

## Development of Visual Inspection for Plastics using Image Processing Technique

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### **Abstract**

*This report describes the development of quality inspection of plastic products by using an 'image processing technique'. The objective of this research is to reduce the occurrence of defect plastic parts in the production line. A visual inspection is carried out prior to the production line using a dot template film to compare black dot sizes during which there is the possibility for defect parts to leak into the production line. A Fish Bone Diagram was used to analyze the primary cause of the inspection error and a Matrix Diagram was used to calculate the relative scores between cause and effect. We found the three main causes of the problem, which are eye strength, misalignment when film is deposited on parts and light quality. Then a 'Why Why' Analysis was used for the analysis of the root cause of the problem and an image processing technique was applied for error observation as opposed to a film template. For making a decision easily, the defect part is divided into two types, a black dot size on a plastic part being smaller than 0.2 mm. and a black dot size on a plastic part being bigger than 0.2 mm. A comparison of 'before' and 'after' was applied to the image processing technique for inspection. It showed that we can decrease the occurrence of poor quality plastic parts in the production line from 73,017 DPMO to 1,214.79 DPMO.*

**Keywords:** *Image Processing, Inspection, Plastic injection*

### **1 Introduction**

Nowadays, plastic is an important material factor for human life and industry. For example, in daily life, plastic is used to make clothes, accessories, and kitchenware. In addition, it is also widely used in many industries such as automotive, electronics, and

mechanic industry. As a result the plastic injection industry in Thailand has been growing and production technology has been developing. Although new technologies are applied in production processes, quality inspection by humans is still frequently used in many factories, such as for example the GPV Asia Thailand Company. In plastic

parts inspection processes, the operator will measure the dimensions and check colors and surface appearances by visual inspection. Moreover, for the inspection of a large product sample size, many operators are assigned to support the production for a long period of time. Eye fatigue and boredom will affect the quality of the inspection of plastic parts allowing poor quality plastic parts to contaminate the production line. After studying the production process of Ascom, the main customer of GPV, the result showed that a high frequency of defective parts were present in the production lines. The main product defect observed is a black dot on the surface, which can be caused by dirt, scratching, and so on. This in turn wastes time due to sorting, production line stoppages, and delivery delay. Although the sampling of incoming parts is randomly inspected, this system is not however efficient enough for preventing the incoming of defective parts to the production line. To increase the effectiveness of quality inspection, this project aims to analyze methods to detect black dot problems by using an image processing technique. This technique is designed to measure the dimensions of black dots on plastic parts of model AS281144R at the incoming inspection process. The scanner is a piece of equipment that collects part images and then calculates the circumference of dots Via Matlab V.7. The computer Pentium IV 2.4 GHz 224 MB has been applied for the calculation by separating parts into two conditions as follows:

1. If the black dot dimension is smaller than 0.2 mm., the plastic parts will be accepted.
2. If the black dot dimension is bigger than 0.2 mm., the plastic parts will be rejected.

The expected benefits of this research are:

1. Increasing efficiency of inspection to be more correct and accurate.
2. Reducing poor quality parts entering the manufacturing process.
3. Applying this project to inspect other plastic parts.

## **2 Literature review**

Quality Control is a process by which entities review the quality of all factors involved in production. Quality Control is checked by the human, machinery, and used technology. The measurement and testing

