Real-time Monitoring of Crack Sensors Using Electrohydrodynamics

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1. Introduction

As seen in the recent appearance of large aircraft and large-scale accidents, if an aircraft accident occurs, the fuselage has been damaged and the damage of property and human life is very large. As a result, aircraft are required to be weight lightening and safety at the same time, and sufficient reliability must be ensured during operation life [1]. When a composite structure is subjected to an external impact, cracks such as matrix crack, fiber cutting, indentation, and delamination are generated in the inside [2]. These cracks gradually grow to reach design limits, resulting in failure to meet the fatigue life or failure of the structure. Therefore, the nondestructive inspection technology has attracted attention after the appearance of the composite material aircraft [3]. Nondestructive inspection is a method of inspecting from outside without destroying cracks or defects inside the structure. Until now, it has been developed with various individual technologies such as thermography, tomography and ultrasonics. Most of NDT/NDI/NDE have some limitations to inspect inside of complex structure [4]. However, these conventional inspection methods are costly and time consuming. Also, it can't be inspected while the aircraft is in operation.

Therefore, the aircraft can't predict the exact time of fatigue failure, and there is a limit to prevent cracks occurring during maintenance cycles. The aircraft needs structural health monitoring technology to detect cracks that occur during operation. In this paper, the sensor mechanism that can detect cracks in real time using electrohydrodynamic technology is studied.

2. Experiments

Fig. 1 shows the schematic diagram of the experimental setup of the EHD equipment used in the sensor fabrication. The flow controller continuously supplies ink at a set flow rate and maintains a high voltage between the nozzle tip and the substrate for continuous pattering. 3-axis (X, Y, Z) control through direction controller is possible. Aline can be formed on the substrate in the X-Y axis direction and distance between the nozzle and the substrate in the Z axis direction can be adjusted. If the distance between the nozzle and the substrate is not properly adjusted, unstable patterning such as whipping or spraying is performed [5]. The ink used in this experiment was silver nano paste with high electrical conductivity.

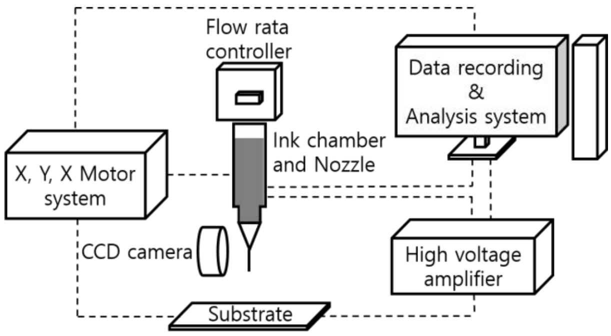

Figure 1 Schematic diagram for the experimental setup in EHD printing

Fig. 2 shows the mechanism of the sensor proposed in this paper. The DAQ sends current to the input signal to sense the changed resistance and receives it through the output signal. The damaged area can be detected through the intersection of the changed resistances in the horizontal and vertical directions. The two patches were patterned in the horizontal direction and vertical direction, respectively, so as to form a layer, thereby forming a grid structure.

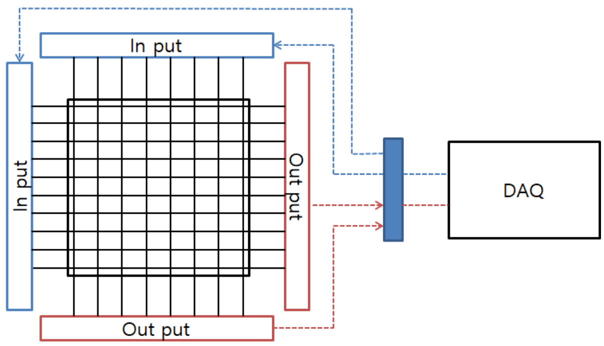

Figure 2 Grid sensor designed for real-time damage detection

In order to verify the real-time performance of the fabricated sensor, a sensor was attached to a honeycomb core made of a 3D printer, and the structure was broken to confirm a change in resistance. The DAQ was used to detect the change in resistance when the structure was broken and it has been measured resistance change until completely broken.

