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IMAGE PROCESSING BASED VISUAL INSPECTION FOR SPECIFYING BARREL DRUM QUALITY

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ABSTRACT

In medium scale manufacturing industries the quality control of production items are inspected by sensors or manual presence. It is difficult to find defects and fatigue to quality personnel to check quality of each product continuously for batch production. Using sensors for quality inspection leads to high investment and maintenance cost of production. The limitation of these methods of quality inspection motivates present work. The proposed work is based on application of MATLAB; image processing is used to detect the defects and inspecting the dimensions of product with low investment and maintenance cost of production and reduces the fatigue to personnel. In barrel drums manufacturing industry the proposed work is engaged to check quality of batch production. Image processing visual inspection is inspected for detecting any missing characteristic like recognition of color, object, defects in manufacturing, and dimensions in barrel drum. The obtained dimensional values from MATLAB is taken instead of manual inspected data and find quality of barrel drums by statistical quality control tools for batch production.

KEYWORDS – Image Processing, MATLAB, Dimensions, Defects, Statistical Quality Control Charts, Specification Limits.

1. INTRODUCTION

Machine vision developed as a vital new method for mechanical investigation and quality control in the mid 1980's. At the point when appropriately connected machine vision can be give exact and economical examination of work piece, consequently expanding item quality. Machine vision is also used as an in-process gauging tool for controlling the process and correcting trends that could lead to the production of defective parts.

This ability is used to acquire the image parameters, and then helps to make appropriate decisions which are extremely useful for inspection and quality control applications. It enables machine vision to be used for a variety of functions including identification of shapes, measurement of distances and ranges, gauging of sizes and dimensions [2, 3]. The capabilities allow users to employ machine vision systems for cost effective and reliable of 100% inspection of work piece. The real time visual inspection is an integration system of lighting system, image acquisition, computer, controller and handling equipment. In previous general Ali F. Marhoon makes the quality is measured using fuzzy [1]. Chang Jiang Li performed an automatic vision defect inspection system that is capable of detecting defects on chrome-plated surfaces [2]. Hao Feng performed fastener defects of different types by using ranking method [4]. The images can be taken on continuous production and portability of machine inspection also possible [6]. Safaa L. Diab Applied image processing and Neural Network (NN) tools to decide accepting/ rejecting inspected [8]. Sanveer Singh has proposed a method of learning process and then inspection is carried out by the system [9].

Barrel drum inspection is one of the time consuming work in manufacturing industry. To minimize the scrap and rework cost of items produced the frequent inspection and quality checks of items are necessary [5]. In industries manual and automated sensor based inspection methods are used to check quality of products. In manual inspection, because of frequent and routine inspection of barrel drum may lead to fatigue in personnel. In sensor based inspection results rate of inspection is high but the cost of inspection and maintenance are more competitively.

The difficulties in Barrel drum inspection can be rectified by using Image processing. The entire method of image processing visual inspection is coded in MATLAB. Execution of code in MATLAB results in ease of identifying defects in the product. The MATLAB based image editing and colour detection was proposed by Rafael C [7].

However, the image processing visual inspection is most convenient way of inspecting barrel drum in batch production. As above references stated defects and dimensional specifications are checked by Machine Vision system, it eliminates tedious, laborious and unreliable environment. It provides consistent data for quality check by statistical quality control tools.

A suitable system of inspection with separate process parameters is developed in this work. In this system, by image processing region props are used for determining the length and diameter of the barrel drum and detection of object parameters are implemented. The algorithm of process parameters is developed for the acceptance and rejection of barrel drum by checking the quality using statistical quality control tools.

2. EXPERIMENTAL SETUP AND PROCESS

The system setup consists of lighting system, cameras, and personal computer. The lighting system involves a light source behind the object, because the edges of an object are to determine clearly in the captured image. Two cameras are fixed, one at the top view and another focusing at front view. The barrel drum images captured and labeled with its batch serial number. The captured images are compressed and the defects are detected by using image processing. If any barrel drum contains defect, the program identifies defect in that particular image by indicating its labeled serial number.

The influence of process parameters mainly required for inspection of barrel drum quality is taken. To obtain objective parameters Inspection is done by MATLAB. By MATLAB inspection the diameter and the height of barrel drum can be find out for a batch of production. The steps to inspect the barrel drums: 2.1) Image captures, 2.2) Image compression, 2.3) Color detection, 2.4) Thresholding 2.5) Object recognition and 2.6) Dimensions. The obtained measuring vales of a batch are optimized by using control charts for quality.

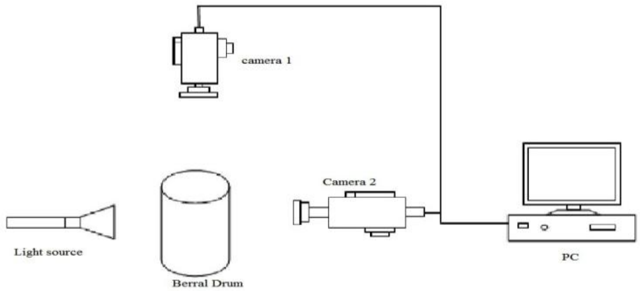

Fig. 1: Experimental Setup.

Overviews of these steps are given as follows.

