Crack Detection on Pressed Panel Products using Image Processing Techniques with Camera System

Hoyeon Moon[1], Hweekwon Jung[1], Changwon Lee[1], and Gyuhae Park[1*]

[1]*School of Mechanical Engineering of Chonnam National University, Gwangju, KS008, Korea*

Corresponding author gpark@chonnam.ac.kr*

ABSTRACT

The detection of cracks on panel products is a vital step for ensuring the quality of panel products. General crack detection technique has been performed by human inspectors who are good at detecting crack, which is spend many times and much money. Therefore, it is necessary to detect efficiently crack on panel products by machine vision system during the press forming process. In this study, we performed an automated crack detection using two image processing techniques with camera system. The first technique is evaluating the panel edge lines which are extracted from a percolated object panel image. This technique does not require a reference image for crack detection. Another technique is based on the comparison between a reference and a test image using the local amplitude mapping on the edge line image. The reference image of panel product is automatically acquired by camera system using image difference and time interval technique. As a result, cracks are efficiently detected using two crack detection techniques based on image processing. For demonstrating the proposed techniques, experiments were performed in the laboratory and the actual manufacturing lines. Experimental results show that the proposed techniques could effectively improve the crack detection rate with improved speed.

1. INTRODUCTION

Various mechanical parts are produced by sheet metals with several manufacturing processes, including press forming process. During the press forming process, sheet metals undergo large deformations in high speed, which may result in manufacturing defects such as cracks, necking, and side-wall wrinkles on products (Altan, 2007), (Kalpakjian & Schmid, 2014).

Detection of the crack on panel products during the manufacturing process is a vital step for ensuring the quality of panel products. General crack detection technique on pressed panel was performed by human inspectors. The detection rate of this technique depends on the skill and the experience of human inspectors. Therefore, the development and implementation of an automated and accurate crack detection technique is necessary during the press forming process.

Image based defect detection methods could provide several advantages over existing methods in the press line because they are non-invasive, accurate, and could easily implemented in the manufacturing line for crack detection (Chambon & Moliard, 2011). Image processing techniques are developed in order to detect surface damage on panel products, including rails, PCB panels, printed materials and LCD panels (Chauhan & Bhardwaj, 2011).

Therefore, in this study, we developed two crack detection techniques using image processing for pressed panel products. For demonstrating the proposed two detection techniques, several experiments were performed with low-cost commercial camera systems in the laboratory and in the real-press lines.

2. TWO CRACK DETECTION TECHNIQUES

2.1. Crack detection technique without base image

This technique consists of four steps shown in Fig. 1. The manufacturing process, images are acquired utilizing a camera system which is installed in a press line as the first step. In the second step, the panel product as an object is extracted from backgrounds by considering the statistical distribution of color pixels (Otsu, 1975). After then, the acquired image is transformed to a binary image, which consists of two components of backgrounds as a zero and object of interest as a one. In the third step, a percolation model (Hussain & Reed, 1997), (Yamaguchi & Hashimoto, 2010) is used to extract edge lines of the object. In the last step, the extracted edge lines of the object are analyzed by tracking the angles of edge lines. If panel products contain no crack, they have smooth variances of edge-line angles. However, when a crack occurs in a panel product, it has a sudden and an acute variance of the edge-line angle, as shown in Fig. 2. While tracking the edge lines, the relative angle variances are analyzed and evaluated at each point of the line to detect and localize the defects.

