ICCM 23
INTERNATIONAL CONFERENCE ON COMPOSITE MATERIALS
BELFAST 2023
30 JULY – 4 AUGUST

The ICC, Belfast Northern Ireland
30th July – 4th August 2023

PIEZOELECTRIC ENERGY CAN BE HARVESTED FROM WIND-INDUCED VIBRATIONS BY UTILIZING A FISHTAIL-LIKE ENERGY HARVESTER

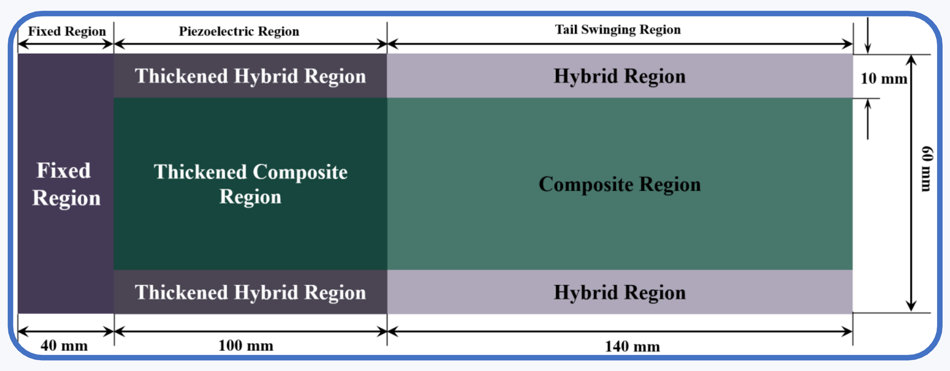
Fuhong Dai, Xiaohui Liu

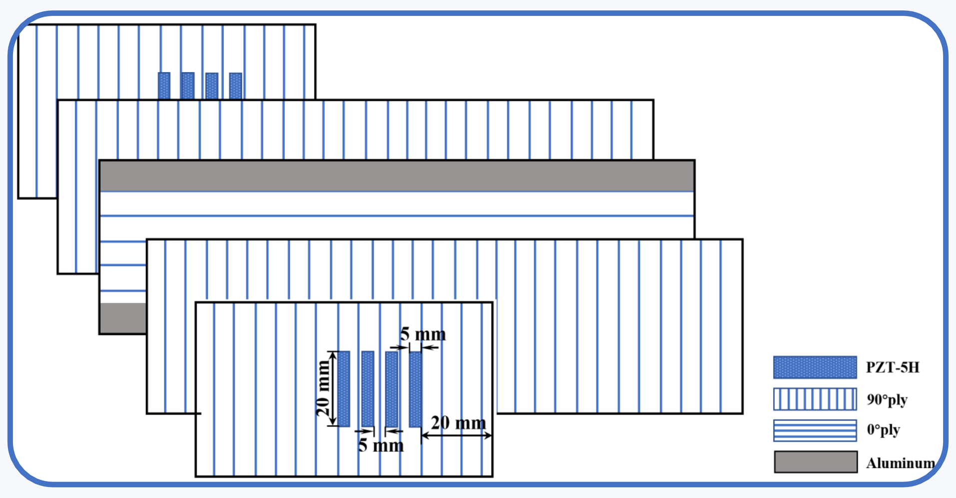
National Key Laboratory of Science and Technology on Advanced Composites in Special Environment, Harbin Institute of Technology

1. INTRODUCTION

With the gradual advancement of microelectronic devices, such as low-power infinite monitoring sensors, there has been considerable interest in utilizing piezoelectric materials for energy harvesting from wind-induced vibrations. This study introduces a novel piezoelectric energy harvester called the fishtail-like piezoelectric energy harvester (FPEH), which is composed of a segmented layered bistable composite structure. Additionally, two alternative piezoelectric energy harvesters with different layered configurations are designed and compared. Through finite element simulations and experimental evaluations, we demonstrate the superior power generation capabilities of the FPEH compared to the other two piezoelectric energy harvesters. The FPEH achieves a peak output power of 1.57 mW with an optimal external load resistance of 40 KΩ under a wind speed of 8 m/s.