2.1. Image capture:

A computerized picture can be considered as a discrete representation of information having both spatial (format) and force (shading) data. We can likewise think about regarding as a picture as a multidimensional sign. After the manufacturing process of the barrel drum each barrel drums are captured with high definition camera for better results. The front view and top view of barrel drum is captured for a batch production.

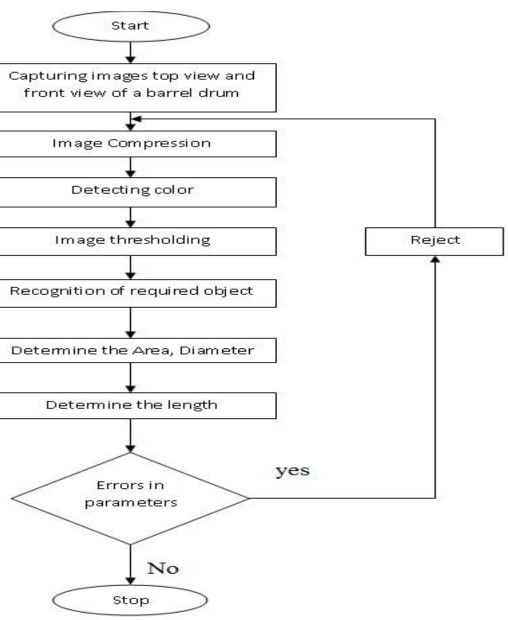

Fig. 2: Experimental process in Flow chart.

2.2 Image compression:

The set of images are captured and storage. The main consideration is choosing image storage format. Due to high pixel in image, the storage size also high. When these images are compelled then analyzes process takes additional time. So image format is compressed, compressing an image can mean it takes up less disk storage and can be transferred over a network in less time. Lossy compression is used in this process. Lossy compression operates by removing redundant information from the image. The important aspect in compression which allows the original image to be reconstructed perfectly from the reduced data without any loss of image information and so-called lossy compression (lossless compression) techniques which reduce the storage volume (sometimes dramatically) at the expense of some loss of detail in the original image.

2.3 Color detection:

Hue, saturation, and intensity are three properties used to describe color. To change color, adjust the saturation. To make it darker or lighter, alter the intensity. Machine vision uses HSI color space in identifying the color of different objects. For every color, it will have a RGB value. In our inspection blue color of barrel drums are to be detected. The RGB value for blue color is (0, 0,225). Color detection is used to detect the color painted on the barrel drum.

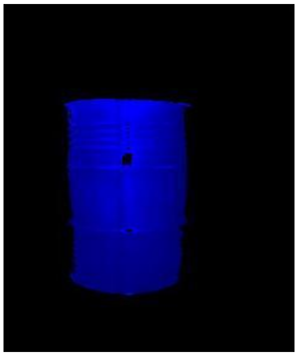

Fig. 3(a): Front view

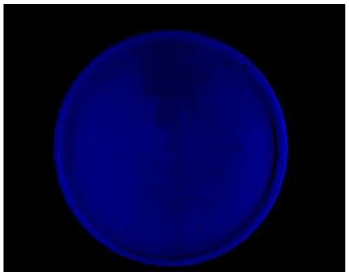

Fig. 3(b): Top view

2.4 Thresholding:

To recognize any specified object in an image, the very first thing is to identify the edges of that particular image. To detect the edges the partial region is to identify in an image. Thresholding consists of segmenting an image into two regions: a particle region and a background region. Thresholding involves the conversion of each pixel value into a binary value, representing either white or black. If the pixel value is greater than the threshold, it is given the binary bit value of white say 1. If the pixel value is less than the threshold, it is given the binary bit value of black say 0. This is done by comparing the intensity value of each pixel with a defined thresholding value. Reducing the image to binary form by means of thresholding usually simplifies the subsequent problem of defining and identifying the object in the image.

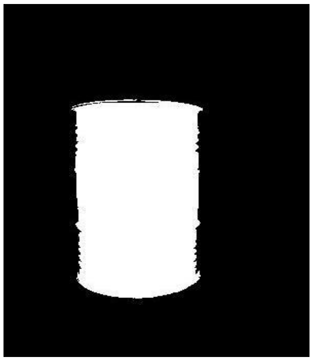

Fig. 4(a): Front view

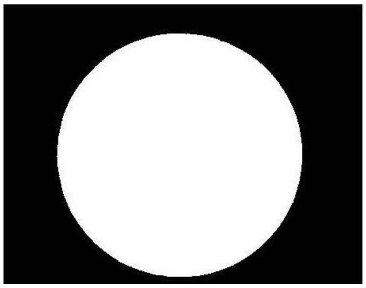

Fig. 4(b): Top view

2.5 Object recognition:

An object recognition system finds objects in the real world from an image of the world, using object models which are known a priori. The recognition of object is surprisingly difficult. The object recognition problem can be defined as a labelling problem based on models of known objects. Formally, given an image containing one or more objects of interest and a set of labels corresponding to a set of models are known to the system. The assign of correct labels to regions, or a set of regions, in the image are done by system. The object recognition problem is closely tied to the segmentation problem without at least a partial recognition of objects, segmentation cannot be done, and without segmentation, object recognition is not possible. The circle object for top view images and a rectangle object for front view images are detected with segmentation.

