The manufacturing technology impact analysis of small-power high-speed electric motors to refine their analytical models.

The main scientific goal of the project is the analysis the impact of various physical phenomena caused by the technology used to electrical motor build, mainly related to the degradation of the lamination structure, caused by punching and assembly, and to develop methods to include these phenomena in analytical models of electric motors. First, scientific experiments will be carried out to determine the width of the damaged material zone of the lamination specimen that is the result of the cutting process. This goal will be achieved by using two cutting technologies: punching and laser cutting. The second research goal is the determination of the equivalent magnetic and energetic properties of damaged material, which can be used in circuit models to design and optimize fractional kilowatt electric motors and electrical devices. It should be emphasized that the tests will be carried out based on a non-invasive measurement method, which does not require specialized (and consequently expensive) measuring equipment. The ultimate research goal will be the development methods useful to include the results of these tests in electric motor analytical models.

The project will have significant impact in the field of the fundamental research, consisting in expanding knowledge of physical phenomena associated with the manufacturing technology of electric motor cores and give consideration to preparation of methods including these phenomena in electric motors modeling. The obtained results of research may in the future be used to achieve greater convergence of the measured electromagnetic parameters and losses in the manufactured motors, with those calculated ones at the design stage, especially in energy-saving electric motors. Electric motors and the mechanical devices drive by them, are the basic class of electricity users. It is estimated that around 43 to 46 percent of the world's electricity is used by propulsion systems with electric motors, with induction motors dominating. The core loss constitute a significant part of the total loss and therefore minimizing them has a significant impact on electricity consumption. A specific feature of the core loss is that they also occur at the idle motor run, i.e. when it does not generates mechanical power.

The main questions to be asked when starting to implement the project result from the presented research goals and relate to the possibility of assessing the change in magnetic properties and iron loss of various laminations used to build cores of fractional kilowatt electric motors. The change is a result of usage various cutting and core assembly technologies. In this point of view, it should be hypothesized that these technologies damage ferromagnetic material properties in various degree. The equivalent characteristics determination of magnetic material taking into account a material damage, which will be the basis for analytical calculations of motor parameters, is another problem to be solved. It can be hypothesized that this will require the determination of a characteristics family, assigned to a wide range of magnetic induction and frequency, including frequencies significantly exceeding the nominal one. The most important question concerns the problem, which physical phenomena associated with the motor manufacturing technology adversely affecting its operating parameters, can be mapped in the analytical model and how it will improve the proposed model accuracy, especially in calculating motor loss and its efficiency.

The tests will be carried out for isotropic sheets having a crystal structure, thickness from 0.2 mm to 0.5 mm, with a magnetic field frequency from 10 Hz to 400 Hz. Before taking measurements, the lamination will undergo a cutting process by two technologies: mechanical cutting and laser cutting. The performance of experimental measurements will be the first stage of the project. The measurements carried out will allow obtaining the data necessary to make numerical models of the samples tested. The obtained results will be the basis for determining the proposed analytical formulas and also for the built numerical models of the tested specimens. The second part of the measurements will be performed on a stand that allows determining the impact of the core assembly process on its properties. The third part of the measurements concerns the observation of the crystallographic structure using a microscope. As a result of the observation, it is expected to determine the grain size in raw material and the damaged area near the cut edge. Based on the performed experimental research as well as analysis of measurement results and preliminary calculations performed using numerical models, it will be possible to estimate the width of the damaged zone. This assessment will be used to assess the usefulness and effectiveness of the analytical formulas proposed in the second stage of the project. In the second stage of the project, analytical formulas will be proposed that will allow estimate the width of the damaged zone. Research for machine cores will be supported by numerical simulation of phenomena in the core using the finite element method.

In the final stage of work, the refined motor analytical model taking into account the impact of production technology will be verified on the basis of the numerical model and tests performed for physical models of selected electric motors.