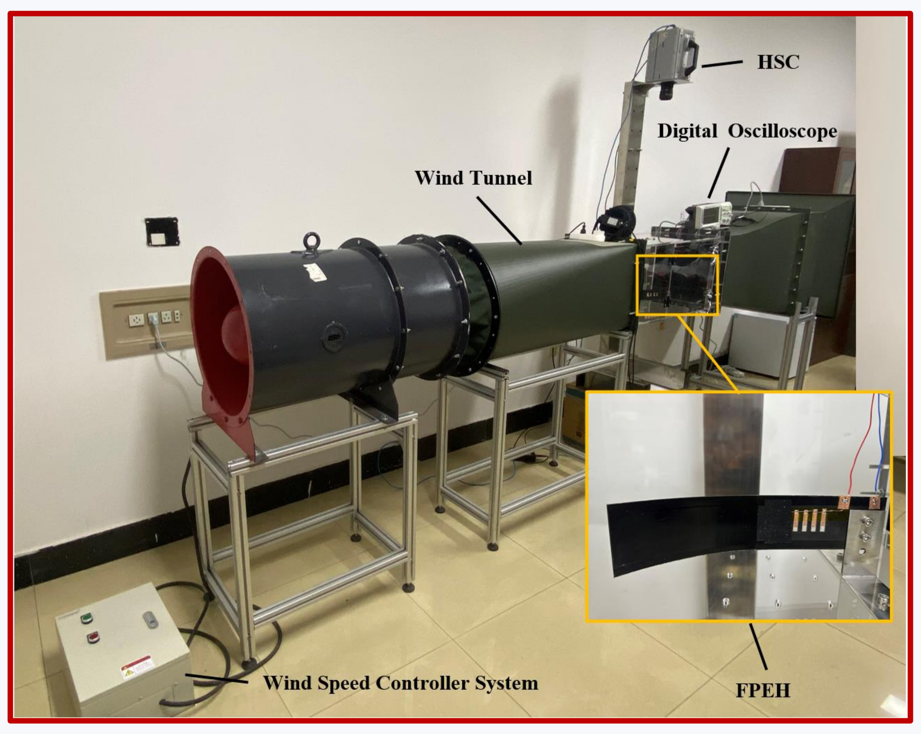
2. A FISHTAIL-LIKE ENERGY HARVESTER

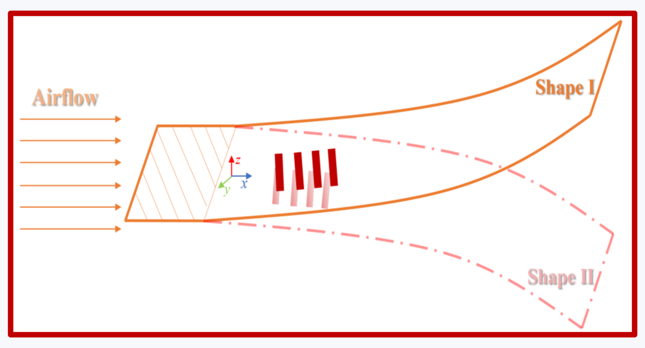




- **Thickened Hybrid region:**
  - **$[90_2/Al/90_2]_T$**
- **Hybrid region:**
  - **$[90/Al/90]_T$**
- **Thickened Composite region:**
  - **$[90_2/0/90_2]_T$**
- **Composite region:**
  - **$[90/0/90]_T$**
- **8 pieces of PZTs**
- **PZTs are connected in parallel**

3. EXPERIMENTS





- FPEH was fabricated by usual autoclave techniques and the PZT transducers were bonded on BHSL by epoxy resin included in prepregs during the curing process

4. ANALYTICAL MODELLING

- The assumption that FPEH transforms between two stable configurations ideally is supposed
- The strain variations of PZT transducers during the continuous snap-through process are the strain differences between two stable configurations
- Using a standard AC-DC circuit, the output power of BPCL under ideal continuous snap-through vibration pattern is deduced as below

