Research Progress in Mechanical and Manufacturing Engineering Vol. 4 No. 1 (2023)
181-187

RPMME

Homepage http://penerbit.uthm.edu.my/periodicals/index.php/rpmme
e-ISSN : 2773 - 4765

Defect Size Comparison Using Infrared Thermography Method and Actual Measurement On Glass Fiber Reinforced Polymer

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DOI: https://doi.org/10.30880/rpmme.2023.04.01.019
Received 15 Dec 2022; Accepted 31 Mac 2023; Available online 1 June 2023

Abstract: Three types of specimens have been inspected using Infrared thermography, one of the specimens is perfectly patched without any defect in the specimen, and the remaining two specimens have defects during patching. The active infrared thermography approach is used by using a heat gun on the surface of the specimen at a temperature of 200°C. The thermal image for specimen B1 shows no defect occurring while specimens B2 and B3 show defects in the specimen. The defect dimension in the thermal image is measured using ImageJ software after being analyzed in FLIR Tools software. The surface of the specimens have been ground to reveal the defect and actual dimension have been measured for comparison. The result of the comparison dimension defects were being analyzed and explained in this study.

Keywords: Non-Destructive, Infrared Thermography, Glass Fiber Reinforced Polymer, FLIR Tools, ImageJ

1. Introduction

A composite material is described as a mixture of materials including one or more different component elements that, when combined, generate a material that is stronger, stiffer, tougher, and more durable than each component itself. Fibre Reinforced Polymer(FRP) parts have been widely attractive in the aerospace, automotive, marine, oil and gas, and civil construction industries in recent years. This study is aimed at Glass Fibre Reinforced Polymer (GRFP) which has lightweight, has a specific strength, stiffness, and fatigue resistance, and also can withstand severe loads and provide great impact resistance [1]. The infrared thermography technique has received extra interest and is broadly popular as a situation-tracking device due to its excessive sensitivity and precision imaging characteristics as noted before. Consequently, this technique is

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useful because of its numerous blessings as proposed by [2]. However, infrared thermography still has its weaknesses too in phrases of cost, accuracy, and capabilities to address the device. This became proposed within side the journal by [3]

The desire for lighter and quicker boats, as well as boats with minimal environmental effects, has pushed the usage of fiber-reinforced plastic (FRP) materials or composites in the marine sector, lowering the use of metals like steel and aluminium. Layers of multi-axial fiberglass textiles bonded with resin matrix make up a typical composite, which provides great strength and stiffness in several directions. Corrosion resistance, fuel economy, and magnetic signature were all enhanced using composites [4]. The boat is one of the marine sectors made of Glass Fibre Reinforced Polymer and it also can be slightly damaged because of heavy-duty or accidentally hit a hard thing. The boat has been repaired but the boat has a defect in the repaired area because of bad repair work. The defect cannot be seen because the defect is in layers.

The objectives of this research are to identify the presence of a defect on patched Glass Reinforced Fiber Polymer (GRFP) by infrared thermography. The study also verified the actual dimension and sizing of the defects and compare the size between the result from the thermography image and the actual dimension.

2. Methodology

There are approaches for measuring the temperature. Firstly is via way of means of taking the precise analysis of temperature values of the goal objects that's referred to as quantitative [5] The second manner is qualitative which takes the relative temperature values of a hotspot with respect to different elements of the system with alike conditions [6].

2.1 Equipment and Specimen

The specimen used was three types of glass fiber reinforced polymer (GFRP) with the size 200 mm x 200 mm x 7 mm with a different defect. Generally, the method of non-destructive testing which is active infrared thermography would be applied on the surface of the GFRP to get the thermal image. All the data was collected repeatedly into 10 images for each trial. The equipment used was a FLIR T640 camera to collect the image data and a heat gun was used to give heat to the surface. The measurement tool used in this experiment was Vernier caliper and ImageJ software.

