Postdoctoral research position
Within the CPER EE4.0 project: SOUTENAVIB 2

Title: Development and characterization of piezoelectric systems for vibration analysis, energy harvesting, and predictive maintenance of electrical machines

Background

In the context of predictive maintenance, electrical machine diagnostics provide indicators of the mechanical, electrical, and power electronics health of the machine and its associated components, enabling their condition to be monitored remotely. The measured parameters transmitted to the monitoring system provide insight into machine operation, while data analysis makes it possible to assess the degree of component degradation and fatigue. Maintenance interventions can therefore be anticipated, helping to improve machine availability and operational reliability.

Energy harvesting is a promising approach to powering self-sustaining diagnostic systems using the small-amplitude displacements associated with vibrations. Since the early 2000s, energy harvesting for the autonomous power supply of miniaturized devices, such as sensors, actuators, and wireless communication systems, has attracted considerable research interest. The aim is to recover small amounts of energy from ambient sources (mechanical, thermal, radiofrequency, etc.) using various physical transduction mechanisms.

The materials used to convert mechanical vibrations into electrical energy are primarily piezoelectric materials. The most widely used piezoelectric ceramics are lead zirconate titanate (PZT)-based materials. However, these ceramics contain lead, a toxic substance. Current legislation increasingly seeks to restrict or eliminate the use of lead in electronic components. The integration of new lead-free materials would therefore significantly reduce their environmental impact.

This project brings together three laboratories in the Hauts-de-France region of France: CERAMATHS[(1)], IEMN[(2)] of Valenciennes, and ROBERVAL-UTC[(3)]. It aims to develop new piezoelectric-material-based systems for vibration analysis and condition monitoring of electrical machines. These systems will serve two main functions: (i) detecting anomalies in electrical machines using piezoelectric sensors; and (ii) harvesting vibrational energy to power these sensors.

Postdoctoral Research Tasks

The postdoctoral researcher will contribute to the CERAMATHS laboratory's activities within the project, focusing on the development of piezoelectric sensors for vibration monitoring and piezoelectric energy harvesters. A literature review will be conducted to identify the most suitable lead-free piezoelectric compositions for vibration measurements, as well as the geometries offering the highest sensitivity. Lead-free piezoelectric ceramics and/or composites will then be synthesized. Several piezoelectric devices with different levels of geometrical complexity will be fabricated and tested. Additive manufacturing processes, such as fused deposition modelling (FDM) and stereolithography (SLA), will be investigated. The resulting materials and sensors will be characterized in terms of their physicochemical, electromechanical, and vibration-diagnostic properties, in collaboration with the project partners.

Candidate Profile

The candidate must have a PhD in Materials Chemistry, preferably with experience in the processing and/or characterization of piezoelectric ceramics. Experience in instrumentation, measurement techniques, and additive manufacturing would be an advantage.

Keywords

Lead-free piezoelectric sensors; predictive maintenance; energy harvesting; additive manufacturing; piezoelectric characterization.

Funding and Project Duration

Employer: Université Polytechnique Hauts-de-France (UPHF)
Project: Electrical Energy (EE4.0), funded by Hauts-de-France-Region
Start date and duration of the postdoctoral position: 18 months, starting on February 1, 2027.
Monthly gross salary: between €2,970 and €3,119, depending on experience.

Location:

Université Polytechnique Hauts-de-France (UPHF)
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(3) Laboratoire Roberval de l'Université de Technologie de Compiègne