Verification of Measurement System for Shearography Machine

JIRAPHON SRISERTPOL[1], PAPHAKORN SOONANON[2], PREECHA CHAMPATHONG[1] AND SORADA KHAENGKARN[1]
[1]School of Mechanical Engineering, Institute of Engineering
[2]School of Industrial Engineering, Institute of Engineering
Suranaree University of Technology
111 University Avenue, Muang District, Nakhon Ratchasima, 30000
THAILAND
jiraphon@sut.ac.th

Abstract: - A shearography machine is a Non Destructive Testing machine to inspect an internal crake of tries in which a defect is shown by Shearography image analysis. For this machine, a camera head position and a level of vacuum are two importance parameters to check defects. These are always shifted during machine operation. So those parameters have to be adjusted before staring test which time is consumed. In order maintain the quality of shearography image analysis, this paper presents a system to verify a quality of measurement via the camera head positions and the vacuum pressure level inspection for Shearography machine. A verify block is used to calibrate a true size of internal crake and the system is established base on LabVIEW. For this study, there are two cases of conditions that affect to the measurement size of internal crake: camera positions (a vertical, a horizontal and a spindle axis) and the level of vacuum. The results showed that the camera head positions and the level of vacuum are involved to the size of the internal crake.

Key-Words: - Shearography, Computer Vision Processing, Measuring System and LabVIEW®

1 Introduction

A quality of part is an important to not only satisfies customer need but also to respond social community, especially a high precision product such as aircraft components produced at high level of product quality. Since a value of aircraft component is high, this business needs a high quality checking with a reasonable cost. However, the high precision checking is also time consuming process. In order to reduce time of quality checking process and avoid to damage component, therefore, a non-destructive testing equipment has been introduced. A Shearography is non-destructive testing equipment that is used to check an internal crack of part. This equipment operates based on an interferometric concept. Its output is shearogram images that show an invisible crack inside component. In practice, this tool has to be always checked initial conditions, such as a level of vacuum pressure and a position of camera, before testing product. These conditions are influence to shearogram image that presents erroneous dimension of internal crack. In order reduce error, shearography had to be calibrated by capturing at least sixteen images which quality cost and time are consume. Additionally, a specialist is needed to operate.

This paper presents a calibration process to verify a measurement system of Shearography by applying a concept of computer vision process[1]. This process is implemented based on LabVIEW program. A concept of this process is to determine initial conditions of measurement system of Shearography by using gage block that contains a known dimension of internal crack. Then, the relative parameters between the initial conditions of measurement system and shearogram image are calculated. These parameters can be used as a range to calibrate equipment. In this paper, a position of Shearography camera (horizontal axis and vertical axis), a vacuum level and machine coefficient are studies.

2 Related works

A digital image of Shearography has to be used for several proposes such as to determine strain and flaw of cellular thin surface based on a assigned load[2], to analyze a biological of cell and issue[3], to measure dimension and identify surface area of object based on pixel of digital image [4-9].

2.1 Principal of digital shearography

Shearography is a non destructive testing method to identify internal crack or flaw of component. This technique apply concept of interferometic [10], as

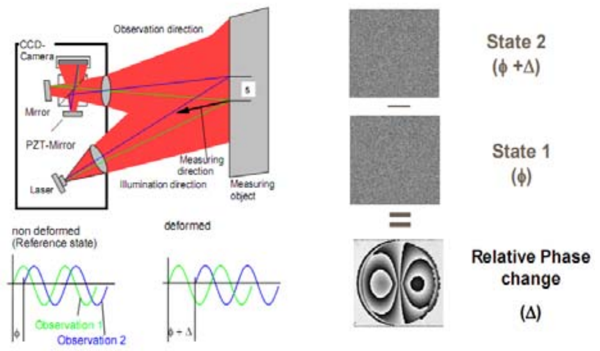

Figure 1: Principal of Shearography

shown in figure 1. Shearography is a non destructive testing method to identify internal crack or flaw of component. This technique applies concept of interferometic, as shown in figure 1.

