Comparative Investigation of PVDF and PZT Based Piezoelectric Smart Structures for Rain and Wind Energy Generation and Polymer Based Piezoelectric Fibre Production

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Introduction

• PolyVinylidene Floride (PVDF) exhibits one of the piezoelectric effect among the polymer piezoelectric materials

• Being a polymer it is light weight and flexible which suits many applications such as energy scavenging from wind, rain, tides etc.

• PVDF is not expensive and can be formed into any shape and sizes at lower temperatures.

Experimental Details

• Laminated PVDF films (obtained from Measurement Specialties Inc. USA) and Lead Zirconate Titanate (PZT) based fibre composite films (obtained from Advanced Cerametrics Inc. USA) were used to measure voltage, current and power out put from rain and wind.

• PVDF polymer (obtained from Solvay Solexis S.A.S. France) was extruded via a continuous process on the melt extruder to form piezoelectric fibres by applying a high stretching ratio, heat and high voltage, simultaneously (Poling).

Rain Drop Experiment

Fig 1. Rain drop experiment setup. Impact was induced by releasing water droplets from various heights.

Experiment Results

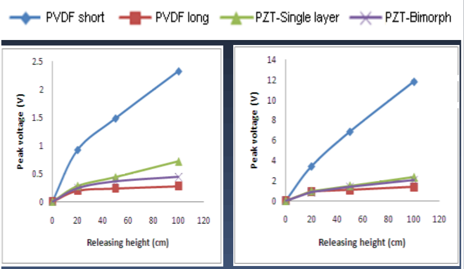

Fig 2. Voltage generated by PVDF films and PZT fibre composites when water drop (with a diameter of 0.5 mm (left) and 2 mm (right)) strikes the surface from various heights. PVDF short film produces the highest voltage.

Wind Tunnel Experiment

Fig. 3 Wind experiment setup

Wind speed was measured using an aerometer placed 20 cm in front of the tunnel. Turbulence was created by a valve opening and closing mechanism.

Experiment Results

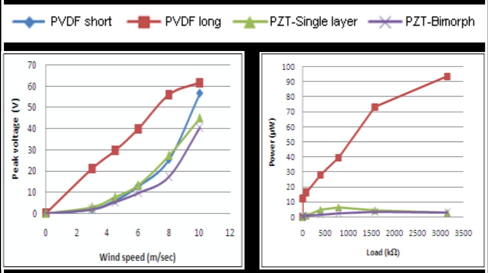

Fig. 4 Voltage (left) and power (right) response of PVDF films and PZT fibre composites for various wind speeds.

• At the highest wind speed, 10m/sec, the power generated by the longer PVDF piezoelectric specimen was 93.6μW while 6.5μW and 3.6μW was recorded for the PZT-single layer and PZT bimorph samples, respectively.

Discussion and Conclusion to Preliminary Experiments

• Voltage generated by the shorter film is higher for water droplet experiment due to the reaction of the film to the forward strain is faster in shorter films which is critical.

• Voltage and power generated by the longer PVDF film is higher than the short film in the wind experiment due the larger surface area of the film on which the wind exerts larger force.

• Voltage generated in various energy scavenging methods depend on the geometry and type of the film used.

•Under certain conditions piezoelectric PVDF materials produce higher peak voltage/power than piezoelectric ceramic based materials when subjected to low impact and moderate wind.

•Preliminary experiment results motivated us to produce polymer based piezoelectric fibres with an advantage of being flexible so it can be easily integrated into textile structures.

PVDF Fibre Production

Fig. 5 Piezoelectric PVDF fibre production

Granular PVDF polymer was fed to screw which had been heated above melting point of the polymer. To gain the piezoelectricity, molecular chain of the PVDF fibre was re-oriented and transformed from alpha-phase to beta-phase by applying a high stretching ratio (4:1), heat (70-80°C) and high voltage (1MV/m), simultaneously.

PVDF Fibres and Testing

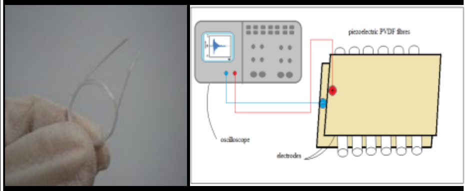

Fig 6. Resulting flexible PVDF fibres (left) were aligned between two copper electrode sheets and voltage response of the structure was investigated (right).

Results

• Built-up structure produced a peak voltage of 5V under a small mechanical impact that is competitive with ceramic based piezoelectric fibres.

Discussion and Conclusion

• Generating energy from rain and wind is possible by using polymer based piezoelectric materials for utilisation in low power electronic devices in potential outdoor applications such as clothing, awnings, tents and so on.

• The availability of flexible piezoelectric fibres will meet the increasing need to integrate piezoelectric fibres into textile structures for renewable energy.

Acknowledgements

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