of the product is mainly used as instruments and machines. The products are featured in beautiful, shape and color can be attracting to customers. Therefore, it must be inspected in terms of external appearance. To inspection shape and appearance of product to be used operators inspect mainly. The viewing and touching is a part of inspection to determine the defects and abnormal of products. If used the eyesight inspect of the product for a long period can cause error and effect to the production. So, therefore as a consequence, the poor quality parts or products are mixed into the production line and sent to the customer. There are caused by fatigue, when operators working for a long period. It cannot prevent them happening. Factors that affect to operator fatigue eyesight, including the work conditions, environment, health and other. Therefore, it has an impact to effectiveness of inspection directly. Whose research on the operator fatigue eyesight from work. Metta R.[4] studied duration factors in VDT-induced Transient Myopia and Visual Fatigue, and Somporn [5] was designed and set up to study visual fatigue during a VDT task and an inspection task under controlled conditions. The results of research, when operators use the eyesight to work for a long period can cause fatigue, stress or eyesight disorder, which are caused by working conditions and environment. Thereafter, researchers have been study ways to reduce errors of inspect the product by eyesight. The errors caused were factors that could not control. Therefore researchers are developing new search technology applied to inspection and reduce error by the operator. Manachai U. [6] presents the image processing applications in aluminum alloy wheel inspection. The 6 defect parameters used for classification are size, gray level, hollow, grouping, alignment and contrast. 603 objects from 30 images are used for creating the defect parameters standard value. From the tests by image processing, it can be concluded that the hit rate of the defect inspection is 78.15% and average processing time is 45 seconds/picture. Vinai P.[7] was the development digital image processing techniques for detecting the cracks on road surface. These techniques can be classified into 5 stages: image conversion, filtering, edge detection, thinning and classification. The result which runs on 80486 DX4-100 microcomputer gives the classification rate of 83.72% and requires 3 to 5 minutes for processing each image. K.M.Schmitt[13] Image processing applied to brick quality control, method were

developed that allowed the identification and measurement of cracks and surface identifications and protrusions, and measurement of the area of uniform pink on the surface of particular brick type considered. It is concluded that the method use could be developed relatively easily into a commercial real time quality system, which could result in considerable cost savings. Using image processing techniques that can reduce errors in detecting and reducing the time to check and reduce the cost of purchasing equipment or machinery is expensive. Inspection use images and software application and processing. Not only does the image processing is used to verify the product is large. It can also be used to verify that the product is very small and cannot detect with the eyes. The research to inspection sugar beet seed with in 1 hour the geometrical parameter of more than 1000 seeds (about 3-4 mm diameter) are measured with accuracy better than 0.1 mm. [14] and inspection of welding using infrared and took the photos using the camera and to inspect by image processing technique for find the depth of the welding.[15] The study's researchers, Image processing techniques can be applied in all industries and to detect the defective of parts to decrease human error. Some industry used image processing technique to replace traditional inspection methods or tools that are costly. The results of research to reduce human error cannot be 100% accurate due to environmental factors (light incident), software, and quality of the camera, a feature of parts, the type of defect or other factors in the process. Research cannot cover a defect that must be checked by the sight is scratched, color, shape, surface, dirt, spots and more. In this paper represents the inspection black dot on the surface of plastics part using image processing techniques, because the plastic is commonly used many products of industries. That emphasizes the beauty of the product to attract customers' attention. The method using scanner to get images of parts and reduce the factors of the environment and the black dots are very small.

In this research presents the development of visual inspection for plastics part using image processing technique. The objective of this research applied using image processing can calculation for separate size of black dot on surface of plastic parts. The first step to analyzed problems and root causes show in section 3. The next step explained the methodology and then implemented in section 4. Finally, the conclusion of results represented in section 5.

### 3 Problem and Root cause analysis

#### 3.1 Problem Analysis

GPV is aware of developing production and the initial improvement target is quality and being competitive about product quality, and therefore product development. The two main customers, Ascom and Grundfos, have been chosen according to the amount of sale value. Due to the lack of customer complaints from Grundfos, but the presence of quality problems regarding Ascom, this will be selected to improve first. In the record, GPV received complaints from Ascom about the quality of material or assembly parts from many causes of problem. The major complaint is the black dot problem. Its dimension is bigger than 0.2 mm. on parts surface. The customer acceptance criteria are not allowed to have black dot bigger than 0.2 mm., as show the Figure 1 (A), and the products will be entirely returned if over 0.2 mm. The black dots are found as show the Figure 1 (B). This problem quite extremely affects to GPV because there are many returned products, delivery expenses and replacement parts. According to this point of view, black dot on model AS.ANA.FBA, there are 5,456 pcs from 63,000 pcs, as 8.53% returned to GPV. By comparison with other model in table 1, plastic parts number AS28114R model AS.ANA.FBA provided the highest number of black dot defect at 12,778 pieces. The number calculated to 14.60% of the model producing quantity.