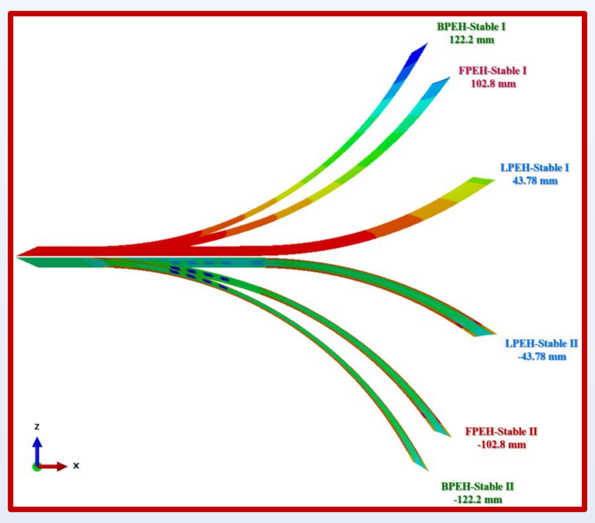
$$D_3 = d_{31}\frac{(\varepsilon_1+\varepsilon_2)}{S_{11}+S_{12}}+\varepsilon_{33}E_3$$

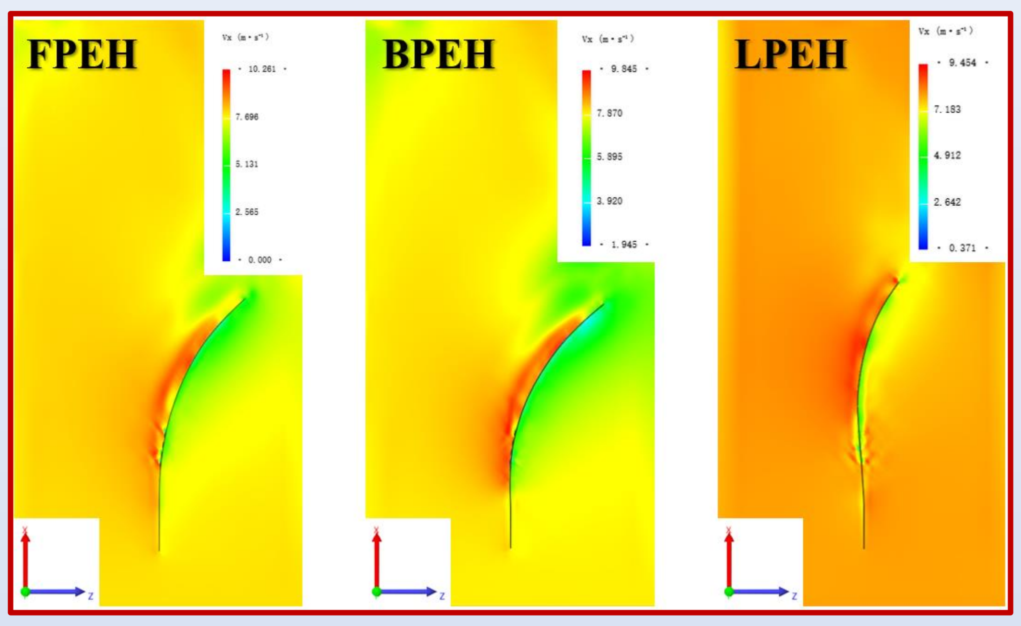
$$\frac{V_{DC}}{R}\frac{T}{2}=\int_t^{t+\frac{T}{2}} I\mathrm{d}t = Q_B - Q_A$$