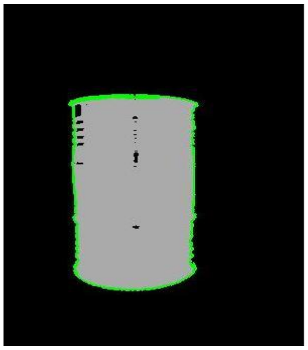

Fig. 5(a): Front view

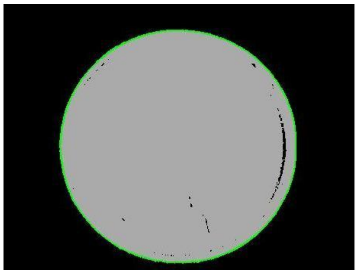

Fig. 5(b): Top view

2.6 Dimensions:

To measure the diameter and height of the barrel drum first we should find out the area of the binary image. 'REGIONPROPS' measure different properties of a bounded image region, like to find Area, Centroid, Bounding box, Major axis, Minor axis, and Perimeter.

$$\text{Diameter of a circle } d = \sqrt{4 \times \frac{A}{\pi}} \quad (1)$$

$$\text{Length of a rectangle } L = \frac{A}{W} \quad (2)$$

These formulas are programmed in Matlab to determine the Diameter and Height of barrel drum. The above parameters are applied on batch production images, by reading multi image program to detecting color, edges, object recognition and dimensions.

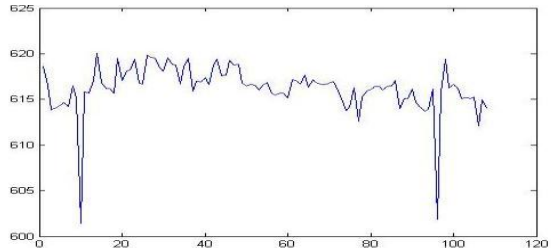

Fig. 6: Sample values of Diameter.

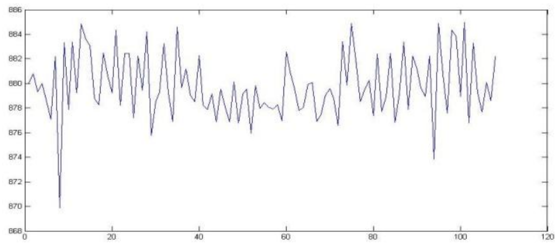

Fig. 7: Sample values of Length.

100 samples of barrel drums are compressed, color, edge, object is detected and Dimensions values are taken:

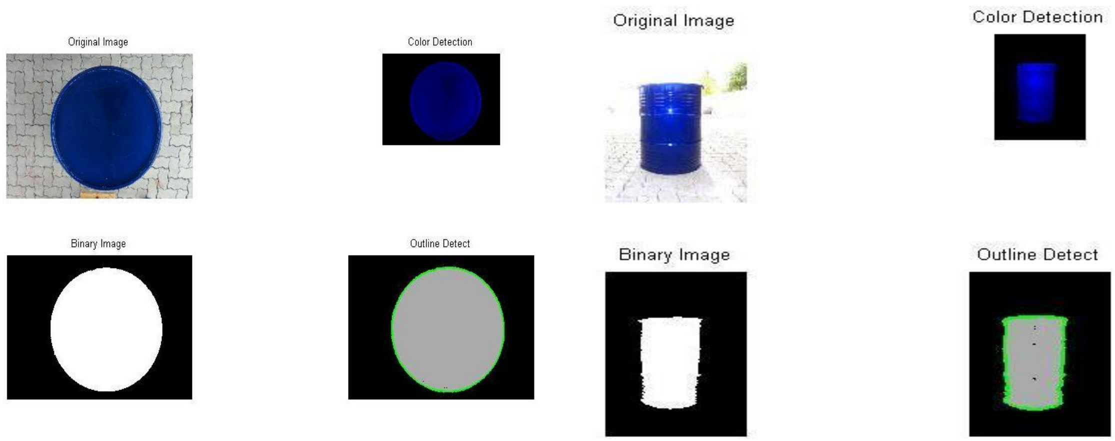

Fig. 8: Detection of color, edge and object for barrel drum top and front.

2.7 Applications:

Different types of products can be inspected by using this visual Inspection Technique and determine the defects and dimensions.