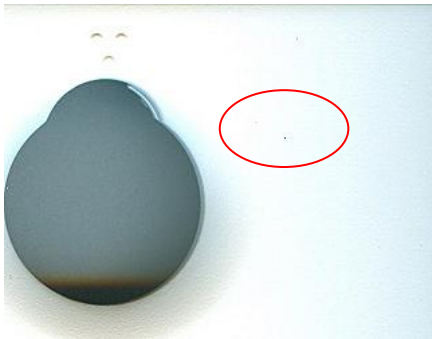
**Table 1:** Percentages of plastic parts were accepted by black dot criteria.

Model	Plastic parts Number	Percentage of black dot defect parts
AS.ANA.FBA	AS28114R	14.60%
AS.ASA.AAA	ASM60570LR	8.06%
AS.ANA.DBA	AS280915	7.19%
AS.ANA.DAA	AS280903CR	4.29%
Other	Other	2.32%
Total	-	8.16%

### 3.2 Project indicator

The targets to decrease black dot plastic parts get into manufacturing process are

1. Decreasing error of incoming inspection, which measures by number of internal failure report about black dot problem and quantity of defect parts in production line. There is 12,778 pieces or 73,017 DPMO that the number will decrease to not more than 6,210 DPMO.
2. Reducing the figures of defect parts which are delivered to Ascom. There is 5,456 pieces or 42,692 DPMO that the number will decrease to not more than 6,210 DPMO.



(A) Accepted parts, Black dot dimension not bigger than 0.2 mm



(B) Rejected parts, Black dot dimension bigger than 0.2 mm.

### 3.3 Root cause analysis

1. Doing brain storming defined cause of problem by using fish bone diagram.
2. Analysis of other factors which possibly effect error inspection.

According to the fish bone diagram, that can be written to matrix diagram to show relative between cause and effect, and arrange influence factors which effect to customer behavior by giving scores. As shown in table 2. Moreover, there is Pareto diagram which also explains significant and insignificant of different as shown in Figure 2.

#### 3. Factor analysis and corrective action

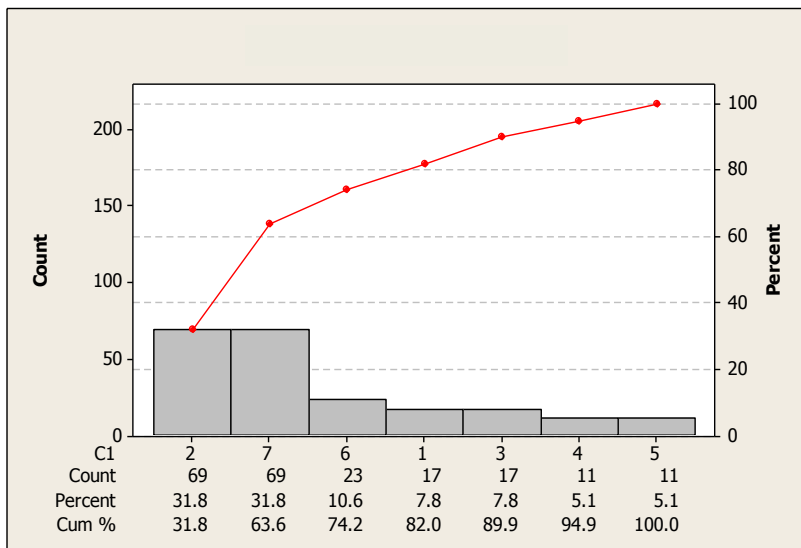
The fish bone diagram study does not go in the correct direction to solve root cause of problem, so Why-Why analysis is brought to find out real root cause and preventive of problem recurrent. The expert teams offered an option to apply image processing technique to measure black dots on plastic surface. The software use for processing images is Matlab which is used software and can be applied in many languages.

