Ultrasonic Array Testing Method for Validation of Aeronautical Components in Aluminium Alloys Produced by Additive Manufacturing

Abstract: In recent years, additive manufacturing has been commonly used for rapid prototyping of complex components in aerospace industry. However, due to the manufacturing process, the components produced can be anisotropic and inhomogeneous, and various defects such as porosity, cracks, deformation, and lack of fusion can occur during fabrication. Since the quality of the components produced needs to be ensured, ultrasonic techniques can be used to qualify the manufacturing process for structural applications. In this work, a component made of aluminium alloy 2319 was produced by wire arc additive manufacturing. In this component, artificial defects were machined and inspected using ultrasonic phased array technology. The component was inspected using both conventional and Total Focusing Method (TFM) imaging phased array techniques. These techniques were compared in terms of detectability, signal-noise ratio, amplitude response, and overall image quality using 5 MHz, 7.5 MHz, and 10 MHz probes. The use of these techniques makes it possible to detect defects in components and to take a step towards the production of high-quality final components. The results obtained showed that the TFM technique has the potential to provide better detection of the defects, resolution, and measurement capabilities when compared with conventional phased array, and with this it allows effective quality control of the components produced by wire arc additive manufacturing.

Acknowledgements

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Keywords: Aerospace industry; Wire arc additive manufacturing; Phased array technique; Quality control; Total Focusing Method
Abstract

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In this work, a component made of aluminium alloy 2319 was produced by wire arc additive manufacturing (CMT Advanced). In this component, artificial defects were machined and inspected using ultrasonic phased array technology. The component was inspected using both conventional and Total Focusing Method (TFM) imaging phased array techniques. These techniques were compared in terms of detectability, signal-to-noise ratio, amplitude response, and overall image quality using 5 MHz, 7.5 MHz, and 10 MHz probes.

The use of these techniques makes it possible to detect defects in components and to take a step towards the production of high-quality final components. The results obtained showed that the TFM technique has the potential to provide better detection of the defects, resolution, and measurement capabilities when compared with conventional phased array, and with this it allows effective quality control of the components produced by wire arc additive manufacturing.

Results

Figure 1. Images of ultrasonic data for ultrasound standard block obtained using a 5 MHz probe and conventional phased array mode.

Figure 2. Images of ultrasonic data for ultrasound standard block obtained using a 7.5 MHz probe and TFM mode.

Figure 3. Images of ultrasonic data for ultrasound standard block obtained using a 10 MHz probe and conventional phased array mode.

Figure 4. Images of ultrasonic data for ultrasound standard block obtained using a 7.5 MHz probe and TFM mode.

Figure 5. Images of ultrasonic data for ultrasound standard block obtained using a 10 MHz probe and TFM mode.

Figure 6. Images of ultrasonic data for ultrasound standard block obtained using a 10 MHz probe and conventional phased array mode.

Figure 7. Photography of the ultrasound standard block that was produced.

Experimental

Ultrasonic testing equipment used for this test was a GEKKO M2M (Eddyfi Technologies).

Two different modes of inspection were used: the conventional phased array method and the total focusing method (TFM) mode were employed in order to determine all the defects and improve the defect shape in the scanning images. The standard block was inspected using 5 MHz, 7.5 MHz, and 10 MHz ultrasonic arrays in direct contact with the backing plate surface using the conventional phased array mode or TFM mode; the characteristics of the different UT probes used are presented in table 1.

Table 1. Characteristics of the probe used in the inspection.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>64L2.5C2</th>
<th>64L7.5C3</th>
<th>64L5C3</th>
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<tbody>
<tr>
<td>Transducer centre frequency (MHz)</td>
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<td>7.5</td>
<td>5</td>
</tr>
<tr>
<td>Number of elements</td>
<td>64</td>
<td>64</td>
<td>64</td>
</tr>
<tr>
<td>Element width (mm)</td>
<td>8</td>
<td>9</td>
<td>10</td>
</tr>
<tr>
<td>Element pitch (mm)</td>
<td>0.35</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>Sampling frequency (MHz)</td>
<td>100</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Material speed of sound (m/s)</td>
<td>6390</td>
<td>6390</td>
<td>6390</td>
</tr>
</tbody>
</table>

Discussion & Conclusions

From the analysis of the data obtained, it is possible to conclude that the images created using TFM provided higher resolutions in comparison with those obtained from the conventional phased array. The defects placed near the top surface were not detectable using the conventional method, while the TFM images provided a clear reproduction.

Another aspect that can be concluded is that the 7.5 MHz probe proved to be the most suitable probe for carrying out the inspection, since it was through this probe that it was possible to obtain an inspection with better resolution and sharpness in the detection of defects. This aspect is verified for both the conventional phased array mode and TFM.

The results show that the traditional focusing algorithm has a low signal-to-noise ratio (SNR) and high background noise when compared with the TFM algorithm. At the same time, the hole defects present distortion; this fact is related to the influences in the acoustic beam due to the inhomogeneity of the material, which influences the imaging quality.

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