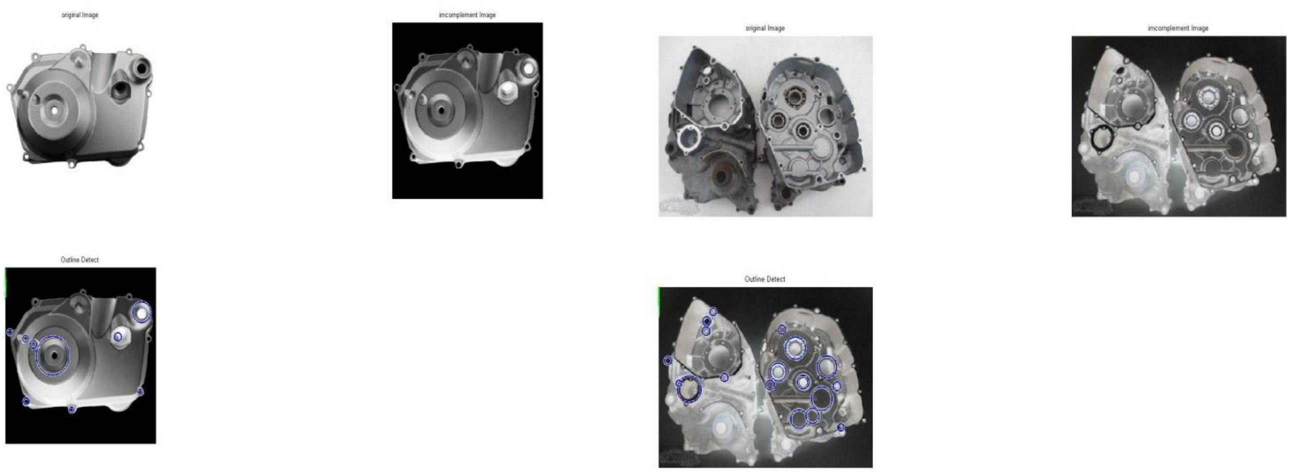

Fig. 9: Finding Defects and Dimensions for Automobile Engine Casing

Fig. 10: Detecting Minor Diameter

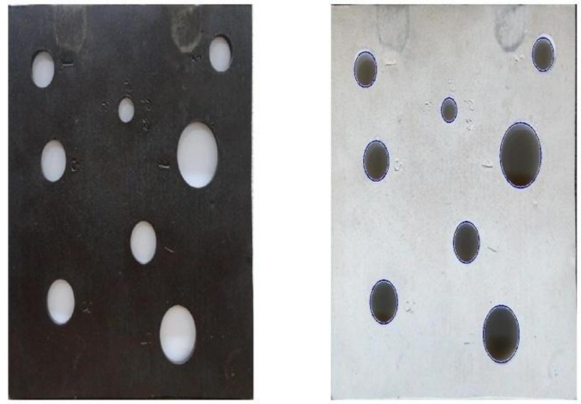

Fig. 11: Detecting Dimensions for Drill Zig

3. DEFECTS

The main defect that are identified in manufacturing of barrel drums are paint patches, welded joints and dimensions.

3.1 Painting:

The major and first recognising of a barrel drum when we saw it is painting, due to in order painting or while it transfer to the drying areas the paint may be went wrong in order and the material of sheet occurs. These color defects can be detected by using color detection. If any patches found the barrel identifies and sent for repainting.

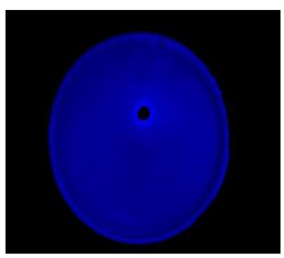

Fig. 12: Paint defect

3.2 Welded joints:

The miss match of weld of sheet causes dimension inaccuracy. If defects are found at welded joints, by sending it again to welding. If found correct then it is used otherwise it is scrap.

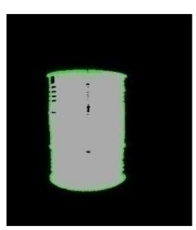

Fig. 13: Defect in welded joints

3.3 Dimensions:

Varying dimensions leads to quality mismatch. The dimensional defect occurs in terms of length and diameter. If any variation is beyond tolerance limit it can be identified and it sent to scrap.

4. QUALITY CONTROL

Quality is customer conformance to requirement or specifications. It judged or realized by comparing it with some standards. The process through which the standards are established and met with standards is called control. This process consists of observing our activity performance, comparing the performance with some standard and then taking action if the observed performance is significantly too different from the standards. To make rational decisions certain graphical tools are used by product data or process data. To represent the decision seven types of quality control tools are used. These tools are effect on quality improvement. Control charts will use variable data of a process. $\overline{X}$-charts and $\overline{R}$-charts quality control are used.

4.1 Diameter:

A batch of 100 barrel drums is inspected and diameters are measured. 40 samples are taken and divided 40 samples into 10 lots.

Table 1: Diameter values for 40 samples in mm.

Lot	Sample 1	Sample 2	Sample 3	Sample 4	Mean	Range
1	618.62	616.56	613.83	614.1	615.78	4.79
2	614.35	614.64	614.18	616.51	614.92	2.33
3	615.1	601.4	615.86	615.68	612.01	14.46
4	617.07	620.06	616.83	616.19	617.54	3.87
5	616.23	615.65	619.51	617.04	617.11	3.86
6	618.1	618.23	619.41	616.81	618.14	2.6
7	616.7	619.82	619.6	619.48	618.90	3.12
8	618.47	618.08	619.56	618.85	618.74	1.48
9	618.75	616.73	618.58	619.5	618.39	2.77
10	615.91	617.01	616.91	617.38	616.80	1.47
∑					6168.3	40.75

Range = maximum size in lot – minimum size in lot. (3)

$$\text{Average of mean} = \frac{\text{cumulative mean}}{\text{Lot Size}} \quad (4)$$

$$\text{Average of range} = \frac{\text{cumulative Range}}{\text{Lot Size}} \quad (5)$$

$\bar{X}$ –Chart control limits:

The control limits are:

$$\text{Center line} = \bar{\bar{X}} \quad (6)$$

$$UCL_X = \bar{\bar{X}} + A_2\,\bar{R} \text{ and } LCL_X = \bar{\bar{X}} - A_2\,\bar{R} \quad (7)$$

UCL_X = Upper control limit.

LCL_X = Lower control limit

$\bar{\bar{X}}$ = central line of the chart and the average of past sample mean's, and

A_2 = constant to provide three-sigma limits for the process mean.