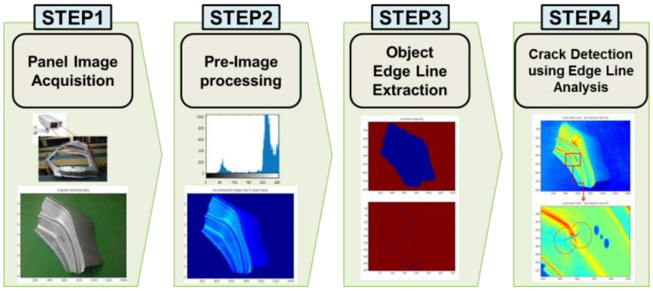


Figure 1. Crack detection procedure without base image

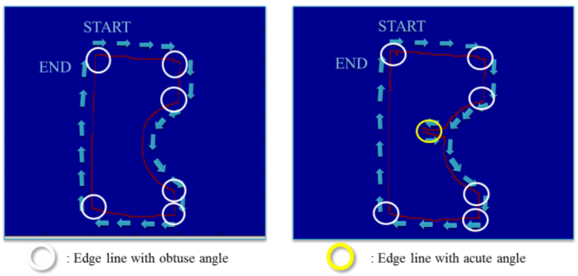


Figure 2. Edge line analysis for crack detection

2.2. Crack detection technique with base image

This technique also consists of four steps shown in Fig. 3. The same as in section 2.1, the pressed panel image is acquired utilizing a camera system. In the second step, the panel image is converted to a gray scaled image for fast image processing. To reduce the noise components caused by the shadow and light effect, wiener filtering is applied to normalize the value of certain pixel based on the neighborhood pixels. After the filtering process, the edges of panel are conserved but the shadow and the difference of light are filtered out. Sobel mask is then applied to filter the image for edge line image generation. If panels are precisely aligned, a pixel by pixel subtraction results in large errors, which causes a false positive indication. Therefore, the local image amplitude map is constructed by segmenting the image by window (Amano, 2006), as the third step (Fig. 4.). In the last step, the crack is detected and localized by subtracting the map between the base and test images. During this step, the size of a local window is determined by considering the size of cracks and the degree of image misalignment. .

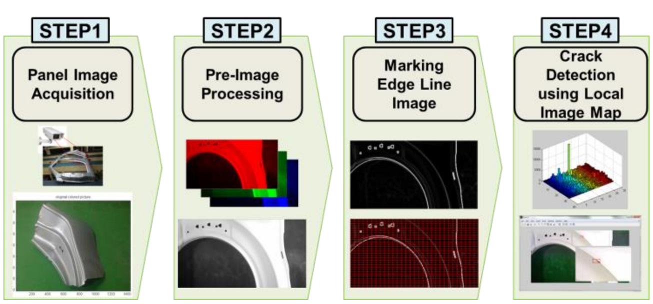


Figure 3. Crack detection procedure with base image

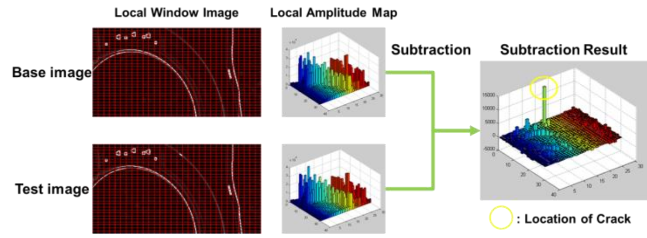


Figure 4. Local image amplitude map for crack detection

3. EXPERIMENT & RESULTS

Experiment was performed to verify two proposed techniques on a real-press line. For this experiment, we use a USB webcam as an image acquisition device (Fig. 5). MATLAB and Intel 7th i7 (4.2GHz) with OS window 10 and 16GB RAM was used as a signal processor. The object is the rear part of a washing machine with the size of 68 x 43 cm. The actual resolution of the video is 720 x 370 pixels, which is capture by the video frame rate of 30 fps. For the test, the resolution is cropped 573 x 323 pixels.