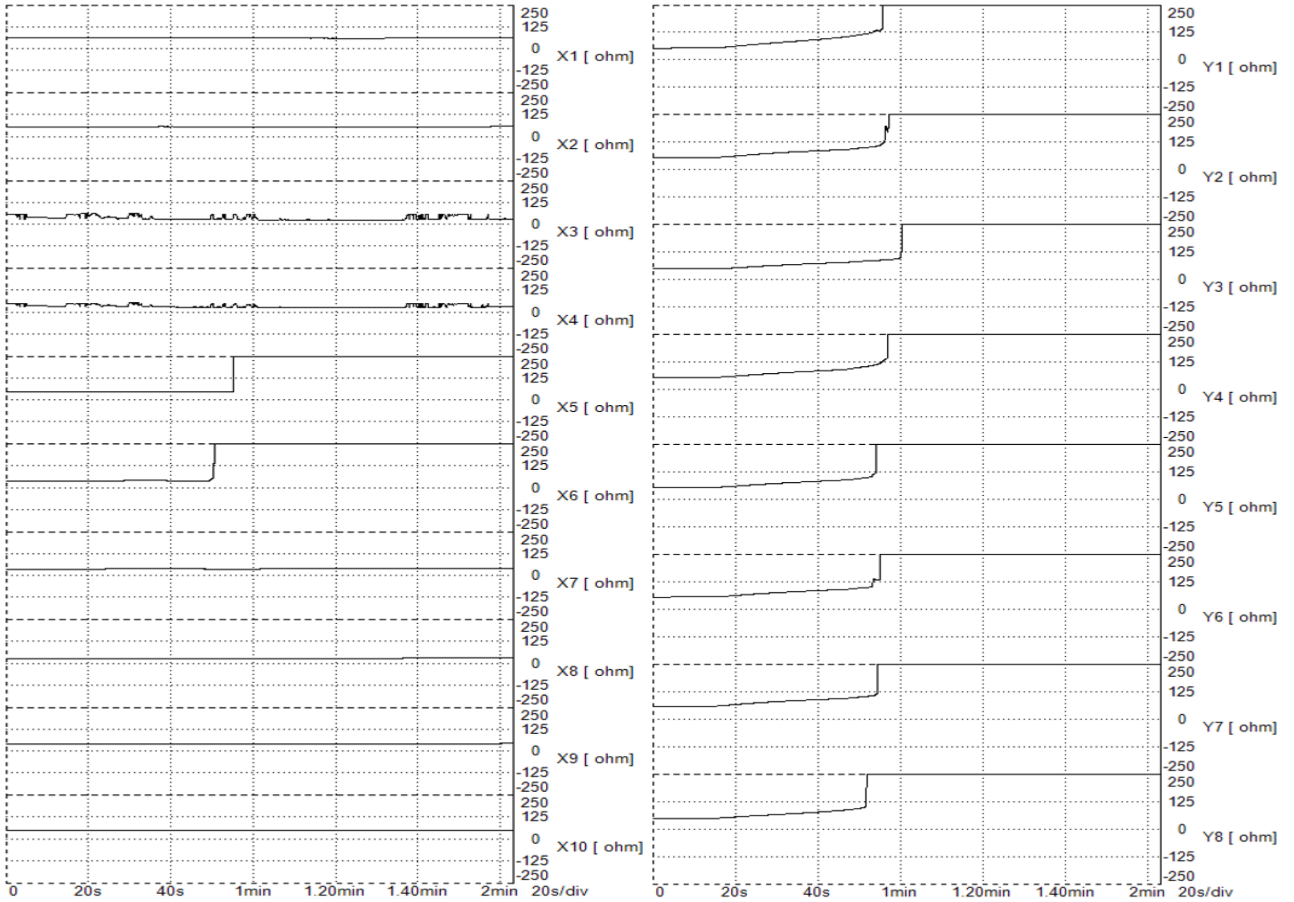

Figure 3 Real-time resistance change of sensor

The connected cable of the sensor uses 8 channels in the horizontal direction and 10 channels in the vertical direction. Fig. 3 shows the changed resistance of each channel until the structure is completely broken. Measured results At 18 seconds after DAQ operation, the resistance of the horizontal lines begins to gradually increase. Thereafter, in all the lines in the horizontal direction and in the vertical direction in the X5 and X6 lines between 52~60 seconds, the resistance is sharply changed. This is because the attached sensor is broken at the same position as the honeycomb core broken by the bending load so that the current can no longer flow. As a result, the resistance of the damaged line increased sharply. As a result of comparing the load graph and the resistance change graph, the change of the resistance sensed by the sensor exactly coincides with the change of the load occurring in the actual specimen. The intersection of all the lines in the horizontal direction with the X5 and X6 lines in the vertical direction coincides with the fracture position of the specimen. This shows that it is possible to accurately grasp the fracture position by crossing the horizontal line and vertical line with the changed resistance**.**

Acknowledgment

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