Development of inspection process of 3D printed CFRP products using laser ultrasonic testing technology and AI model

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3D printing technology is extensively studied and applied to industry, and its applications are expanding from prototyping to rapid tooling or substitution of supply chain. Among various 3D printing materials including plastic or metals, continuous carbon fiber is gaining attention due to its high stiffness to weight ratio. Since continuous carbon fiber 3D printing technology is based on FDM(fused deposition modeling), void formation between printing path or layer separation which both can affect mechanical performance of the products are expected during the production. Therefore, development of inspection technology of void and defect and decision-making process of reproduction is required. In this study, robotic pulse-echo laser ultrasonic inspection system and AI model which classifies the defects are developed. For non-destructive inspection of printed products, Q-switched pulsed laser and laser doppler vibrometer were used for inducing and detecting ultrasonic wave in pulse-echo mode. To scan the intricate surfaces of 3D printed products, a 6-axis robot arm was employed to position the lasers while maintaining the angle of incidence of LDV for better signal. An AI model was developed to classify the depth of defects or layer separations based on the laser ultrasonic signals. By examining patterns in depth map generated by AI model, type and size of defects that the products contain were determined. Finally, mechanical performance degradations due to the classified defects or layer separation were quantified to help manufacturer decide whether the degradation is allowable or not.