A digital image from shearography, as shown in figure 2, presents surface of object that obtains load as butterfly pattern. Since a size of internal flaw captured by shearography is different from an actual size of gage block, the coefficient between digital image and the actual size is established, as follow:

$$\text{Real Size} = \text{Size measurement on image} \times R_m \times R_d \qquad (1)$$

where R_m is machine coefficient and

$$R_m = \frac{\text{Size of Surface Distortion}}{\text{Size of Image Distortion}} \qquad (2)$$

Rd is strip coefficient and

$$R_d = \frac{\text{True Size}}{\text{Size of Surface Distortion}} \qquad (3)$$

To identify the real size of internal crack, Rm and Rd have to be determined. Additionally, theses parameters are depended upon two main factors; a position of shearography camera and amount of load, as shown in figure 3. The ranges of camera movable and the level of vacuum are presented in table 1.

Table 1. The ranges of shearography camera

Parameter	Minimum	Maximum	Unit
Vertical Axis	-280	+690	Millimeter
Horizontal Axis	-600	+600	Millimeter
Tilt Axis	-45	+115	Degree
Vacuum level	0	180	Milli-Bar

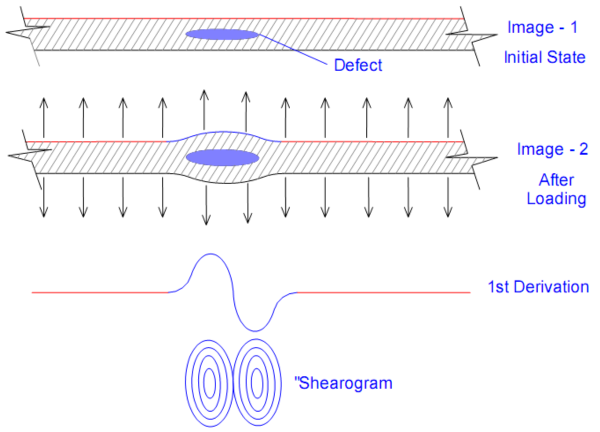

Figure 2: Butterfly pattern

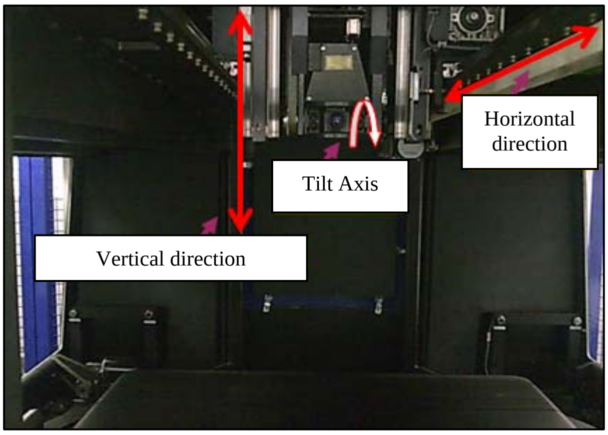

Figure 3: Direction of camera movable

3 Experiment

3.1A system of shearography image processor using LabVIEW

A system of image processing from shearography image and a process of internal crack measurement are implemented based on LabVIEW, as shown in figure 4. In this system, user can select to operate into two modes: automatic mode and manual mode. This system needs three images of shearography to determine an average size of internal flaw. For each measurement, the acceptable range is presented by a green LED light while the unacceptable rang is shown by a red LED light. A control panel of this system is shown in figure 5 and its block diagram is established in figure 6.

3.2 Experimental

In this study, the positions of camera and load are investigated to measure size of internal cracks. The camera is adjusted to new position within acceptable range. Then, the system captures twenty

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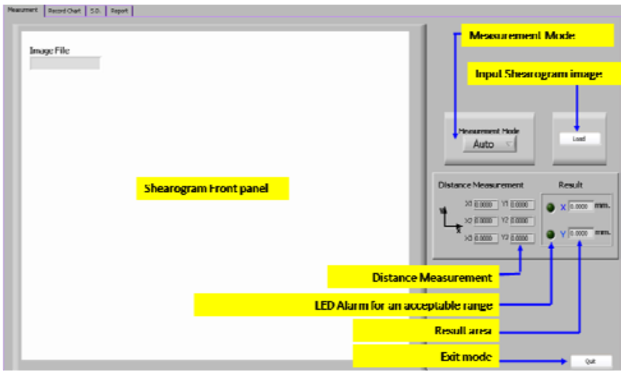

