UNIVERSITY OF EXETER | Energy Harvesting Research Group

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Improved Energy Outputs from Piezoelectric Bimorph Beam by Snap-Through-Action for Energy Harvester Applications

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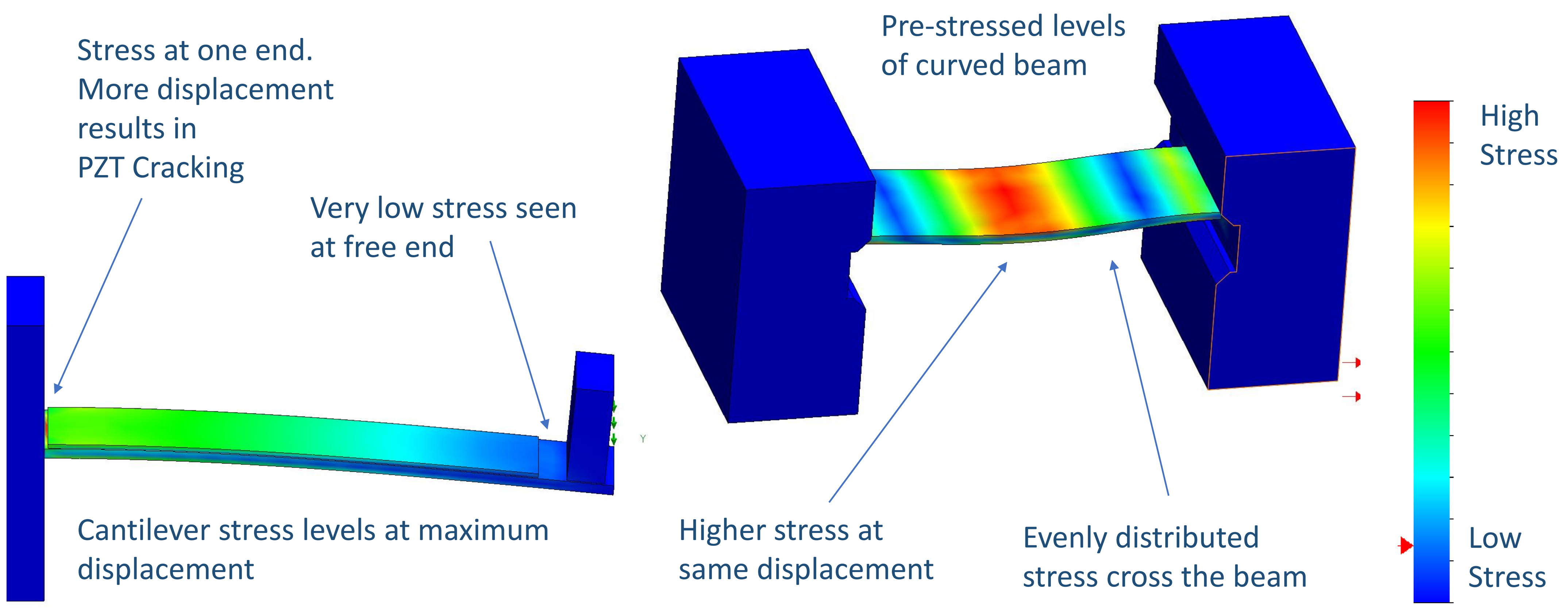
From design to testing, a way of generating high controlled stress levels in a larger area of PZT has been developed. The way in which a piezoelectric bimorph beam is fixed, excited and vibrated are all controlled by a novel design approach by which the centre of beam is displaced by a set amount causing the beam to buckle. **The single PZT beam produced 0.3mW of power when excited at 3Hz and 3mm displacement.**

Concept

By moving away from a cantilever to a double support beam, more power and reliability can be achieved. Piezoelectric energy harvesters have had two main problems that needed to be address; 1. distributing the stress more evenly across the PZT, and 2. cracking of the PZT when the input is greater than a set amount. This concept addresses both of these issues and can be used as a broadband energy harvester.