$\bar{R}$ -Chart control limits:

$$\text{Center line} = \bar{R} \quad (8)$$

$$UCL_R = D_4\,\bar{R} \text{ and } LCLR = D3\,\bar{R} \quad (9)$$

$\bar{R}$ = average of several past *R* values and is the central line of the control chart, and

D_3, D_4 = constants that provide three standard deviation (three-sigma) limits for a given sample size.

Iteration 1:

Trail control limits $\bar{X}$-chart:

$C.L_X = \bar{X} = 616.83$

$U.C.L_X = 616.83 + (0.729)4.075$ from control charts $A_2 = 0.729$

$= 619.80$ $D_3 = 0$, $D_4 = 2.282$

$L.C.L_X = 616.83 - (0.729)4.075$

$= 613.86$

Trail control limits $\bar{R}$-chart:

$C.L_R = \bar{R} = 4.075$

$U.C.L_R = 2.282(4.075)$ from control charts $D_3 = 0$, $D_4 = 2.282$

$= 9.29915$

$L.C.L_R = 0(4.075)$

$= 0$

The Mean values of every sample are plotted in $\bar{X}$ and $\bar{R}$ -charts for all samples. To know whether the Mean values are within control or out of control.

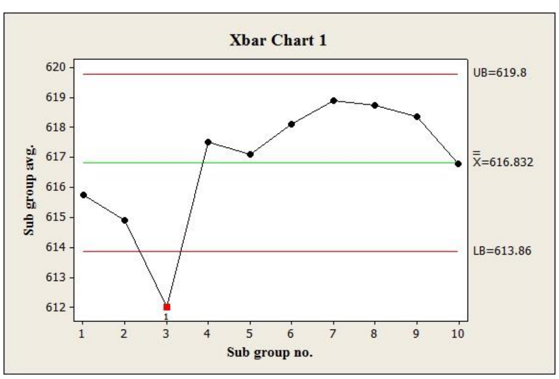

Fig. 14: $\bar{X}$-chart.

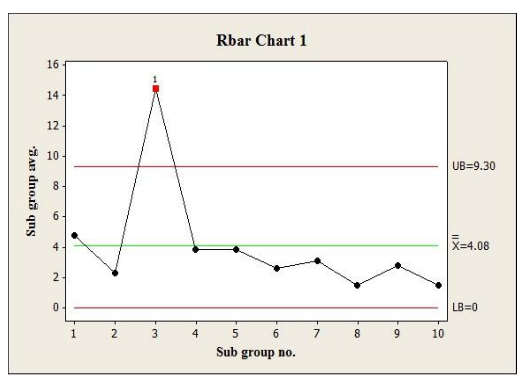

Fig. 15: $\bar{R}$-chart.

Since the process is out of control both in $\overline{X}$ -chart and $\overline{R}$ -chart. Subgroup 3 is falling out of control both in $\overline{X}$ -chart and $\overline{R}$-chart.

Assuming assignable causes and eliminates sub group number 3.

Iteration 2:

Therefore the revised control limits for $\overline{X}$-chart and $\overline{R}$-chart.

Revised control limits:

$$\overline{\overline{X}}_{Revised} = \frac{(Average\ of\ mean) - (eliminated\ sub\ group\ 3\ mean)}{n-1} \quad (10)$$

$$= \frac{(6168.33 - 612.01)}{(10-1)}$$

$$= \frac{5556.35}{9}$$

$$= 617.37$$

$$\overline{R} = \frac{(Average\ of\ range) - (Eliminated\ sub\ group\ 3\ range)}{n-1} \quad (11)$$

$$= \frac{40.75 - 14.46}{10-1}$$

$$= \frac{26.29}{9}$$

$$= 2.92$$

For $\overline{X}$-chart:

$C.L_X = \overline{\overline{X}} = 617.37$

$U.C.L_X = 617.37 + (0.729)2.92$ from control charts $A_2 = 0.729$

$= 619.49$

$L.C.L_X = 617.37 - (0.729)2.92$

$= 615.24$

For $\overline{R}$-chart:

$C.L_R = \overline{R} = 2.92$

$U.C.L_R = 2.282(2.92)$ from control charts $D_3 = 0$, $D_4 = 2.283$

$= 6.66$

$L.C.L_R = 0(2.92)$

$= 0$

The Mean values of every sample are plotted in $\overline{X}$ and $\overline{R}$ -charts for all samples. To know whether the Mean values are within control or out of control.

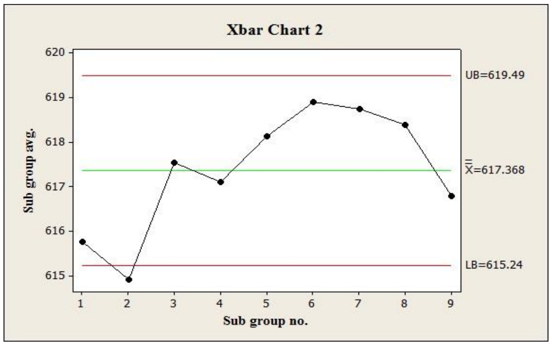

Fig. 16: $\bar{X}$-chart.

