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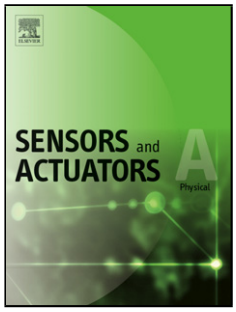

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Active Control of a Smart Composite with Shape Memory Alloy Sheet using a Plastic Optical Fiber Sensor

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Abstract

This paper investigates the morphing characteristics of a fiber metal laminate (FML) based on shape memory alloy (SMA) skin and a carbon fiber reinforced epoxy composite. Prior to manufacture, the SMA surface layer was trained by heating them to 500^{o}C in a furnace and quenching rapidly in a water bath. The SMA skin was then bonded to the composite and a thin silicon heater was attached to the SMA skin. During activation, the deflection of the beam was detected via a plastic optical fiber (POF) sensor bonded to the upper surface of the smart FML. The output from the POF sensor was monitored using a photodetector which in turn was connected to a control unit. This closed-loop arrangement enables the operator to introduce the prescribed set-point deflection values of the beam. The desired deflections of the smart FML are achieved by the control unit switching on, and subsequently switching off, the silicon heater using the POF to provide the feedback signal.

Tests have shown that this smart FML is capable of accurately achieving prescribed values of beam deflection based on the POF sensors signal. The repeatability of the system has been demonstrated by systematically increasing and then decreasing the prescribed deflection and monitoring the subsequent response. In addition, the structure has been shown to be capable of accommodating unwanted disturbances, such as those associated with external loading regimes. During initial studies, using an on-off control strategy, the beam tended to overshoot the required deflection before stabilising at the set-point value some tens of seconds later. This effect was reduced through the tuning of a proportional-integrative-derivative (PID) control setting on the control unit. It is believed that the findings outlined in this paper demonstrate the potential benefits offered by smart hybrid structures.

Keywords: shape memory alloy, plastic optical fiber, sensors, smart structures, fiber metal laminates, active control

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