2.2 Methodology

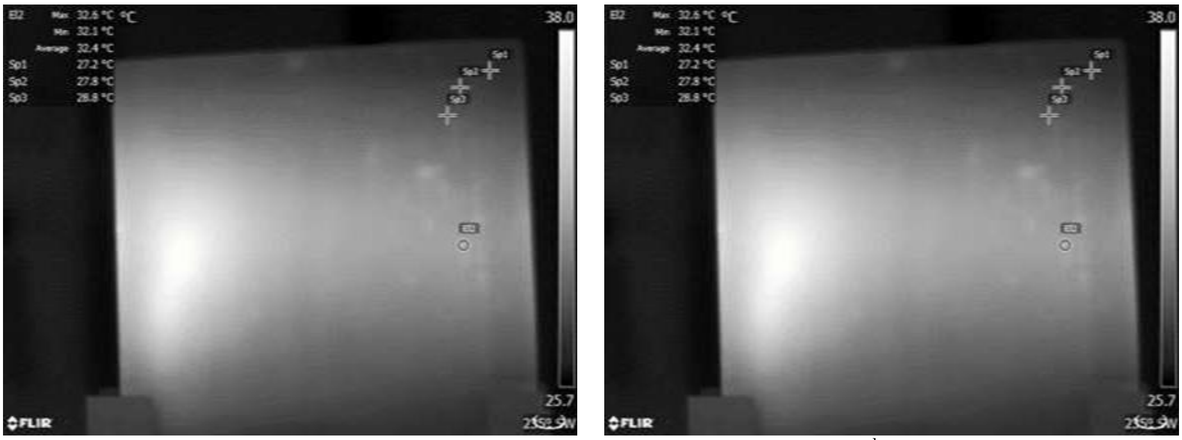
The infrared camera is positioned properly in front of the target object to be inspected without any obstacle in between them. Before starting, make sure the environmental conditions must be approving for accurate temperature measurement. The acquired thermal images are displayed on the monitor and will be virtual colour coded which makes the interpretations easier and quicker. [7] To get a thermal image, the heat gun was blown with hot air at a set temperature of 150°C until 200°C to the surface of the specimen for 30 seconds. Next, the thermal image of the specimen is captured and recorded using an infrared thermography camera. The image is transferred into the computer to be analysed using the thermal imaging filtering technique via FLIR Tools software. This analysis is performed to identify the hot spot and defect area by identifying the thermal pattern. The severity level of the defect in the specimen is then determined using the temperature difference assessment method. Data from FLIR Tools analysis was transferred to ImageJ software to measure the size dimension of the defect. To reveal the defect, hand grinder is used to reveal the defect, and is measured using a Vernier caliper.

3. Results and Discussion

The purpose of this analysis is to use temperature measurement derived from an infrared camera to detect defects that occur in the specimen plate of GFRP. This study will only focus on getting the dimension of the defects to be compared with the actual size of the defect. There are three specimens with a different specimen which is B1 is perfectly repaired and supposedly should be no defect when using infrared thermography. While, specimens B2 and specimen B3, are not repaired properly and the surface of the specimen an uneven surface.

3.1 Thermal image of specimen B1

The most important is the first specimen B1 because it is perfectly repaired and should be no defect when collecting data using an Infrared camera. The analysis from thermal inspection results for specimen B1 using FLIR Tools software is shown in Figure 1 two image trials from 10 images. The red color in the image indicates an area of higher temperature in the specimen plate. There is no defect occur in the thermal image because the result of the sample patch is done perfectly.