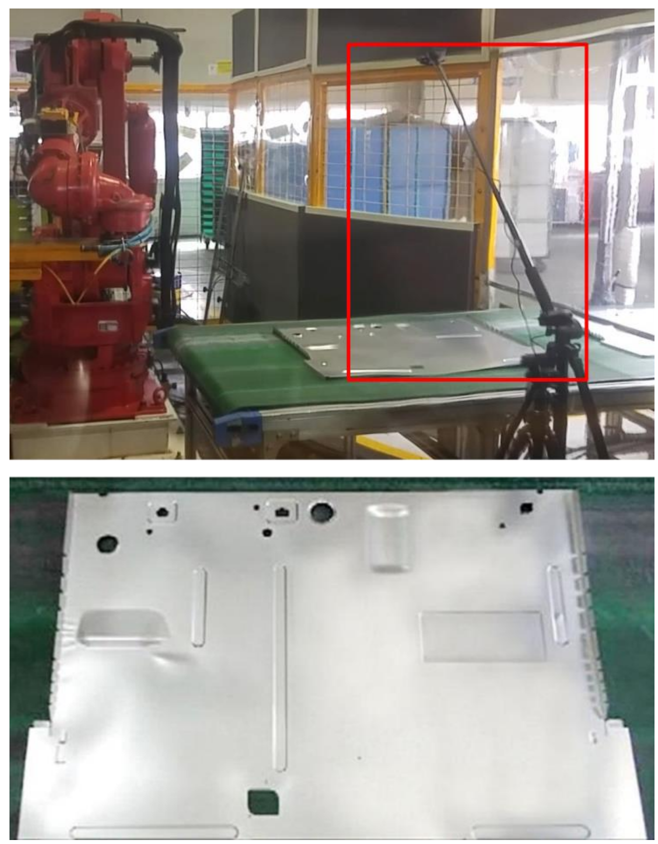
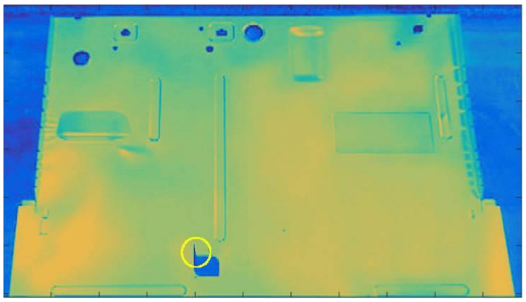


Figure 5. Experiment setup and acquired panel image

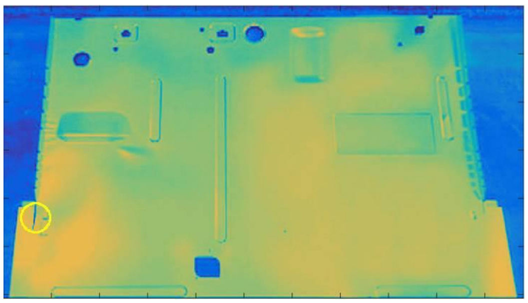
During this experiment, there is no defective product produced. Therefore, three different types of cracks are simulated with different sizes and locations. Simulated crack sizes are 2.72 x 0.272 cm, 3.53 x 0.272 cm, and 3.14 x 0.272 cm.

3.1. Experiment results of edge line analysis

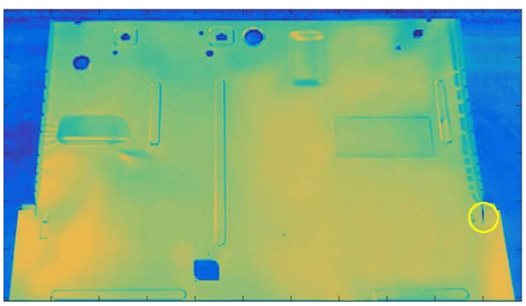
For this technique, we use the averaging filter before applying Otsu's method and set the threshold angle to 70 degree. The results of this method are shown in Fig. 6.