**Figure 1:** Example of accepted and rejected parts

**Table 2:** The matrix diagram shows error of black dot inspection.

Effect Factors	3		3		5		Total score
	Defect in production line		Sorting		Stop production line		
1.Inspection times	○	9	△	3	△	5	17
2.Eyesight exhausted	◎	27	◎	27	○	15	69
3.Uncertain	○	9	△	3	△	5	17
4.Interesting	△	3	△	3	△	5	11
5.Concentration	△	3	△	3	△	5	11
6.Lightness	○	9	○	9	△	5	23
7.Placing film wrong position	◎	27	◎	27	○	15	69

Remark: relationship level; △ less = 3 scores ○ middle = 6 scores ◎ highest = 9



\* Remark:

- 1 = Inspection times
- 2 = Eyesight exhausted
- 3 = Uncertain
- 4 = Interesting
- 5 = Concentration
- 6 = Lightness
- 7 = Placing film wrong position

**Figure 2:** The Pareto diagram shows relative score level.

#### 4 Methodology

##### 4.1 Flowchart of prototype program

The structure of the program is divided following function process by started from image acquisition, enhancement images, and black dot segmentation; determine conference number of parts, and calculating parts perimeter. Finally grouping parts by black dot size, those are bigger or equal to 0.2mm., and smaller or equal to 0.2mm. As shown in figure 3.

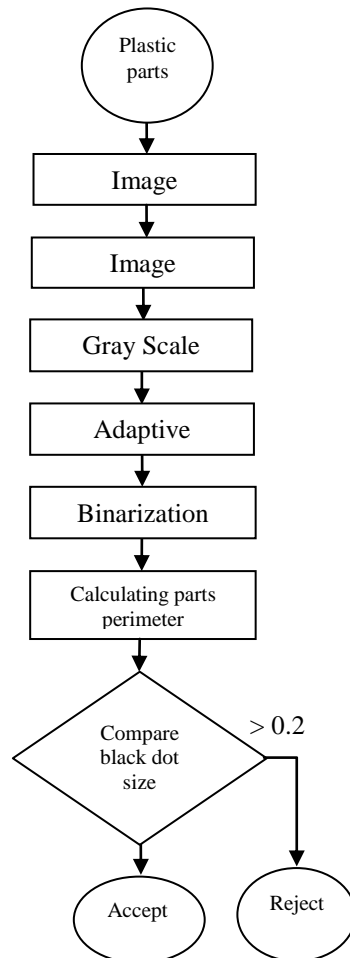
##### 4.1.1 Equipments for inspection by program

The equipments are

1. Scanner ,HP Scanjet 3770 1206x2400 dpi 48 bit
2. Computer, Pentium IV processor 2.4 GHZ 224MB
3. Software, MATLAB V.7

##### 4.1.2 Detail and procedure of program

To finding a boundary of black dot in testing process is as follow in figure 3.



**Figure 3:** Flowchart of black dot inspection by prototype program

### 1 Image acquisition

The process of scanning images using a scanner to sweep image and get a 2D (2 dimensions) image. As shown in Figure 4. Then, the signal converter from analog to digital signal and analysis all images by Matlab software v.7. The detail of specific pieces of front surface part only, and adjust the perpendicular piece and all planes to the accuracy of processing program.



Figure 4: Image acquisition

### 2 Image binarization

The image was converted to gray image to find lightness level and adjust lightness in each area. Therefore the gray image was converting to binarization image. As shown in figure 5



Figure 5: Binarization image

### 3 Black dot segmentation process

This process was important to identify the black dot which find boundary area and indentify symbol in each dot. As shown in Figure 6.

