Energy Harvesting for Sensors

Graduate

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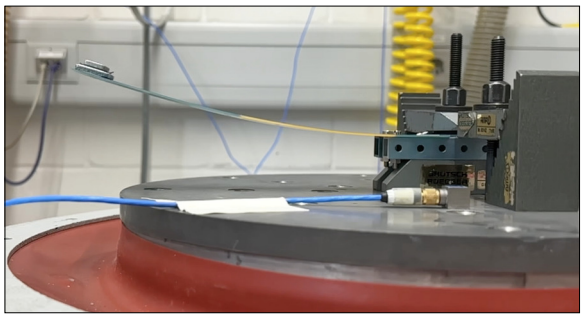
Initial Situation: In rotating machines, reliable power supply for sensors is a major challenge. Cable connections are often complex and prone to interference, while batteries need to be replaced regularly. The goal of this work was therefore to develop an energy harvesting system that operates without external energy sources.
The periodic loads occurring in the borehole of a roller, resulting from the interaction of centrifugal and gravitational forces, were to be utilized. These alternating forces excite a mechanical energy transducer, which converts the motion into electrical energy and thus enables continuous power supply of a wireless sensor system.

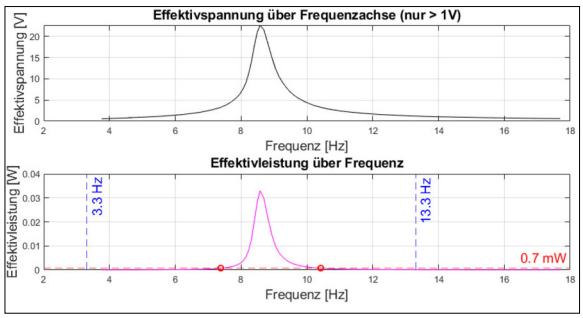
Approach: A piezoelectric bimorph cantilever was used as the energy transducer. It is clamped at the face side inside the borehole and excited into vibration by the resulting force variations. To investigate the performance of the system, shaker measurements were carried out. The results showed that the cantilever generates very high open-circuit voltages above 80 V_{pp} in the resonance range. The obtained output powers were in the milliwatt range, clearly exceeding the average power demand of 700 µW required for the target sensor. For practical testing, a roller demonstrator was additionally built to replicate the motion of a real roller.

Result: The tests on the roller demonstrator confirmed the laboratory results: In rotational speed ranges close to the resonance frequency, the sensor system could be successfully powered. Using a rectifier circuit, a 3.3 V regulator, and a buffer capacitor, a stable output voltage was provided. This enabled continuous operation of the target sensor and even successful establishment of a wireless Bluetooth connection.
The work therefore demonstrates that piezoelectric energy transducers represent a promising solution for self-sufficient sensor supply in rotating systems.

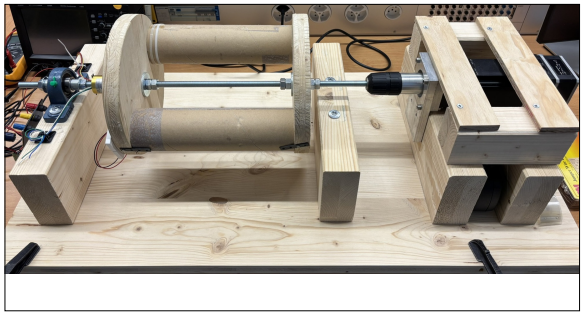
Deflection of the piezo cantilever during the shaker test
Own presentment



Voltage and power response over frequency during the shaker test, clearly showing the resonance
Own presentment



Test setup of the roller demonstrator with the energy harvesting system inside a cardboard tube
Own presentment



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