of holes in a section of plate captured at 3000mm height

A graph is depicted with the Hole number to its deviation from actual diameter (=25mm) which is shown in figure 9(c)

Hence it is observed that 3rd and 8th hole have a diameter of 24.98mm (pixels) from actual value of 25mm (pixels), with deviation of 0.02mm. It requires 24 camera shots for capturing all the sections of plate, which gives full plate analyses.

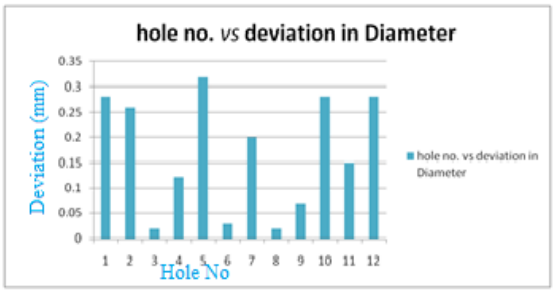


**Figure 9 (c):** Hole number vs. deviation in diameter in section

## V. CONCLUSION

The Proposed method is envisaged to develop and automate a process for drilled hole inspection in large rectangular plate through Image processing technique. The algorithms developed have been applied for detecting holes and inspecting its parameters like area, diameter, centroid, perimeter, ovality when captured at different heights on a tube sheet / baffle plate of size 1200mm*800mm, that has been designed using NX-UG (CAD tool). A deviation report has been prepared with expected parameters to the calculated parameters captured at various heights. From the observations, it is noted that when the plate is captured at 3000mm height in NX, holes in a section of 210mm*210mm of the plate are exhibiting maximum deviation of diameter as 0.2mm, which is good consideration. The significance of the end result depicts a considerable reduction in time for inspection of one work piece by automatic programming, elimination of the manual handling, improving the quality, increasing the productivity, eliminating rework at site.

Further, the developed process and algorithms needs to be applied on real time plate images captured using an MP camera. A lot of filtering process such as adaptive filters or Sobel filters will be required for real time images prior to apply the developed algorithms.

## REFERENCES & BIBLIOGRAPHY

[1] Ismailibrahim1,Syedabdulrahmansyedabubakar2 ,usamohdmokji3, Jameelabdullaahmedmukred4, Zulkiflimdyusof5, Zuwairie Ibrahim6, "A Printed circuit board Inspection system with defect classification capability" , International Journal of Innovative Management, Information & Production, Volume 3, Number 1, March 2012.

[2] Tefanoprea 1, Joan lita 2, Ion BogdanCioc 3, Daniel AlexandruViUan 4, "Determination of Misplaced drill holes on a PCB", Electronics, Communications and Computers Department, University of Pitesti Str. Targul din Vale, Nr. 1, Pite,ti, ROMANIA.

[3] Avadhoot R. Telepatil 1, Shrinivas A.Patil 2, "Parameter Estimation of Metal blooms using Image processing techniques", International Journal Of Innovative Research In Science, Engineering and Technology(ISO 3297: 2007 Certified Organization)Vol. 2, Issue 8, August 2013.

[4] S.Sivasankar1, R.Jeyapaul2, S.Kolappan3, N.Mohamed Shaahid4, "Procedural Study For roughness, Roundness and waviness Measurement Of EDM Drilled Holes Using Image processing Technology", Computer modeling And New Technologies, 2012, Vol.16, No.1, 49–63.

[5] Label- http://in.mathworks.com/help/images/labeling-and-measuring-objects-in-a-binary-image.html /

[6] R.C.Gonzalez1, R.E.Woods2 "Digital Image Processing" TMH 3rd edition

[7] Raman Maini1, Dr. HimanshuAggarwal2, "Study and Comparison of Various Image Edge Detection Techniques", International Journal of Image Processing (IJIP), Volume (3): Issue (1).

[8] Ming C Leu, Albin Thomas, Krishna Kolan "NX 9.0 for Engineering Design" Department of Mechanical and Aerospace Engineering, Missouri university of science & technology

**BIOGRAPHY**

**Deepak Sachan** received the B.Tech. Hons. Degree in ECE from Madam Mohan Malviya Technical University, Gorakhpur in 2009. He has 7 years of experience in automation area. Since 2010, he is working in Research and Development division of Bharat Heavy Electricals Limited, a Maharatna PSU of India. He is working in Technology and Development Lab of BHEL R&D and his main areas of research are Robotic applications, manufacturing automation, image processing, inspection technologies, software development and various new technologies like 3D printing, RFID, GPS based vehicle tracking system etc.

**A Sainath Chaithanya** completed B.Tech in ECE from Geethanjali College of engineering & technology, R. R. Dist., Telangana,. Completed M.Tech in VLSI System design from Anurag group of institutions (formerly CVSR college of engineering) an autonomous institution of JNTU Hyderabad, Telangana,. Currently working as Asst. Prof in Dept of ECE in RGUKT, Basar. His interesting fields include VLSI- physical and logical designs, embedded systems, digital system design, Image processing.

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