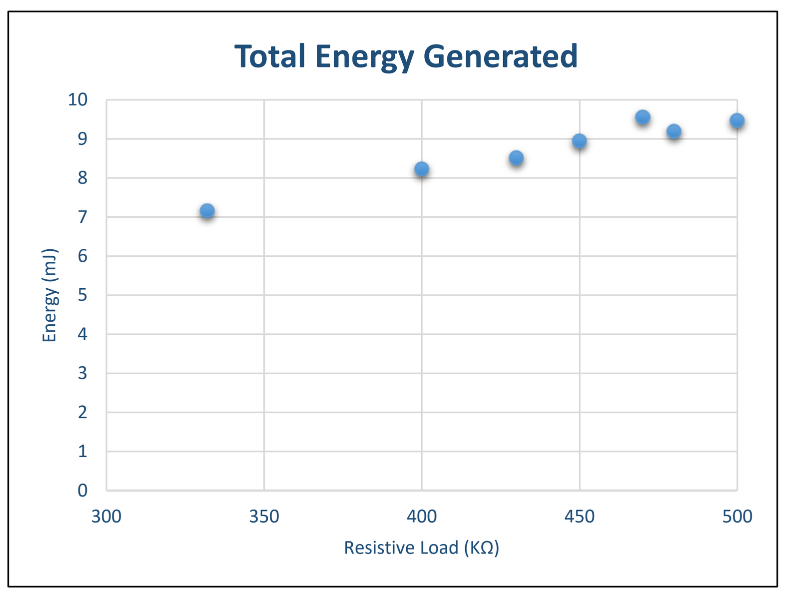
Both ends of a PZT Bimorph beam are supported in a restricted manner but are able to pivot about the end faces of the beam. The distance between the supports is less than the length of the PZT beam. When the beam is in place, it is curved to a calculated amount.

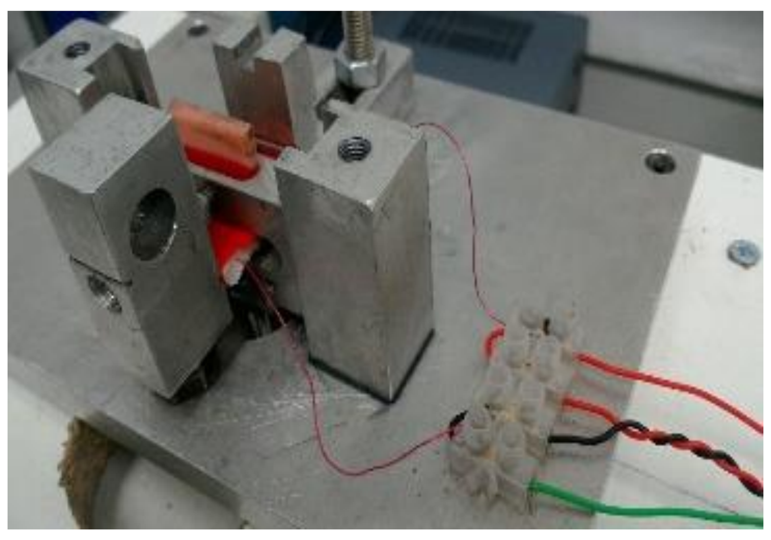
A force is applied to the centre to the outer curved face to induce a "Snap-Through-Action" (STA) of the beam. The beam is then sat in a negative curvature state and is excited from the other face again. The input frequency, maximum displacement, and resistive loads were varied in a set of early stage experimental tests. These illustrations demonstrate the differences in stress areas in a PZT beam.



Experimental Results

A bespoke test rig was designed and attached to a *Data Physics V20* shaker unit. This held a PZT Bimorph beam measuring 31x12x0.28mm. The STA frequency was set at 3Hz for the first set of tests. It was kept low in order to be able to analysis the STA in more detail. The distance between the supports was 30.8mm. This give the PZT beam a radius curvature of 78.7mm. The graph below shows the results from a series of test where the resistive load attached to the beams electrodes was increased. Each test excited the beam at 3Hz, at a displacement of 3mm, for a time of 30seconds.





Bespoke Rig and Test station

The single PZT beam could produced 9.55mJ of energy with a load of 470Khms @ 3Hz. This gave a 0.3milliwatts average power figure.

Conclusion

Two key improvements over the traditional cantilever design can be drawn; 1, The stress area is larger than previous research undergone using a cantilever style energy harvester and 2, The stress area is maximum in the centre of the beam and evenly distributed across the length, to the ends. This increases the beams fatigue handling and reliability. Other interesting points that can also be made are; 1, By the beam "Snapping-Through" the stress in the beam in completely flipped in the time it takes for the beam curvature to reverse. This means high efficiency in stress changes. And 2, The fact the beam is in a pre-stressed state before STA starts, the potential difference is increased due to the start and end stress levels being further apart. This means a higher peak voltage level

Future Research

This poster presents a concept and basic early results for increasing power output from a piezoelectric bimorph beam by changing the way the beam is stressed. Future research could use this style of transducer for decreasing energy harvester's size while maintaining the same power output.

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