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MANUFACTURING AND PERFORMANCE TESTS OF COMPOSITE STRUCTURES BASED ON THERMOPLASTIC MATRICES WITH EMBEDDED PIEZOCERAMIC ACTUATORS

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ABSTRACT

A piezoelectric actuator was developed to be embedded in composites with thermoplastic matrix material. The new innovative manufacturing process of both the actuator and the active composite structure is illustrated. Composite cantilever beams containing these new material-embedded actuators were manufactured. The performance of these structures was determined using deflection measurement and vibration tests. The results show a good performance of the integrated actuators and thus demonstrate the functional capability of the designed process.

Keywords: fibre-reinforced composites, thermoplastic matrices, function-integration.

INTRODUCTION

High-technology lightweight applications increasingly have to fulfill high standards concerning vibro-acoustic quality due to rising environmental and comfort demands. Here, new function-integrating fiber-reinforced thermoplastic composites with material-embedded piezoceramic modules (TPM) offer a very high lightweight potential due to the possibility to actively influence e.g. the vibrational behavior of the structure. Hence, a new generation of active components with material-integrated vibration and noise control functionalities can be developed. At present, piezoceramic actuators are mostly adhesively bonded to the structure causing high manual efforts. Thus, a piezoceramic module and the corresponding manufacturing process was designed which allows a material homogeneous integration of the actuator into the composite structure (Hufenbach et al., 2011). The used composites with thermoplastic matrices enable efficient production processes (e.g. Novacki, 2001; Adhikari et al., 2009), which are suitable for high volume applications.

MANUFACTURING OF PIEZOCERAMIC MODULES AND SMART COMPOSITES

For a material homogeneous integration of the novel TPM into composite structures based on thermoplastic matrices a continuous process chain was developed (see Figure 1). The manufacturing process contains two main steps: (1) TPM manufacturing based on a roll to roll process for the layup, consolidation, contacting and polarization of the TPM and (2) embedding process including the assembling in a so called “e-preform” and the subsequent supply to a hot pressing process with a simultaneous online polarization.

Using this new production process, active composite cantilever beams (300 x 60 x 2 mm) with integrated TPM were manufactured. The TPM position was chosen near to the clamping for high deflection at the free end and a good excitation of the first mode shapes.

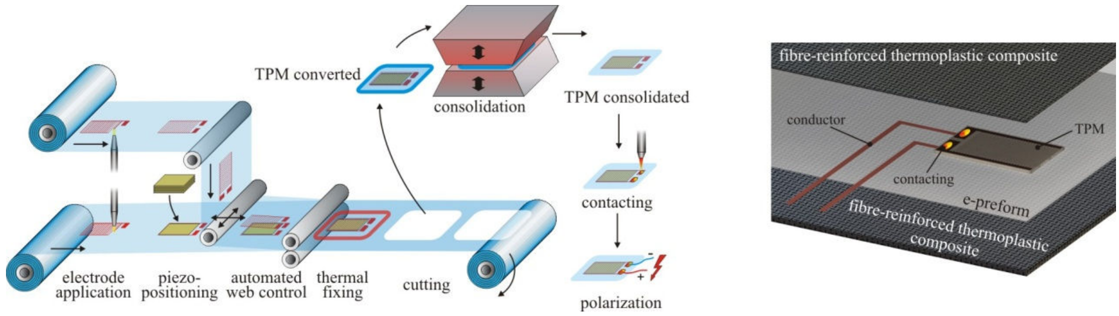

Fig. 1 - Schematic TPM manufacture (left) and active composite lay-up (right)

PERFORMANCE TESTS

Flexural deflection and vibration tests were done to test the performance of the active beam structure. The flexural deflection under constant voltage was measured using laser triangulation. At an actuator voltage of 625 V the deflection of the free end of the beam was 0.4 mm. In addition to the static deflection the ability of a dynamic excitation of the beam structure was tested. While driving the actuator with a sinus sweep signal a laser scanning vibrometer was used to measure the velocities of the beam at several points. The resulting frequency response function as well as the measured mode shapes are shown in Figure 2.

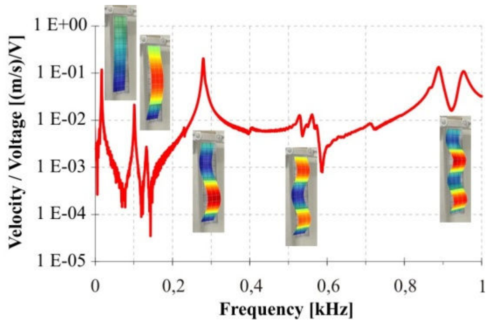

Fig. 2 - Displacement measurement and eigenfrequency analysis of the active bending beam

Both tests confirm the correct operation of the piezoceramic material after the manufacturing process. These investigations show the suitability of TPM for the embedding into composite structures based on thermoplastic composites.

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