1. Research project objectives/ Research hypothesis

Piezoelectric generator is a device intended to convert mechanical energy into electrical energy by using the phenomena occurring in piezoelectric materials. Subject of the most recent research are the beam generators built of base material which exhibits no piezoelectric properties and of composite made of piezoelectric ceramics and polymer matrix. Beam structure of the generator is usually achieved by bonding the base material with the piezoelectric composite. Note that the electric energy is acquired only by those parts of the structure which are made of piezoelectric materials as well as bonded joint in beam generators tends to degrade under variable stress and external influences. Those findings are the basis for an innovative design concept of piezoelectric generators, in which self-supporting piezoelectric composite will be applied, thus eliminating the need to introduce the base material. The generator design proposed will enable acquisition of energy by almost the entire beam structure which will lead to an increased effectiveness of energy conversion, compared to traditional generators with bonded beam structure. Eliminating a bonded joint which is sensitive to micro cracks and ageing will extend durability of the generator.

The objective of the project is to carry out a comprehensive analysis of the phenomenon of energy conversion in beam generators with completely integrated composite structure without the role of base material layer in modifications of the chemical composition and spatial distribution of grains or layers of ceramic piezoelectric material in the composite, chemical composition of the polymer matrix and beam structure of the generator. The generator structure will be modified in order to expand its operating frequency bandwidth. Durability tests of the composite generator beams will also be a part of the project.

2. Research project methodology

The project comprises four parts: modelling, computer-aided simulations, laboratory tests related to the material and laboratory tests related to measurements. In modelling, the acceptable consistency of the results of calculations and of experimental tests will be ensured by models of beam composite structures based on Euler-Bernoulli and Thimoshenko theories. Computer simulations will be performed in the ANSYS environment with the finite element method and will cover selected models of composite generators developed in the modelling part, and verified experimentally in laboratory tests. The laboratory tests related to the materials will include research and fabrication of ceramic-polymer particulate composite materials and laminates. In powder synthesis, the classic synthesis in solid and special methods will be used: sol-gel and hydrothermal synthesis. Particulate composites will be made by mixing directly the ceramic phase with polymer, and laminates with methods based on powder suspension and physical dispersion. In laboratory tests related to the measurements, the experiment, observation and comparative analysis methods will be adopted.

3. Expected impact of the research project on the development of science, civilization and society

The results of the project will affect development of the scientific branch of material engineering through development of knowledge on behaviour of ceramic and polymer composites which can be used in processes of converting mechanical energy into electrical one. The influence on development of the branch will be achieved in the following aspects: modification of chemical and phase composition of piezoelectric and polymer phases, modification of the way of distribution of these phases in composite and in area of protection of the environment - by the elimination of lead from piezoelectric phase. All these modifications will lead to increasing the amount of the energy converted in comparison with currently existing composites. The results of the project will also affect development of the scientific branch mechatronics through development of alternative sources of energy, piezoelectric generators, for micro-devices e.g. sensors. This development will be visible by the rise of electrical energy obtained by piezoelectric generators as well as by lengthening the time of the reliable work of these generators. The findings of the project will also add to the development of wireless systems for monitoring of engineering processes or ambient parameters, e.g. temperature, which will influence the growth of technologies and improve the quality of human life.