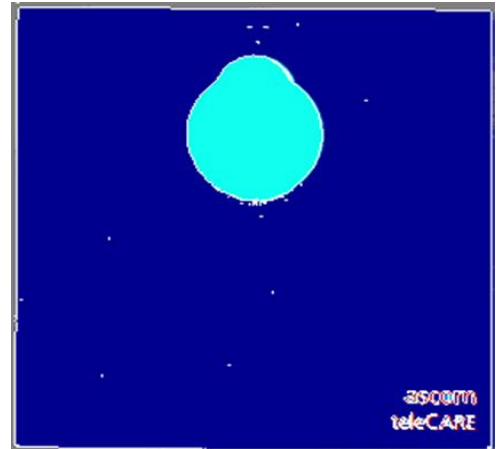


Figure 6: Result of black dot segmentation

### 4 Perimeter calculating and Black dot dimension separating

- Perimeter calculating

For the process of finding the boundary of black dot using Inner Boundary Tracing [8]. Find contour the border of pixel in 8- connectivity, as shown in figure 7 search 8 directions is determine to be define the direction from 0-7.

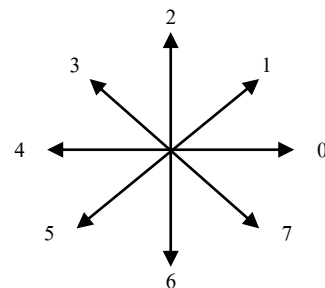


Figure 7: Finding 8-connectivity

Process to finding border of Inner Boundary Tracing in 8-connectivity are as follows

- 1) Search the pixel from top left unit a pixel of a new region is found; this pixel  $P_0$  than has the minimum column value of all pixels of that region

having the minimum row value. Pixel  $P_0$  is a starting pixel of the region border. Define a variable dir which stores the direction of previous move along the border from the previous border element to the current border element. Assign

Dir = 7 if the border is detected in 8-connectivity

2) Search the 3x3 neighborhood of the current pixel in an anti-clockwise direction, beginning the neighborhood search in the pixel positioned in the direction.

(dir+7) mod 8 if dir is even. (Figure 8)  
 (dir+6) mod 8 if dir is odd. (Figure 8)

3) The first pixel found with the same value as the current pixel is a new boundary element  $P_n$ . Update the dir value.

4) If the current boundary element  $P_n$  is equal to the second border element  $P_1$ , and if the previous border element  $P_{n-1}$  is equal to  $P_0$  stop. Otherwise repeat step 2.

5) The detected inner border is represented by pixels  $P_0 P_1 P_2 \dots P_{n-2}$

The figure 8 is example of finding border using Inner Boundary Tracing follow step above. The first pixel is pixel  $P_0$ . Then search in pixel positioned in direction follow step 2 found pixel  $P_1$  and border direction from  $P_0$  to  $P_1$ , direction is 0. (Figure 7), consideration of the surrounding pixels  $P_1$  follow step 2 and the next pixel is  $P_2$ . The direction of border from  $P_0$  to  $P_1$ , direction is 7. (as shown in figure 7) Update the dir value until the condition in step 4 and pixel of image are  $P_0 P_1 P_3 P_4 P_5 P_6 P_7 P_8 P_9$  and  $P_{10}$