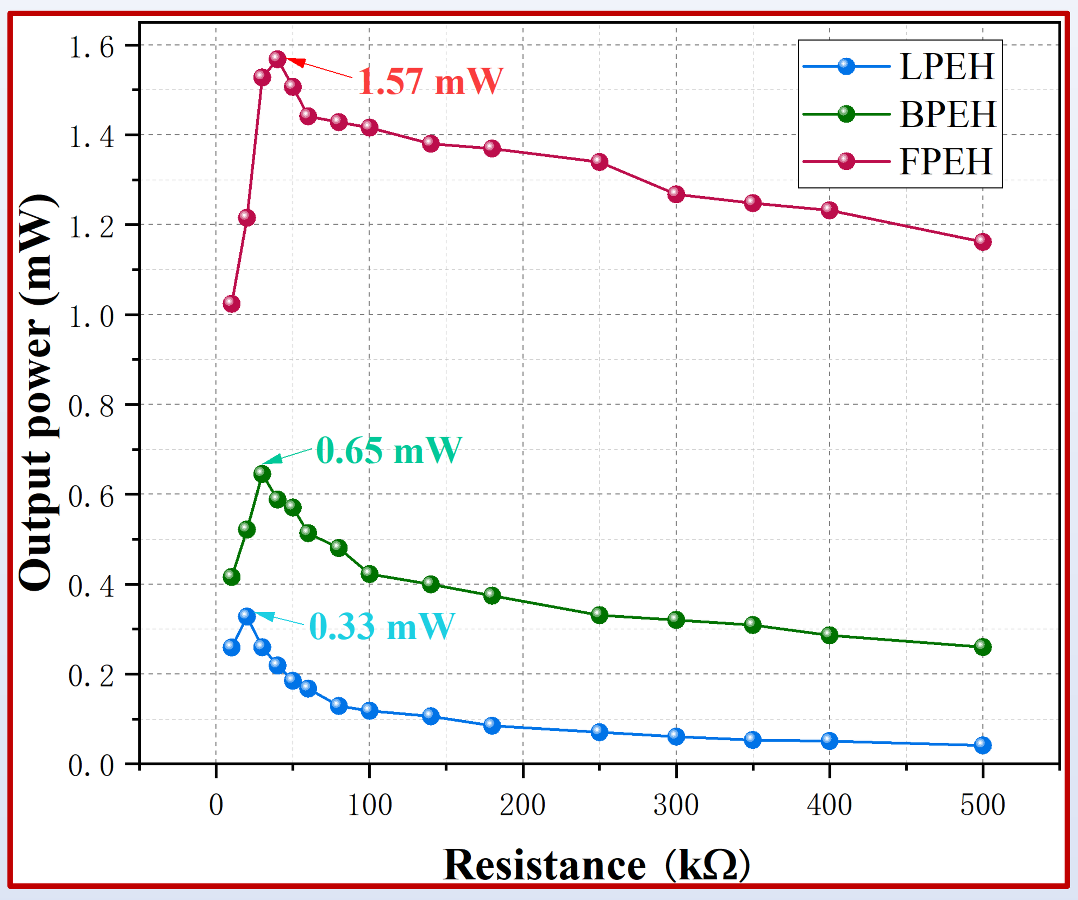
$$Q_B - Q_A = A\left(\frac{d_{31}(\Delta\varepsilon_1+\Delta\varepsilon_2)}{S_{11}+S_{12}} - 2\frac{V_{DC}}{t}\varepsilon_{33}\right)$$

$$P=\frac{R\left(Ad_{31}\frac{(\Delta\varepsilon_1+\Delta\varepsilon_2)}{S_{11}+S_{12}}\right)^2}{\left(2\varepsilon_{33}AR\frac{1}{t}+\frac{T}{2}\right)^2}$$

5. Results and discussion







6. CONCLUSIONS

- The FPEH achieved a maximum output power of 1.57 mW at an optimal external load resistance of 40 KΩ and a wind speed of 8 m/s, and its piezoelectric region was thickened to generate greater strain and increase energy harvesting efficiency.
- The FPEH, with its segmented layered bistable composite energy collector design, demonstrated superior power generation performance compared to two other PEHs with different layered configurations.

REFERENCES

1. Liao W, Sun H, Wang Y, et al. A novel damage index integrating piezoelectric impedance and ultrasonic guided wave for damage monitoring of bolted joints[J]. Structural Health Monitoring, 2023: 14759217231159427.
2. Pan D, Dai F, Li H. Piezoelectric energy harvester based on bi-stable hybrid symmetric laminate[J]. Composites Science and Technology, 2015, 119: 34-45.