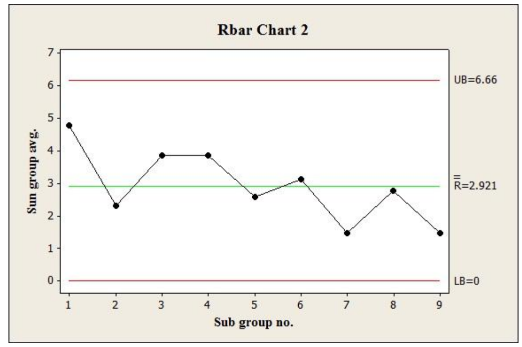

Fig. 17: $\bar{R}$-chart.

Since the process is out of control both in $\bar{X}$ -chart and $\bar{R}$ -chart. Subgroup 2 is falling out of control both in $\bar{X}$ -chart and $\bar{R}$-chart.

Assuming assignable causes and eliminates sub group number 2.

Iteration 3:

Therefore the revised control limits for $\bar{X}$-chart and $\bar{R}$-chart.

Revised control limits

$$\bar{\bar{X}}_{\text{Revised}} = \frac{(Average\ \ of\ \ mean\ ) - (eliminated\ \ \ sub\ group\ \ 2\ mean\ )}{n-1} \tag{12}$$

$$= \frac{(5556.35 - 614.92)}{(9-1)}$$

$$= \frac{4941.41}{8}$$

$$= 617.67$$

$$\bar{R} = \frac{(Average\ \ of\ \ range\ ) - (Eliminated\ \ \ sub\ group\ \ 3\ range\ )}{n-1} \tag{13}$$

$$= \frac{26.29 - 2.33}{9-1}$$

$$= \frac{23.96}{8}$$

$$= 2.995$$

For $\bar{X}$-chart:

$C.L_X = \bar{\bar{X}} = 617.67$

$U.C.L_X = 617.67 + (0.729)2.995$ from control charts $A_2 = 0.729$

$= 619.85$

$L.C.L_X = 61.67 - (0.729)2.995$

$= 615.41$

For $\bar{R}$-chart:

$C.L_R = \bar{R} = 2.995$

$U.C.L_R = 2.282(2.995)$ from control charts $D_3 = 0$, $D_4 = 2.283$

$= 6.83$

$L.C.L_R = 0(2.995)$

$= 0$

The Mean values of every sample are plotted in $\bar{X}$ and $\bar{R}$ -charts for all samples. To know whether the Mean values are within control or out of control.

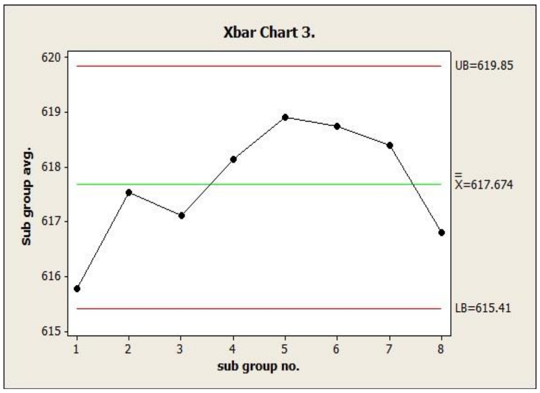

Fig. 18: $\bar{X}$-chart.

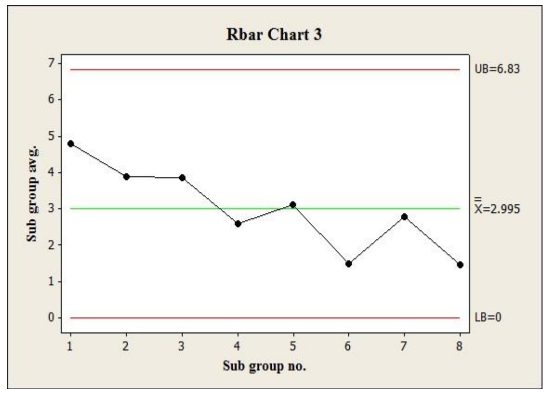

Fig. 19: $\bar{R}$-chart.

Hence all the sub groups are within the control limit and we can say process is under control.

4.2 Length:

A batch of 100 barrel drums is inspected and lengths are measured. 40 samples are taken and divided 40 samples into 10 lots.

Table 4: Length values for 40 samples in mm.

Lot	Sample1	Sample2	Sample3	Sample4	Mean	Range
1	880.04	880.79	879.31	880.01	880.03	1.48
2	878.54	877.07	884.6	869.89	877.52	14.71
3	883.33	877.89	883.38	879.22	880.95	5.49
4	884.85	883.65	883.05	878.77	882.58	6.08
5	878.25	882.5	880.64	879.22	880.15	4.25
6	884.35	878.28	882.43	882.43	881.87	6.07
7	879.21	882.23	879.43	884.19	881.26	4.98
8	875.79	878.53	879.27	883.22	879.20	7.43
9	879.26	876.93	884.59	879.64	880.10	7.66
10	881.17	879.03	878.53	882.28	880.25	3.75
				∑ =	8803.9	61.9

$$\text{Average of mean} = \frac{\text{cumulative mean}}{\text{Lot Size}} \quad (14)$$

$$= \frac{8803.94}{10} = 880.39$$

$$\text{Average of range} = \frac{\text{cumulative Range}}{\text{Lot Size}} \quad (15)$$

$$= \frac{61.9}{10} = 6.19$$

Iteration1:

Trail control limits $\overline{X}$-chart: $C.L_X = \overline{X} = 880.39$

$U.C.L_X = 880.39 + (0.729)6.19$ from control charts $A_2 = 0.729$

$= 880.39+4.517$

$= 884.81$

$L.C.L_X = 880.39 - (0.729)6.19$

$=875.78$

Trail control limits $\overline{R}$-chart:

$C.L_R = \overline{R} = 6.19$

$U.C.L_R = 2.282(6.19)$ from control charts $D_3 = 0$, $D_4 = 2.282$

$= 14.12$

$L.C.L_R = 0(6.19)$

$= 0$

The Mean values of every sample are plotted in $\overline{X}$ and $\overline{R}$ -charts for all samples. To know whether the Mean values are within control or out of control.