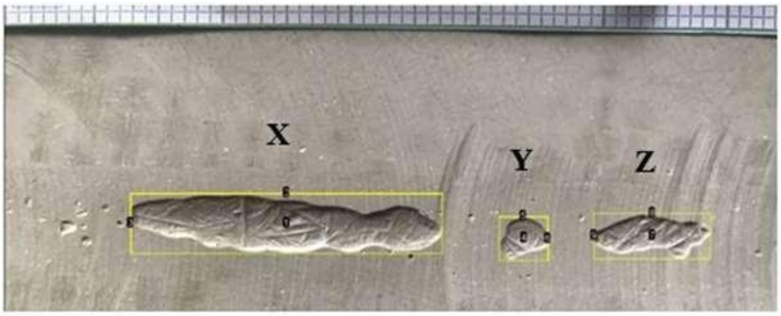


(a) 1st Trial (b) 2nd Trial

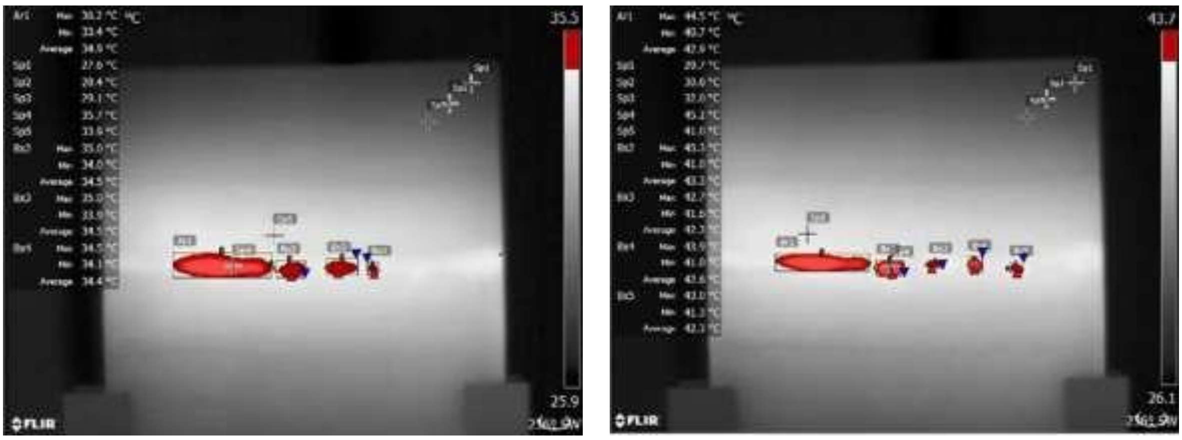
Figure 1 Thermal image specimen B1

3.1 Thermal image of specimen B2

Based on Figure 2, is an analysis of thermal inspection results for specimen B2 using FLIR Tools software. To reveal the defect from the raw image, the temperature “limit above” was used and the temperature was selected based on the temperature around the defect to obtain the temperature difference. The increment of the temperature limit is 0.2°C was used to get the area of defect based on the temperature difference.



(a) Defect in Specimen



(b) 1st Trial (c) 2nd Trial

Figure 2 thermal image of B2

The graph in Figure 3 analyses defects X in the B2 specimen result between actual measurement and trial. Trial 6th, 7th, and 8th have longer measurement compared to the actual which is 57.09 mm, 60.77 mm and 62.06 mm. for the vertical measurement most of the trial is bigger than the actual measurement.