(a) Crack(2.72 x 0.272 cm) detection result



(b) Crack(3.53 x 0.272 cm) detection result

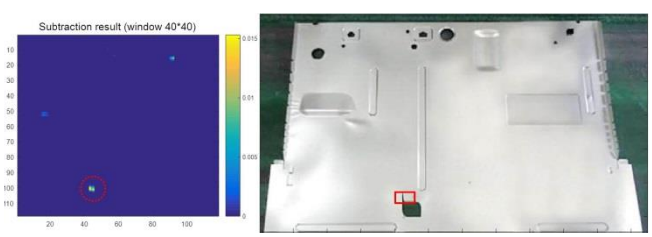


(c) Crack(3.14 x 0.272 cm) detection result

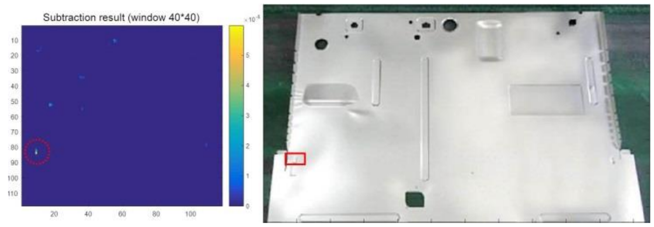
Figure 6. Crack detection result using edge line analysis

3.2. Experiment results of local image amplitude map

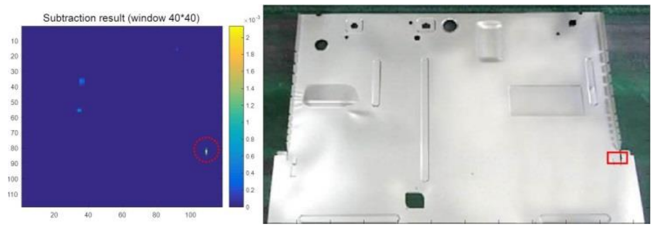
For this technique, we set the local window at 40 x 40 and the threshold of image amplitude at 0.1E-6. The results of this technique are shown in Fig. 7.



(a) Crack(2.72 x 0.272 cm) detection result



(b) Crack(3.53 x 0.272 cm) detection result



(c) Crack(3.14 x 0.272 cm) detection result

Figure 7. Crack detection result using local image amplitude map

4. CONCLUSION

This research proposed two crack detection techniques with image processing for fast and automated crack detection on pressed panel products. The first crack detection technique does not require the base image using the edge line analysis. Another proposed crack detection technique requires the base image in undamaged using the local image amplitude map. In order to apply in the real-field applications, further research should focus on improving the image processing with statistical analysis.

ACKNOWLEDGEMENT

This research was supported by Basic Science Research program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (2015-2628). This work (C0396927) was also supported by business for Cooperative R&D between Industry, Academy, and Research Institute funded Korea Small and Medium Business Administration in 20.

REFERENCES

Altan, T. (2007). Dissecting defects Part I : Examining process variables to find stamped part quality flaws. *Stamping Journal*.

Amano, T. (2006). *Correlation based image defect detection*. Paper presented at the 18th International Conference on Pattern Recognition (ICPR'06), Hong Kong.

Chambon, S., & Moliard, J.-M. (2011). Automatic road pavement assessment with image processing: Review and comparison. *International Journal of Geophysics*, *2011*.

Chauhan, A. P. S., & Bhardwaj, S. C. (2011). *Detection of bare PCB defects by image subtraction method using machine vision.* Paper presented at the Proceedings of the World Congress on Engineering.

Hussain, I., & Reed, T. R. (1997). A bond percolation-based model for image segmentation. *IEEE transactions on image processing*, *6*(12), 1698-1704.

Kalpakjian, S., & Schmid, S. (2014). *Manufacturing Processes for Engineering Materials* (5 ed.).

Otsu, N. (1975). A threshold selection method from gray-level histograms. *Automatica*, *11*(285-296), 23-27.

Yamaguchi, T., & Hashimoto, S. (2010). Fast crack detection method for large-size concrete surface images using percolation-based image processing. *Machine Vision and Applications, 21*(5), 797-809. doi:10.1007/s00138-009-0189-8