Figure 5: Front panel of calibrate program

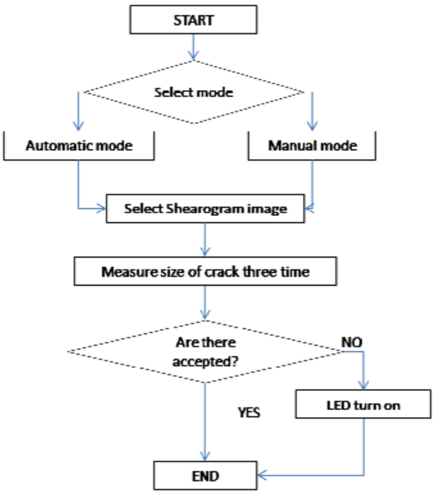

Figure 6: Flow chart of calibrate program

shearography images on each position to determine the average size of internal crack. The parameter of experiment is designed as shown in table 2.

Table 2: Experimental design

Position of camera	Acceptable range	Adjust range	Number of images
Vertical axis	300-400 mm.	20 mm.	20
Horizontal axis	380-430 mm.	5 mm.	20
Tilt Axis	80-90 degree	2 degree	20
Vacuum level	30-100 mBar	10 mBar	20

4 Result

The sizes of internal crack before applying R_m and R_d were measured, as shown in table 3. Then, R_m and R_d were calculated and applied to measurement system and the sizes of internal crack are shown in table 4.

Table 3: Size of internal crack before applying R_m and R_d

No.	Size of internal crack (Pixel)	Size of internal crack (Pixel)	No.	Size of internal crack (Pixel)	Size of internal crack (Pixel)
1	83.0020	69.4496	11	81.1651	67.0057
2	84.3554	69.0561	12	83.5728	66.0804
3	84.3713	68.4350	13	84.0517	68.3838
4	84.3713	68.4704	14	83.2613	68.1762
5	81.8036	67.0060	15	84.1212	68.4924
6	83.5687	66.0791	16	84.3394	68.4974
7	83.8588	68.0236	17	84.6737	68.9005
8	84.3928	67.7767	18	84.2855	68.5678
9	84.9855	68.0624	19	84.6615	68.7250
10	84.4205	67.8569	20	84.4415	67.8607
			Mean	83.8852	68.0453

Table 4: Size of internal crack after applying R_m and R_d

No.	Size of internal crack (mm)	Size of internal crack (mm)	No.	Size of internal crack (mm)	Size of internal crack (mm)
1	40.2535	40.0415	11	39.7240	39.8694
2	39.0285	39.1851	12	40.1342	40.0543
3	39.8706	38.6430	13	40.2383	40.0573
4	40.0090	39.7802	14	40.3978	40.2930
5	40.2638	39.6358	15	40.2126	40.0984
6	40.0695	39.8029	16	40.3920	40.1904
7	40.2770	39.6827	17	40.2871	39.6849
8	38.7239	39.1849	18	40.0671	40.6141
9	39.8726	38.6438	19	40.2660	40.6035
10	40.1011	39.9908	20	40.2638	40.6035
			Mean	40.0226	39.8330

From the experiment, the average sizes of internal flaw were presented as follow:

$$X_{axis} = R_m \times R_d = \frac{\text{True Size}}{\text{Size of Image Distortion}} = \frac{40}{83.8352} = 0.4771$$

$$Y_{axis} = R_m \times R_d = \frac{\text{True Size}}{\text{Size of Image Distortion}} = \frac{40}{68.0453} = 0.5878$$

Sizes of internal crack based on camera positions and vacuum level are shown in figure 7-10.