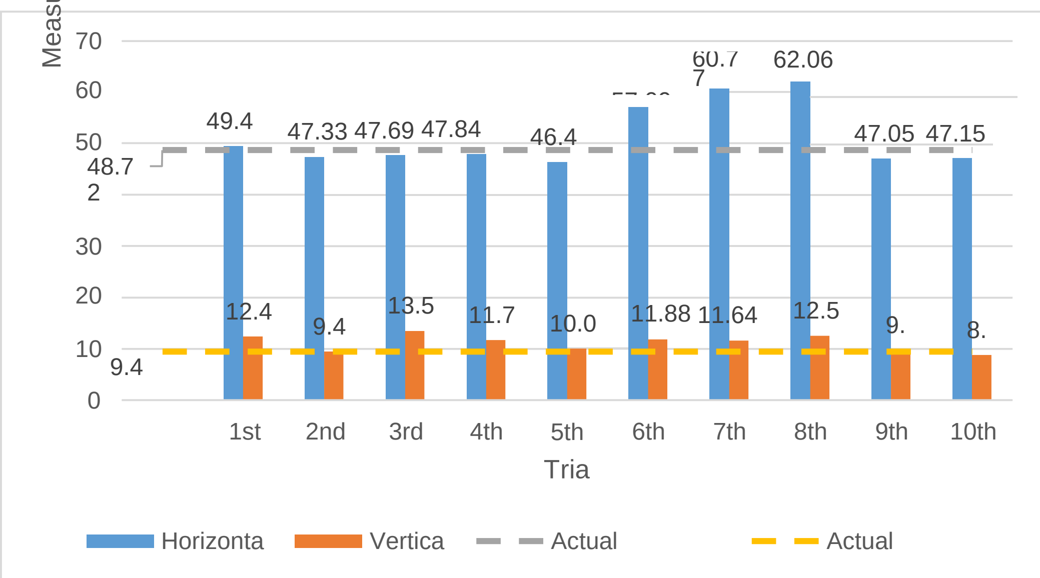


Figure 3 Analysis defect X in B2 specimen result between actual measurement and trial

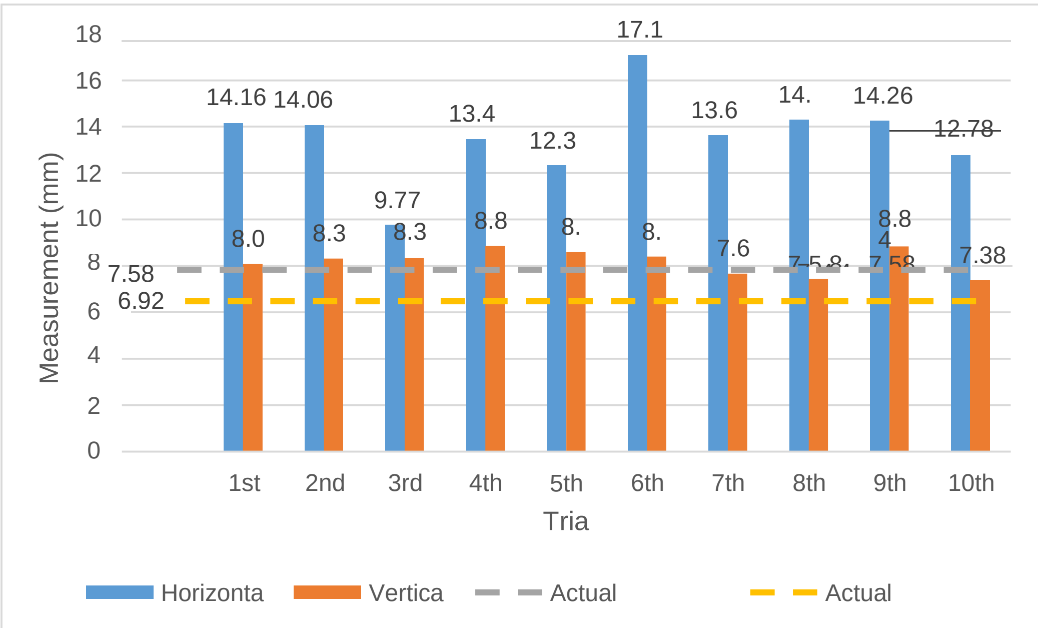


Figure 4 Analysis defect Y in B2 specimen result between actual measurement and trial

Figure 4 shows the graph analysis of defect Y in the B2 specimen result between the actual measurement and trial. Trial 6th has the longer length and trial 4th has the highest vertical measurement between them. Most of the trial measurement has a bigger amount of trial between actual dimension. It happened because the temperature of each of the thermal images from the FLIR camera is not the same temperature besides the filtering process or the analysis process to reveal the defect using increment 0.2°C.

Figure 5 shows the analysis defect Z in the B2 specimen between the actual measurement and trial.

Most of the horizontal measurement has longer measurement than the actual measurement while most of the vertical measurement has lower measurement compare to the actual measurement which is 7.12 mm. The 7th trial has no value because, in the thermal image, the defect did not occur and cannot be differentiated from the temperature with temperature around the area defect.

