Crack detection around fastener holes with Total Focusing Method ultrasonic system

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Abstract

In complex shape assemblies currently used in aeronautics, it can be tricky to be able to detect cracks around fastener holes. This is the challenge that phased array ultrasounds are facing with the objective to extend the aircraft lifetime with minimum inspection effort and avoiding fastener removal. After a first concept developed few years ago [1] by Dassault Aviation and based on large ultrasonic linear array in a pseudo-tandem configuration, a new test campaign has been made. Taking benefit of the Total Focusing Method, images are obtained in transverse mode considering rebounds on the backwall (TTT and TTTT). Results are presented and discussed to illustrate the capability and the reliability of the method.

1. Introduction

In civil and military aircraft complex shape assemblies are currently used with top skin, main part and bolts. Then it can be tricky to be able to detect cracks around fastener holes. Phased array ultrasound technique allows this, and has been developed to replace Eddy Current testing which required dismantling. New imaging techniques have emerged and it is now possible to use Total Focusing Method to get real time images with high resolution, high rate display and of course with the best quality in terms of focalisation.
This paper explains the technique and shows the results on this complex assembly.

2. Total Focusing Method

Based on FMC data, the TFM (Total Focusing Method) achieves coherent summation of echoes from reflectors in order to maximize amplitudes where they are located. First step is to define an area where the image will be built. Then, for each point of this image, the Time of Flight (T) is calculated from the Emitter to the Receiver. Amplitudes are extracted from the FMC and summed for each point of the image.

3. Assembly description

The component is made by two aluminium parts superimposed and having filler thin layer in between (wet assembly).
First aluminium layer is from about 3mm to 10mm thick. Second aluminium layer is about 21-24mm thick. Bolts are not removed for this inspection. Hole diameter is in the range 4-10mm.

Artificial crack type defects are made at various depths around holes.

Note that the coupling between the top skin and the bottom skin is not perfect but is enough to do the inspection by ultrasound.

4. Mode selection

Using different modes of propagation, this imaging method is applied to inspect holes in an aluminium assembly.

The modes used in this study are the following:

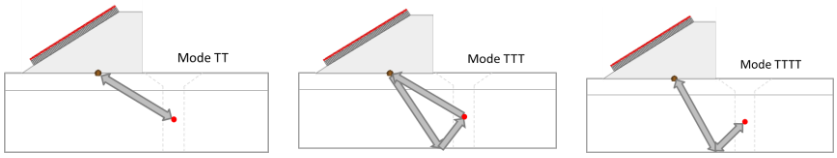

Figure 1. Mode propagation used for TFM imaging to detect cracks along holes

5. Phased array unit and probe

For this experiment we used the GEKKO 64x64 phased array unit with real time TFM on board. A 64 element probe at 5MHz and a wedge are used for TFM imaging.
Images are computed with 65000 pixels offering a very good quality resolution regarding the size of the area to be inspected.

6. Results

Main results are presented below either with TTT either with TTTT.

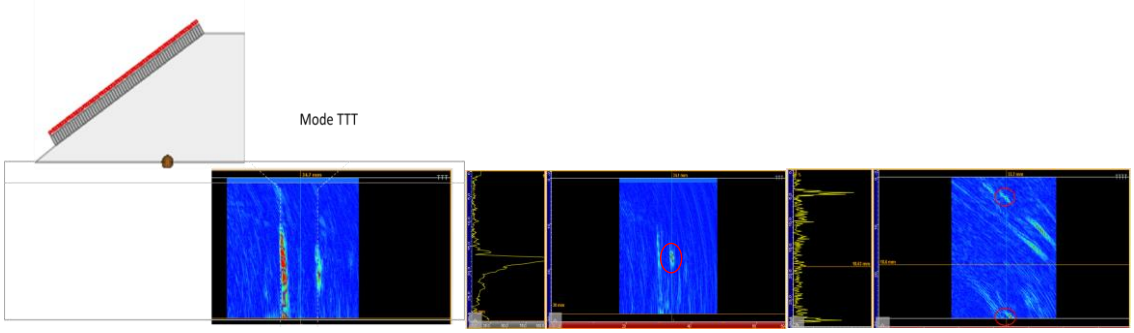

Figure 2. Hole wall response (left) with Mode TTT – Defect in the Middle with Mode TTT (middle) – Defect in the top and in the bottom with Mode TTTT (right)

Note that the mode TTTT requires to know perfectly the thickness which is tricky when it varies from one position to another. To get rid of that it is possible to double the thickness of the part parameter and to use the direct mode TT.

3. Conclusions

TFM allows an easy interpretation of the results and a good positioning of the probe thanks to the perfect imaging of the hole walls. Quite all the defects are very well

detected and sized with SNR similar to the previous setup in phased array. Only 2 of them have a lower SNR. This is due to the aperture of the probe and the benefit of the tandem mode which is not yet implemented in the GEKKO. This will be developed in order to improve again this type of inspection.

References and footnotes

1. Neau G., Hopkins D., Tretout H, and Boyer L., "Phased-array applications for aircraft maintenance, manufacturing and development", Aerospace Testing Expo 2006, UKIP Media & Events 2006.