

Quantitative Analysis of Defects in Composite Materials using Thermography Software

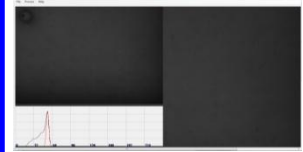
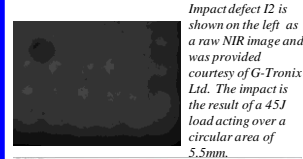
Keywords: thermography software, composite materials, defect detection, Full-Width Half Maximum (FWHM)

Quantitative Analysis of Defects in Composite Materials by Thermographic Software

Statistical and algorithmic thermography software techniques are used in the analysis of thermographic images in order to give quantitative analysis of the image data to automatically detect potential defects using techniques such as the Full Width Half Maximum (FWHM) approach. The analysis concentrates on impact damage in composite materials because it is highly relevant to the transport industry. Composite materials are, in turn, increasingly being used for surface transport such as buses, trucks, trams and trains. The benefits of using composite materials over conventional materials like steel and aluminium are that they offer the potential for higher strength and stiffness together with superior corrosion immunity, lower weight and a reduction in cost. However, composite materials are particularly susceptible to impact damage that may not be visible to surface inspection, hence, the importance of NDT techniques like thermography and quantitative analysis to give a 'real' size to any potential flaw.

Aim of Quantitative Analysis of Defects in Composite Materials by Using Statistical Methods

The purpose of [Kingston Computer Consultancy's](http://www.kcccltd.com) (KCC) involvement is to develop software that is intuitive for inspection engineers to use, can profile different defect types and can automatically detect, and ideally characterise, potential defects in inspected composite materials. In particular, this case study relates to the extension of requirements to include quantitative analysis of the thermography based image data through the Full Width Half Maximum (FWHM) approach.

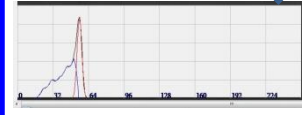


Histogram of greyscale across image of I2

Greyscale values for the complete image



Selective Gaussian distribution (red)

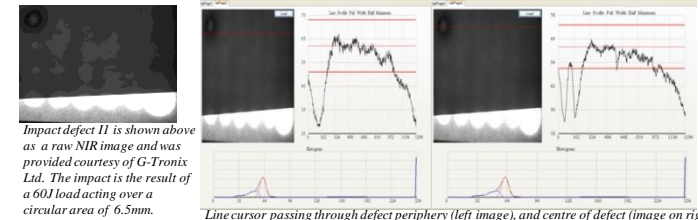


Range of greyscale values of interest (blue)

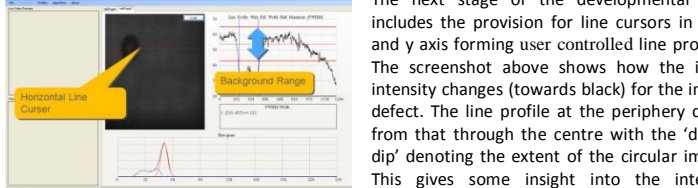
Statistical Analysis of Image

The first stage of statistical image analysis focused on separating areas of potential defect from the image background where there is no anomaly. The focus was to identify impact damage. The method adopted involved analysis of the greyscale spread for the complete image. This enables us to filter out the background information that we do not need. However, the distribution of greyscale values was not even about the modal value. Hence, a selective Gaussian distribution was used to model the image data in order to identify and separate the modal value so that some sense can be made out of the unevenness in shape of the distribution. This enabled a histogram of the range of greyscale values for the image to be superimposed with a mirror of the 'good' distribution side. This Gaussian distribution then approximates to the background greyscale of the image. The Gaussian distribution was used in the next phase of development to isolate our greyscale for our defect range. It was calculated by using the 'raw data' range of greyscale values and subtracting the modal distribution, formed by the Gaussian approximation of background.