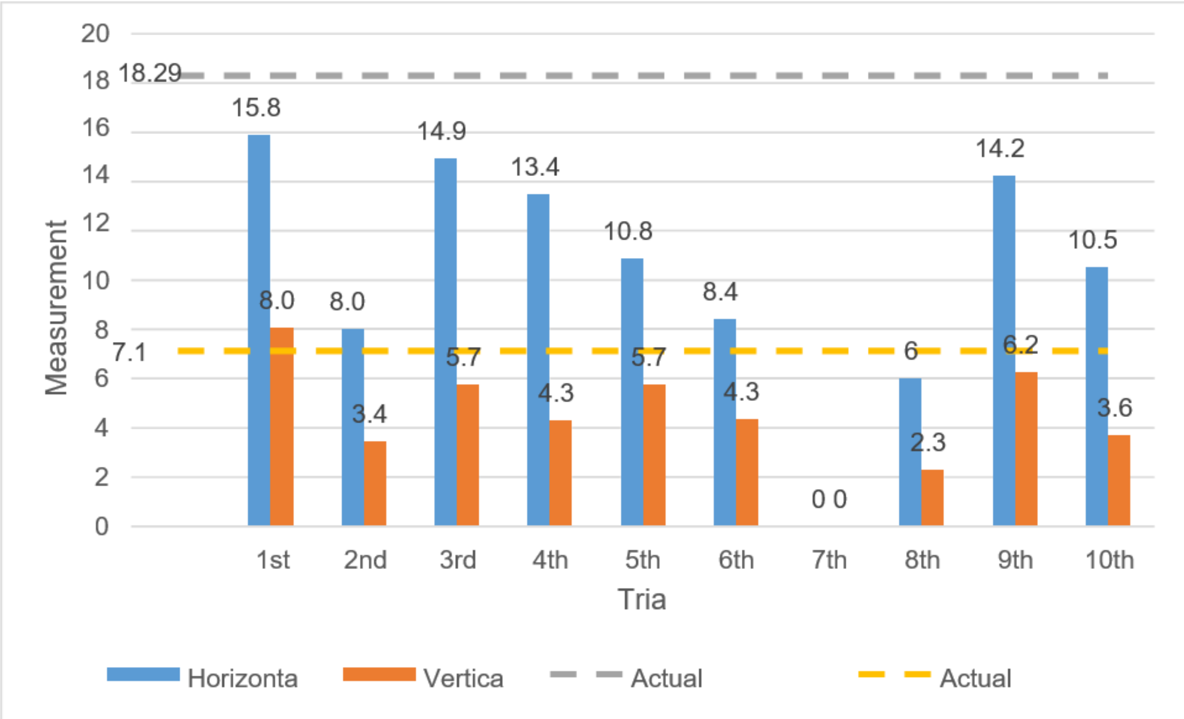


Figure 5 analysis defect Z in B2 specimen result between actual measurement and trial

3.2 Thermal image of specimen B3

In Figure 6, trials 5th 8^{th,} and 10th occurred in another higher temperature area because the surface of the specimen is a bit higher and received more heat while blown by a heat gun. The area is not been measured because it is not a defect and not all images have such defects

(a) 1st Trial (b) 2nd Trial

Figure 6 Trial Infrared thermography of B2

Figure 7 shows the graph analysis defect B3 specimen result between the actual measurement and trial. Actual measurements for Horizontal show significantly different compare to trial measurements. The depth of the defect is not uniform which is the deepest depth for the defect is 1.04 mm to 1.58 mm. in the thermal image, it cannot detect the actual measurement of horizontal dimension which is only 46.5 mm to 56.44

mm while the actual measurement is 200.64 mm.

