Use of piezoelectric thick film sensors to measure stress distribution within a lap joint

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1. INTRODUCTION

Piezoelectric thick film sensors have been developed to be embedded into the adhesive layer of a lap joint and used as strain sensors. A novel approach of obtaining quantitative, interfacial strength information by using piezoelectric liquid adhesive is proposed in this work. This application allows the direct measurement of the variation of the interfacial strength in a joint along the overlap area, aiming at the optimisation of the adhesive bonded joint design of the aeronautic industry. In the present work, preliminary results showed the performance of a single sensor within the joint assisting in the characterization of the sensor [1]. The piezoelectric adhesive was applied between the two adherents of the joint, using the two metal substrates as the electrodes of the sensor. Based on previous work of the author's group, this piezoelectric adhesive was made of a fine piezoelectric ceramic powder PZT (lead-zirconate-titanate) which is uniformly distributed within an epoxy resin matrix [2]. The idea of the 0-3 piezoelectric composite was to incorporate the sensor into the adhesive layer as part of the adhesive without greatly affecting the mechanical properties of the bond. The lap joints were tested and characterised using the dynamic four-point bending test, showing an increase of the output signal as the applied strain amplitude is increased.

2. EXPERIMENTAL DETAILS

A two-component epoxy resin (RSL135 and RSH137) was chosen for manufacturing the piezoelectric composite and a ''soft'' piezoelectric powder, commonly known as Navy type II (PZT 5A, Sunnytec), was used as the filler. The ceramic particles were in the form of fine, micron-sized particles and ultrasonic bath procedure was used to disperse the particles within the epoxy matrix. The piezoelectric adhesive was applied to one of the adherents of the joint as part of the adhesive, forming finally a PZT sensor of 10×100 mm² embedded within the joint (Fig.1). The two metal adherents of the bond were used as the two essential electrodes of the sensor.
The final step of the manufacturing was the 'poling' of the sensor, which was used to activate the sensor by aligning the electric dipoles within the crystal lattice of the PZT particles [3]. A high voltage up to 800V was applied between the electrodes for a period of 2-10min at room temperature.
The sensors were tested under dynamic four-point bending test. The signals were conditioned using a custom made charge amplifier with sensitivity of 1.0mV/pC. All experimental data were acquired by a NI 9219 (DAQ) board using a LabView data logging program. The sampling rate for real time data acquisition tasks was chosen to be 1000Hz. The experiments were carried out over a range of strain amplitudes and showed significant variation of the output signal.

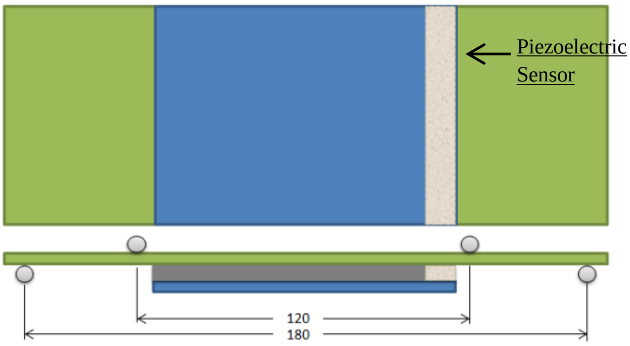

Figure 1: Single Piezoelectric Sensor embedded into the lap joint – Experimental configuration

3. RESULTS

Dynamic four-point bending test was used to measure the output signal of the sensor over a strain amplitude range of 0.05-0.45mm and strain rate 10mm/sec. The probe signal was measured as the difference from peak to peak (ΔVp-p) of the output signal as a function of the applied strain amplitude. Fig.2 shows the increase of the output signal as the applied amplitude is increased.

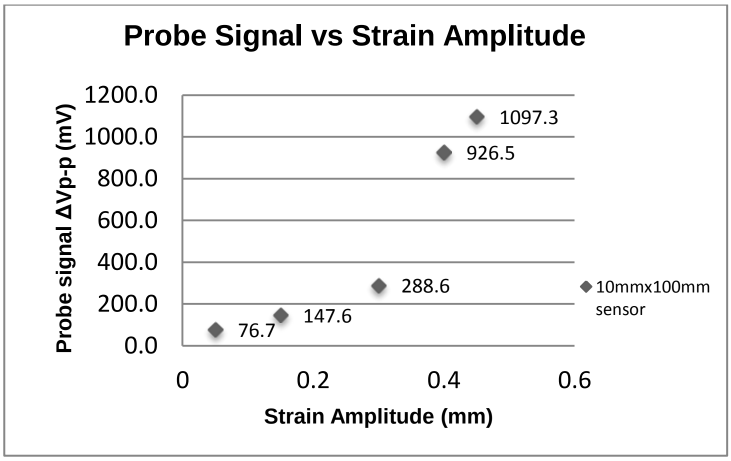

Figure 2: The output probe signal as a function of strain amplitude range

4. CURRENT WORK

Having established a formulation for setting up a single piezoelectric sensor as an in-service device within a lap joint, work will now proceed to the application of several sensors within the bond (Fig. 3). The results of this work will be reported at the conference.

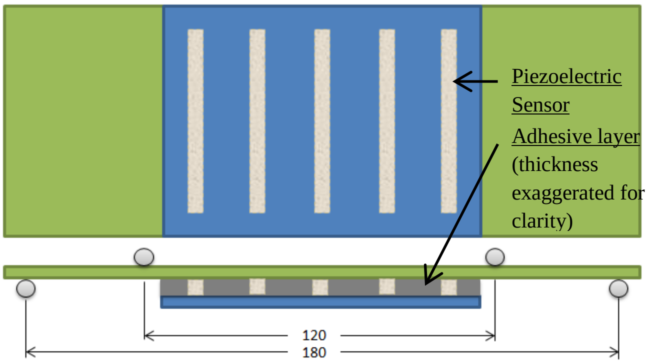

Figure 3: Top view of the piezoelectric sensors within the lap joint - Section of the experimental setup

5. CONCLUSIONS

In this work a piezoelectric adhesive strain sensor has been developed and successfully characterised, based on previous work of the authors group. It had been proven that the probe signal shows a significant variation as the applied strain amplitude varies.

References

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