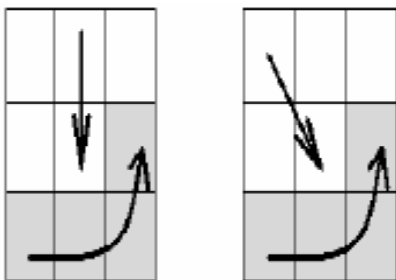


Figure 8: Inner boundary tracing: search sequence in 8-connectivity

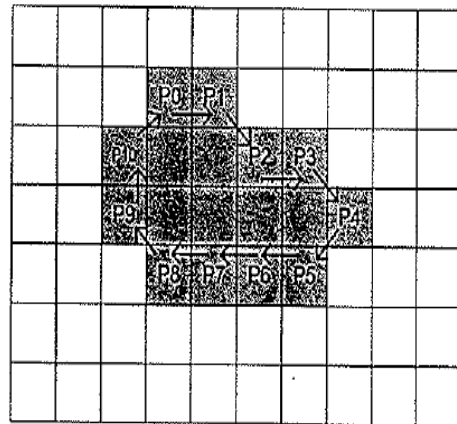


Figure 9: Sample of Inner Boundary Tracing

Equation for finding the length of perimeter can be calculation follow as

$$\text{Perimeter} = (\text{number of borders in direction } 0 \ 2 \ 4 \ \text{and } 6) + \dots \dots \dots \quad (\text{Figure 7})$$

$$+ \sqrt{2} \times (\text{number of borders in direction } 1 \ 3 \ 5 \ \text{and } 7)$$

From sample in figure 8 the borders in direction 0 2 4 and 6 including the border of pixel  $P_0$  to  $P_1$ , pixel  $P_2$  to  $P_3$ , pixel  $P_5$  to  $P_6$ , pixel  $P_6$  to  $P_7$ , pixel  $P_7$  to  $P_8$  and pixel  $P_9$  to  $P_{10}$ , all 6 borders. The borders in direction 1 3 5 and 7 including the border of pixel  $P_1$  to  $P_2$ , pixel  $P_3$  to  $P_4$ , pixel  $P_4$  to  $P_5$ , pixel  $P_8$  to  $P_9$ , pixel  $P_{10}$  to  $P_0$ , all 4 borders. Therefore, the length of perimeter of the figure 9 can be calculated as follow.

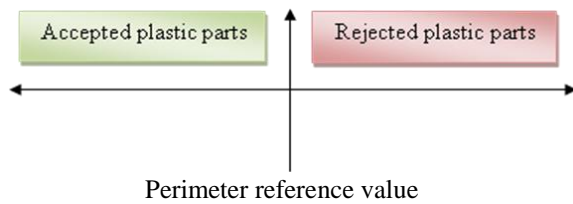
$$\begin{aligned} \text{Perimeter} &= 6 + (\sqrt{2} \times 5) \text{ unit} \\ &= 13.071 \text{ units} \end{aligned}$$

- Black dot dimension separating

The perimeter length was calculated to compare of perimeter value of black dot standard. To separated the type of black dot with the following classification as.

1. If length of black dot perimeter is less than reference value, the plastic part will be accepted.
2. If length of black dot perimeter is more than reference value, the plastic part will be rejected.





**Figure 10:** Range of perimeter reference value and plastic part separating

**4.2 Black dot perimeter reference value determinant**

The result of experiment by measure 30 accepted parts, found that their perimeters are nearly and the value are not much difference. The lowest reference perimeter is 7.900 units and the highest is 8.367 units.

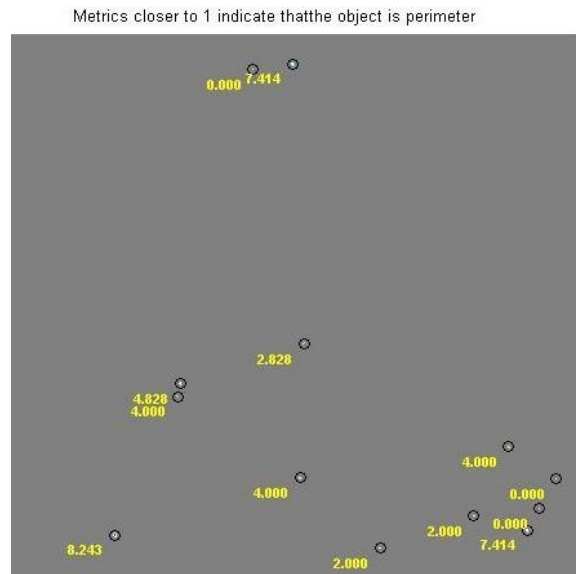
**4.3 Effectiveness testing of prototype program**

The 50 Plastic parts were taken to inspect by prototype program. Those figures had been picked from 1500 pieces following by random sampling plan, normal table AQL= 0.65% Level G-2. From this inspection it was apparent that the parts were separated correctly 100% and the program accurately calculated perimeter value also. By those reasons, the program can increase of effectiveness inspection as well.