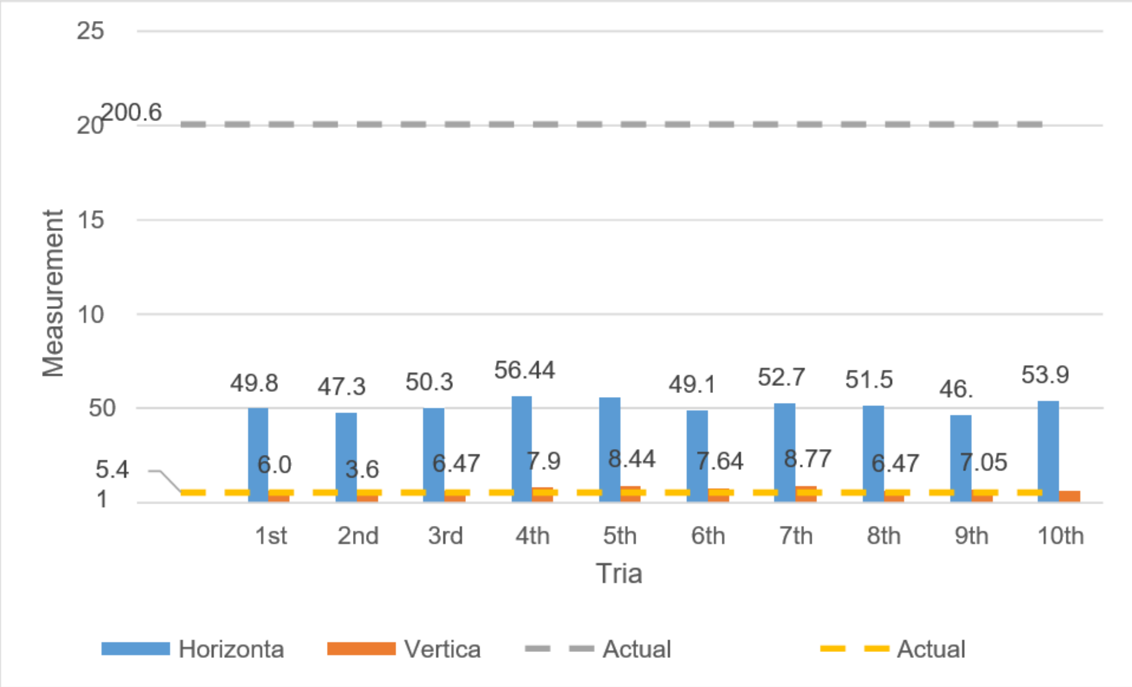


Figure 7 Graph analysis defect B3 specimen result between actual measurement and trial

4. Conclusion

Generally, this study has shown that by using the Active Infrared thermography method there are defects present in the specimen but not all the defects can be detected. Thermal image has been analysed in the FLIR Tools to reveal the defect using temperature differences on the surface of the specimen. Dimension from a thermal image is not as precise as the actual dimension. The data were taken in 10 trials and each trial had seven images and only one image have been selected based on the clear image. The dimensions of each defect have been measured using ImageJ software to compare between actual dimensions which have been measured using Vernier caliper.

The second objective has been achieved by comparing the actual measurement of defect and measurement from the thermal image. The defect X in specimen B2 with an average of 51.28 mm for horizontal measurement and 11.18 mm for vertical measurement while the actual measurement for horizontal and vertical is 49.62 mm and 9.06 mm. Defect Y in the B2 specimen has average measurement for horizontal and vertical is 15.02 mm and 8.19 mm while the actual measurement is 8.00 mm and 6.22 mm. For defect Z in the B2 specimen average measurement of horizontal and vertical is 10.24 mm and 4.40 mm while the actual measurement is 19.34 mm and 6.80 mm. for the last defect in specimen B3, the average measurement of horizontal and vertical is 56.43mm and 6.80 mm while the actual is 200 mm and 6.70 mm. Based on the data comparison, it can be concluded that the measurement from the thermal image that has been measured using ImageJ software has an uncertainty which is ±9.1 mm.

Acknowledgment

This research was made possible by funding from research grant number H774 provided by the Universiti Tun Hussein Onn Malaysia. The authors would also like to thank the Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia for its support.

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