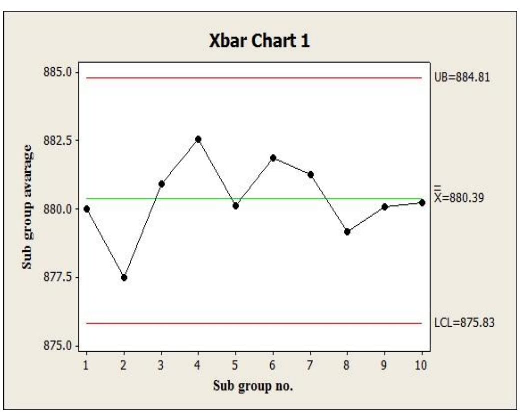

Fig. 20: $\overline{X}$-chart.

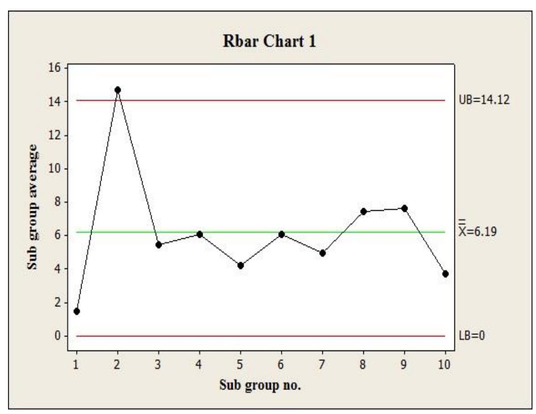

Fig. 21: $\overline{R}$-chart.

Since the process of $\overline{R}$-chart is out of control. Subgroup 2 is falling out of control in $\overline{R}$-chart. Assuming assignable causes and eliminates sub group number 2.

Iteration 2:

Therefore the revised control limits for $\overline{\mathrm{X}}$-chart and $\overline{\mathrm{R}}$-chart.

Revised control limits

$$\overline{\overline{\mathrm{X}}}_{\mathrm{Revised}}=\frac{(Average\ \ of\ \ mean\ )-(eliminated\ \ \ sub\ group\ \ 2\ mean\ )}{n-1} \quad (16)$$

$$=\frac{(8803.9-877.52)}{(10-1)}$$

$$=\frac{5556.37926.38}{9}$$

$$= 880.70$$

$$\overline{\mathrm{R}} = \frac{(Average\ \ of\ \ range\ )-(Eliminated\ \ \ sub\ group\ \ 2\ range\ )}{n-1} \quad (17)$$

$$=\frac{61.9-14.12}{10-1}$$

$$=\frac{47.78}{9}$$

$$= 5.308$$

Trail control limits for $\overline{\mathrm{X}}$-chart:

$C.L_X = \overline{\overline{\mathrm{X}}} = 880.70$

$U.C.L_X = 880.70+ (0.729)5.30$ from control charts $A_2 = 0.729$

$= 880.70+4.1446$

$= 884.84$

$L.C.L_X = 880.70- (0.729)5.30$

$=876.55$

Trail control limits $\overline{\mathrm{R}}$-chart:

$C.L_R= \overline{\mathrm{R}} = 5.30$

$U.C.L_R = 2.282(5.30)$ from control charts $D_3 = 0$, $D_4 = 2.282$

$= 12.09$

$L.C.L_R = 0(5.30)$

$= 0$

The Mean values of every sample are plotted in $\overline{\mathrm{X}}$ and $\overline{\mathrm{R}}$ -charts for all samples. To know whether the Mean values are within control or out of control.

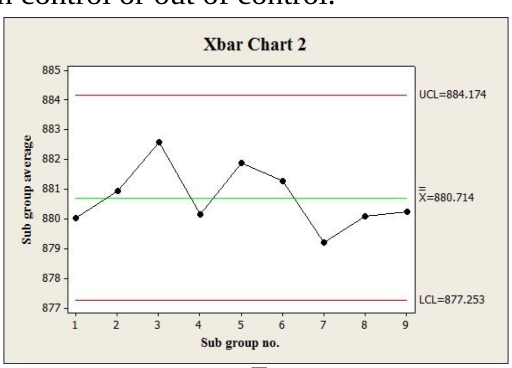

Fig. 22: $\overline{\mathrm{X}}$-chart

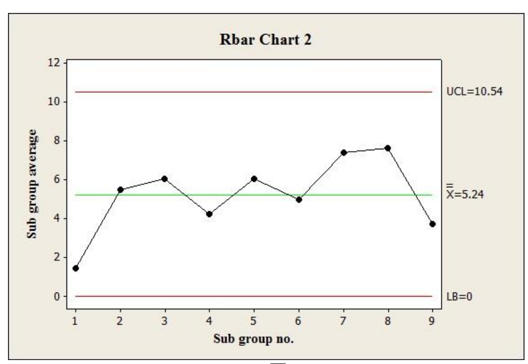

Fig. 23: $\overline{\mathrm{R}}$-chart.

