This project is focused on the study of the influence of the application of current pulses on the mechanical and structural properties of the light metal alloys (such as magnesium and aluminum alloy) in the processes of complex strain path. Many studies have shown that the material plasticity can be increased during the Electrically Assisted Forming (EAF) processes of metals, which is the process of the application of current pulses to metals during their forming. However, there is still no consensus on all fundamental mechanisms of this process. Therefore, the aim of this study is to demonstrate for the first time the application of current pulses to metals during the complex strain path processes, a description of these processes from a mechanical and microstructural point of view, and better understanding of the nature of the phenomena occurring during the process mentioned above. In the industry, solutions are sought that can reduce the energy consumption in terms of production processes and fuel consumption of vehicles. One of the modern groups of materials that can contribute to the search for the solutions is aluminum and magnesium alloys. These alloys are lightweight (in relation to commonly used steels) and their appropriate heat treatment can contribute to the high-strength parameters. However, it is well-known that the plastic forming of these alloys (cold and hot forming) is associated with the presence of some drawbacks that increase the production costs, make it difficult, and lengthen it. That is why a promising solution can be EAF. As mentioned above, the application of current pulses during the metal forming process can significantly increase their plasticity and formability while reducing the force needed for their deformation. Moreover, these changes cannot be explained by the simple Joule heating effect, and hence this phenomenon has been so-called, in the past, the electroplastic effect. The advantages of this phenomenon can not only help to form more successfully, e.g., the forming processes of aluminum and magnesium alloys, avoiding defects occurring in the cold and hot forming processes but also can contribute to reducing the energy consumption needed to make a given element. However, ultimately the same theoretical foundations of this phenomenon have not yet been discovered. Despite many studies, it is still not known exactly what is the effect of current pulses is on the mechanical and especially structural properties of the formed metals.
Therefore, the purpose of this project will be to examine more closely the above-mentioned processes. In this context, the following innovative research plan was proposed:
a) In the range of the mechanical testing:
- tension with and without simultaneous application of high-current pulses performed on a plastometer;
- cyclic torsion with and without the simultaneous application of high-current pulses performed on a plastometer;
- tension + cyclic torsion (complex strain paths) with and without the simultaneous application of high-current pulses performed on a plastometer;
b) In the range of the microstructure evaluation:
- evaluation of the selected specimens of the all processes mentioned above using advanced electron microscopy method such as SEM + EBSD, and TEM.
The expected result of the above research is not only to an improved model used to describe the electroplastic effect, especially in the case of the complex strain paths, but also a set of the specific solutions aimed at increasing the material formability during their electrically assisted. EAF may become in the future a very promising technology, hence a better understanding of this process, especially from the microstructural point of view and in the context of different strain states, is necessary.