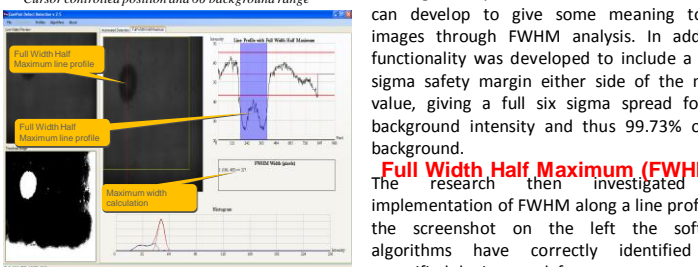
Development of Cursors, Background Ranges and Line Profiles



Line cursor passing through defect periphery (left image), and centre of defect (image on right)



Cursor controlled position and 6σ background range



FWHM value of 217 pixels for impact related defect

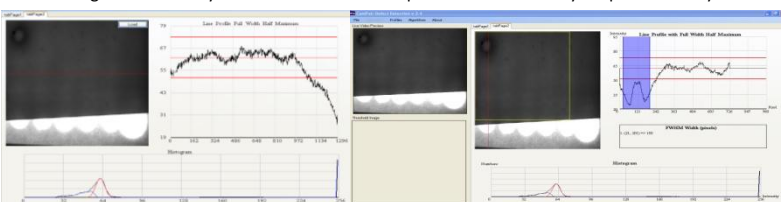
The next stage of the developmental cycle includes the provision for line cursors in the x and y axis forming user controlled line profiling. The screenshot above shows how the image intensity changes (towards black) for the impact defect. The line profile at the periphery differs from that through the centre with the 'double dip' denoting the extent of the circular impact. This gives some insight into the intensity framing the impact defect and how the software can develop to give some meaning to the images through FWHM analysis. In addition, functionality was developed to include a three sigma safety margin either side of the modal value, giving a full six sigma spread for the background intensity and thus 99.73% of the background.

Full Width Half Maximum (FWHM)
The research then investigated full implementation of FWHM along a line profile. In the screenshot on the left the software algorithms have correctly identified and quantified the impact defect.

Image Processing Challenges: Edge artefact removal

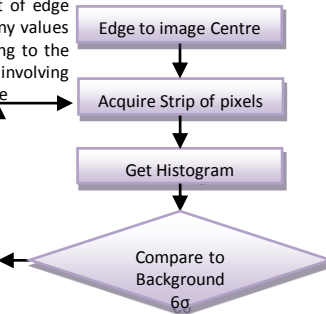
Thermography based images present a significant problem as data because the whole image, including the defect, can be skewed by edge effects. Hence, a sequence of algorithms are implemented to remove any edge artefacts on the image. The impact of edge effects are encapsulated in the screenshot below where the line cursor captures the line profile of the background. Here, any values falling outside of the red lines of the six sigma region must be noise from edge effects. Additionally, the histogram relating to the contrast of the full image shows the impact of the intense white area at the edge of the sample. This is negated by a method involving a scan towards each of the image sides to analyse the first three lines of pixels. When the analysed pixel intensity matches the

intensity of the (6σ) Gaussian background it is cropped to frame the new image edge, artefact free. Hence, negating effects caused by uneven illumination.



Line Profile for Background

Removing Edge Artefacts with resulting cut-down image shown in yellow



Flowchart of edge artefact removal technique shown above

Conclusions

The KCC thermography software has developed statistical and algorithmic methods to process raw IR data images so that quantitative measures have been made on impact defects in composite materials. The images have been processed to adapt variations in the background enabling data extraction to target the greyscales that form the defect contrast of interest. This has led to engineer controlled, and automated, cursor control so that defects can be given quantitative measure through Full Width Half Maximum (FWHM) analysis.

Acknowledgements

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For more information on defect detection of impact damage in composite materials by thermographic software see the following websites:

www.kcccltd.com • www.compairproject.com • www.twi.co.uk • www.gtronix.co.uk • www.ntua.gr For composite materials see www.hexcel.com