Hence all the sub groups are within the control limit and we can say process is under control.

5. SPECIFICATION LIMITS

5.1 Diameter:

Specification limits of a barrel drum Diameter =615±5mm.

Upper specification limit U.S.L = 620mm. Lower specification limit L.S.L = 610mm.

The process average = $\bar{X}' = \bar{\bar{X}}_{new}$ =617.67mm.

Process variability $\sigma' = \bar{R}_{new}/d_2$ from control charts $d_2 = 2.059$ (18)

$$= \frac{2.995}{2.059}$$

$$= 1.45$$

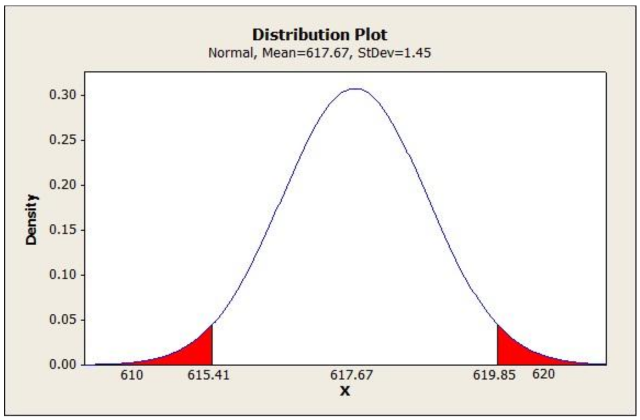

Fig. 24: probability distribution curve for Diameter.

U.C.L- process average

= 619.85-617.67

= 2.18

L.C.L- process average

= 615.41-617.67

= -2.26

$$Z_1 = \frac{U.C.L - \text{process average}}{\sigma'} \quad (19)$$

$$= \frac{2.18}{1.45}$$

$$= 1.50$$

$$Z_2 = \frac{L.C.L - \text{process average}}{\sigma'} \quad (20)$$

$$= \frac{-2.26}{1.45}$$

$$= -1.558$$

From Statistical tables

$A1\ (Z_1 < 1.50) = 0.9332$

$A2\ (Z_2 < -1.56) = 0.0594$

Area 3 = Area1-Area2 (21)

= 0.9332-0.0594

= 0.8738.

Since the confidence limit is 87.38%. So, the process meets specification limit.

5.2 Length:

Specification limits SL = 880±5mm.

Upper specification limits USL = 885mm.

Lower specification limits LSL = 875mm.

The process average = $\bar{X}' = \bar{\bar{X}}_{new}$ =880.70mm.

Process variability $\sigma' = \bar{R}_{new}/d_2$ from control charts $d_2 = 2.059$ (22)

$= \frac{5.30}{2.059}$

= 2.57

U.C.L- process average

= 884.84-880.70

= 4.14

L.C.L- process average

= 876.55-880.70

= -4.15

$$Z_1 = \frac{U.C.L - process\ \ average}{\sigma'} \quad (23)$$

$= \frac{4.14}{2.57}$

= 1.61

$$Z_2 = \frac{L.C.L - process\ \ average}{\sigma'} \quad (24)$$

$= \frac{-4.15}{2.57}$

= -1.61

From Statistical tables

$A1\ (Z_1 < 1.61) = 0.9474$

$A2\ (Z_2 < -1.61) = 0.0537$

Area 3 = Area1-Area2 (25)

= 0.9474-0.0537

= 0.8937

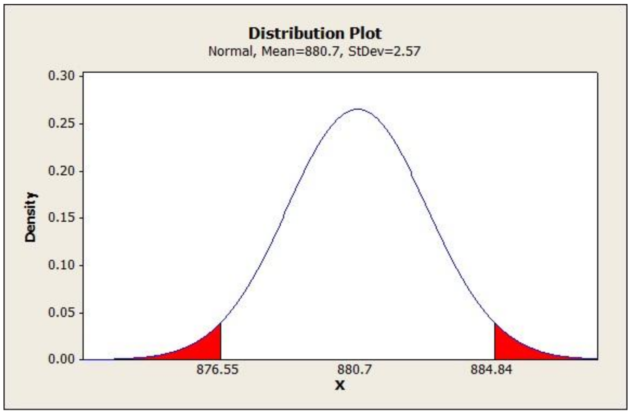

Fig. 25: probability distribution curve for length.

Since the confidence limit is 89.37%. So, the process meets specification limit.

6. CONCLUSION

Quality of barrel drums were checked by image processing control charts whether the production of batch is in control limits or out of the control limits in order to reduce the time delay in quality control and inspection cost. Then specification limits are checked until it reaches to confidence limit and found that quality products produced were found to be 89.37% for height and 87.38% for diameter of the drum are in limit. Quality control can be improved by process parameters. Since most of the manufacturers try to minimize the cost, therefore minimum visual inspection aids the quality of the product can be improved in order to improve the huge and high visual technique. Different Simple Inspection Techniques can improve the product quality

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