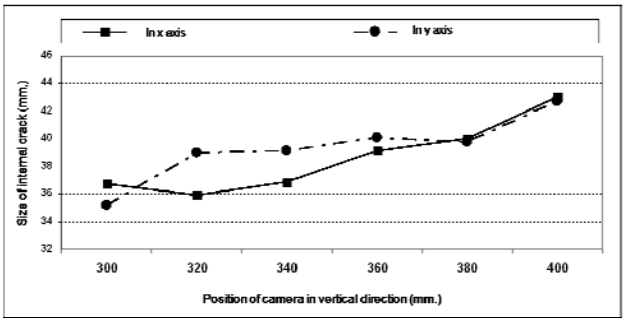

Figure 7: Sizes of internal crack based on camera position in vertical position

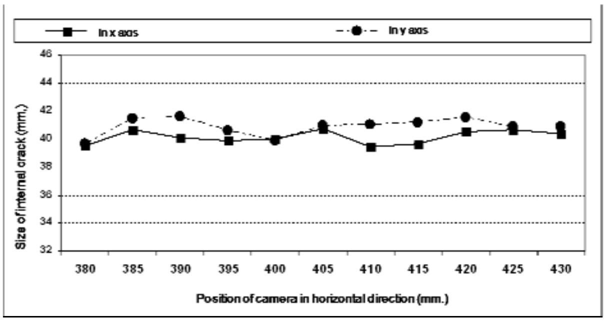

Figure 8: Sizes of internal crack based on camera position in horizontal position

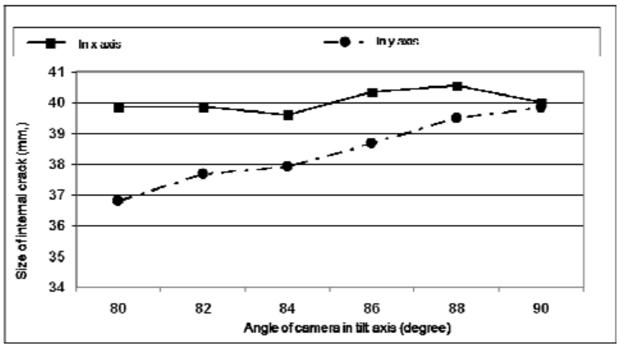

Figure 9: Sizes of internal crack based on camera position in tilt axis

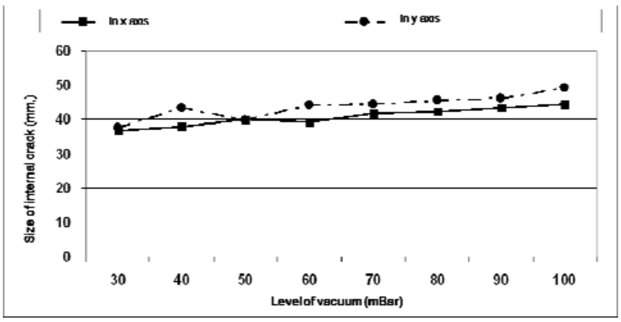

Figure 7: Sizes of internal crack based on level of vacuum

From the experimental result that are averaged from twenty acquired data, the component size was determined that are $\overline{x} = 40.0226$ mm., $\overline{y} = 39.833$ mm., $S_x = 0.4326$, $S_y = 0.5681$. Therefore, the suitable positions of camera at the confident 99% with nineteen degree of freedom $t_{19,99}$ are determined as follows:

$$x_i = \overline{x} \pm t_{v,p} S_x \qquad (99\%) \qquad (4)$$

$$x_i = 40.0226 \pm (2.861 \times 0.4326)$$
$$= 40.0226 \pm 1.2377 \text{ mm. } (99\%)$$

$$y_i = 39.833 \pm (2.861 \times 0.5681)$$
$$= 39.833 \pm 1.6253 \text{ mm. } (99\%)$$

Then, the range of camera to capture shearogram image are $38.7849 \le x \le 41.2603$ mm. and $38.117 \le y \le 41.4583$ mm. The optimum positions of camera are as follows:

- Horizontal position +405 mm.
- Vertical position +380 mm.
- Tile axis 90 degree
- The level of vacuum 50 mBar.

5 Conclusion

The calibration process of Shearography measurement system is presented in this paper. By applying a concept of computer vision process, only one image sector can be used to measure internal crack, comparing with the conventional process that at least sixteen images are needed to calibrate shearography camera which the time is consumed and specialize person is required. By using the proposed process, the quality checking process is improved as a movable range of camera is limited. Additionally, a new user can implements without trail error process that processing time can be also reduced. The future study is to apply with an online process in order to implement in real process.

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