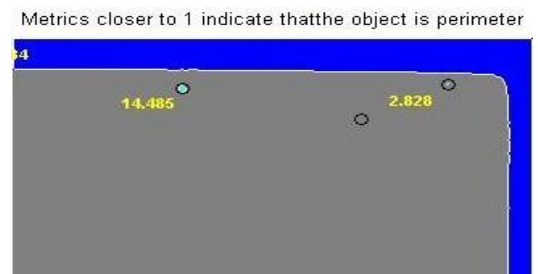
**4.4 Trail inspection program at incoming inspection**

**4.4.1 Program Testing by using at incoming inspection of GPV**

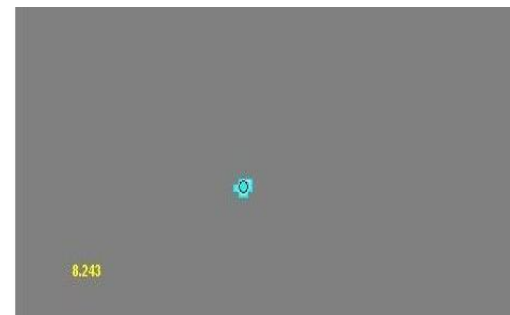
Due to prototype program testing, the black dot dimensions were measured correctly so the program is applied to use for GPV incoming inspection. The sample result of experiment as shown in the Figure 11. Following one month observation, the plastics parts 10,500 pieces from 14 lots were 100% checked as per work inspection of plastic parts model AS28114R except black dot inspection that were checked by the program. The accepted parts from this method will be marked inside of parts before send to manufacturing process. As a result the operators can detect parts at incoming inspection very lots and there is 0.11% or 12 over size black dot plastic parts escape to production line. From investigation, those parts were not inspection by the program.



(a)



(b)



(c)

**Figure 11:** The picture shown sample result of experiment by use image processing technique

**5 Conclusions**

The trial of using the program for a month, 14 lots of plastic parts from supplier were inspected by using image processing technique program for testing effectiveness of program, found that

1. The number of rejected parts was found at incoming inspection process is 840 pieces from 10,500 pieces which account for 8%.
2. The number of rejected parts was found in production line is 12 pieces or 0.11%

After that, the inspection program was applied to use at GPV incoming inspection and supplier final inspection. GPV checked following to random sampling otherwise supplier did 100% inspection. The record inspection data are 4 months, found that

1. The plastic parts form supplier was rejected by GPV 1 lot from 40 lots, that is 2.5 %
2. The rejected parts in production were found is 88 pieces from 36,220 pieces that account for 0.24% or 1,214.79 DPMO.
3. During these 4 months, the product model AS.ANA.FBA was sent to Ascom 10 lots, 8,500 pieces in total quantity. GPV had not had received complaint about black dot from Ascom.

From collection data for 4 months, the ratio of defect part is less than 0.14 at 0.05 significant levels, mean that inspection by image processing technique can detective parts better than inspection by film sheet. So the program can be used and applied to provide work instruction.

**5.1 Summary of comparing result of processing with project indicators.**

The comparison summary is shown in the table 3. According to the table 2 ,the result of this project are similar to project indicators but black dot on parts surface problem escape to production line is 0.24% or ratio of defect part per million is 1,214.79 DPMO.

**Table 3:** Result of black dot inspection by using program compare with project indicators

Detail	Defect	Indicators	Result
1. Number of rejected plastic model AS28114R, which found in production line.	73,017 DPMO	≤ 6,210 DPMO or quality level more than 99.379 %	1,214.79 DPMO
2. Number of customer complaint report from Asom to GPV	42,692 DPMO	≤ 6,210 DPMO or quality level more than 99.379 %	0

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