Electrical machines are responsible for the majority of electricity consumption, including variable-speed drives equipped with permanent magnet excited machines. More and more popular electric drives used in automobiles are contributing to an increasing consumption of electricity.

Important parameters from the performance point of view are: the power to weight ratio of the machine and its efficiency and reliability. All these parameters are required to be as high as possible. Not all types of electrical machines can meet the above criteria, but some geometries have naturally increased performance parameters. High-energy permanent magnet excited machines with an additional excitation circuit seem to have significant research and development potential.

Since its introduction to world markets a first mass-produced hybrid car - Toyota Prius - in 1996, there has been a rapid increase in interest in electric drives in automobiles. Currently, more and more car manufacturers offer hybrid cars - classic examples are: Toyota Prius, Toyota Auris and Yaris in Hybrid edition or Nissan Leaf. The motto of the Lexus company is "Feel the hybrid power". Citroen, Mitsubishi, Peugeot, Porsche and many other manufacturers offer hybrid cars, but it is rarely to see electric cars in Europe. It can be concluded that the hybrid car is a transitional stage between the classic car with a combustion engine and fully electric car. Nevertheless, in Europe today there are electric cars on offer, but their price versus-benefit seems to be excessive. An example is the electric Nissan Leaf and Mitsubishi i-MiEV or BMW i3 or i8.

Electrical machines used in drives of hybrid and pure electric cars are typically high-energy permanent magnet excited synchronous machines, which are designed to obtain high nominal parameters to produce sufficiently high accelerations, while maintaining the smallest possible energy consumption. This translates directly into reduced energy consumption in predefined car cycles.

The authors plan to carry out theoretical, simulation and experimental analysis of modern electrical machines excited by permanent magnets with additional excitation circuits. Such constructions will allow increased efficiency and increased instantaneous acceleration values in particular at low speed, and will assure a high maximum speed for a car. The use of two power supply strategies at the same time; an additional flux from an additional excitation control system and appropriate forcing current in the longitudinal axis of the machine provides the ability to increase torque by flux strengthening – co-interaction with permanent magnets, while increasing the speed there will be applied permanent magnet flux reduction - decreasing flux produced by permanent magnets. This will allow an increase in torque and acceleration achieved in a short time period (by 10 seconds) extensively, and will provide excellent field weakening ability (to "extinguish" the field of permanent magnets to zero). The appropriate control strategy of hybrid machines - optimal balance between d-axis and additional excitation circuit currents- will increase the efficiency of the entire drive system.

According to authors opinion planned research results will allow to start concerted design works on non-typical and energy efficient electrical machines with very high performance capabilities.