Abstract

The habilitation thesis presents the activity and the results of the research obtained, after supporting the PhD thesis, from 1998 until now. The title of the PhD thesis was the "Study of the adjustable brushless synchronous generator" and was presented at the Politehnica University of Timişoara in June 1998.

The habilitation thesis contains the following chapters: motivation, research directions, achievements, the scientific, professional and academic development plan, and finally the bibliography chapter.

The first chapter, motivation, summarizes the didactic and research activity, the results obtained, the cooperation with other universities and the expressed desire to continue the research in the field of electrical engineering at a higher level by obtaining the certificate of habilitation.

In the second chapter the main directions of research are presented: industrial applications of AC electric drives, compensation of reactive energy and superior harmonics to strongly deforming electric consumers, axial electric drive systems for hybrid and electric vehicles, and energy conversion for adjustable wind or hydro applications. For each of the research directions listed, the main achievements are presented.

The chapter of scientific, professional and academic achievements presents the activities carried out within each research direction and the main results obtained in a more detailed fashion.

The Research Direction on Industrial Applications of Variable Speed AC Drives is divided into four subchapters which present concerns regarding the reduction of the active electric energy consumption by using the variable speed, the controlled start of the electric drive systems, the production of electric power with variable asynchronous generators and the artificial load testing of the rotating electric machines. Among the great energy consumers we find the pumping and ventilation systems. Automating these systems and increasing their energy efficiency can be done with PLCs, static frequency converters, communication and data transmission systems. Applying different solutions in practice is a challenge for an engineer but also for a researcher in the field of machine systems and electric drives. Proposed and practiced applications are presented, but some of them are applied even after a long time because of the important investment effort required. Usage of softstarters has caused a qualitative leap in the problem of starting, stopping or braking induction motors with a cage rotor. There have been some theoretical and experimental considerations related to optimization of starting with softstarters. The conclusion is that the most efficient starting method is the one that controls the torque on the shaft. In this case, both the set start time is respected with a fairly good approximation and the set maximum current is not exceeded. On the starting method with voltage ramp and current limitation, current values higher than the set value are reached. In case of starting with a voltage ramp without current limitation, the maximum current values are much higher and the set start time is not respected. The idea behind starting of a power generation system with an variable speed induction generator and a static converter was to find a micro-hydropower structure (MHC) that would allow efficient and fully automated operation with recoverable investments in a range of 5 to 8 years. The maximum load temperature in a rotating electric machine is an essential parameter.

Conventional loading methods require the use of another electric machine coupled to the test machine shaft. The cost of the test equipment and the effective mechanical coupling of the two machines make the conventional method prohibitively expensive, especially for large machines, for vertical rotor (impossible to achieve), or for high speed machines. This was the reason why I approached the topic of research on the artificial loading of rotating electric machines.

The research direction in the field of industrial applications of reactive energy compensation systems and the deforming regime for reducing the cost of reactive energy to depletion comprises two subchapters dealing with the issue of a special type of industrial consumer (a steel mill equipped with furnaces three-phase alternating current arc). During operation, the arc furnace (DC or AC three-phase alternating current) has a variation within very wide limits of the absorbed power, which determines the variation in the required reactive power, the curves of the current and voltage are strongly distorted, generating the appearance of higher harmonics. Due to the inequality of the reactants on the three phases, the unbalanced mode with the flicker effect appears. In order to eliminate these phenomena, it is possible to use synchronous compensators, capacitor batteries and coils on certain harmonics, and the best but also the most expensive variant are the complex active filter systems (SVC) which are controlled by an automatic tracking system in the real time.

Another direction of research, detailed in six subchapters, is represented by axial synchronous machines (with an stator, two permanent magnets rotors and a single inverter for vector control of the both rotors speed) intended for electric hybrids or pure electric vehicle applications. Constructive topology, circuit model, optimal design, control methods, and quasi 3D-FEM analysis were presented for validation of analytical data on machine torque developed. A new family of electric machines is proposed to improve the radial and axial dimensions, with high torque density and high efficiency. The torque capability of the machine with concentrated fractional stator windings and surface permanent magnets has been demonstrated.

The last research direction approached in the habilitation thesis has as theme the theoretical and experimental study of the adjustable electric generators for wind or hydro applications. Fifteen subchapters were presented for the homopolar and homo-heteropolar reactive synchronous generators with stator excitation and for the dual stator windings induction generator with the cage rotor. The concern for homopolar and homo-heteropolar generators with stator excitation research is a natural continuation of the theme approached in the doctoral thesis. Increasing in time of the computing power of electronic computers and the new computational programs with 2D and 3D finite elements, as well as more performant dynamic simulation programs, have enabled the analyzes to be approached at a higher level. I have continued experimenting with a low-power experimental model. The dual stator windings induction generator scheme proposed in this chapter uses an inverter with apparent power lower than the corresponding generator power. The expected ratio between the inverter power and the generator power is 50% in the case of dual stator windings induction generator. The advantage of dual stator windings induction generator is the lack of brushes. Dual stator windings induction generator can be used in variable speed applications. It is possible to extract low power even at low speeds, which cannot be obtained when the generator is directly connected to the grid, or when the generator has an inverter on the excitation

winding and a diode bridge on the main winding. The dual stator windings induction generator typology is an advantageous solution when it supplies unpretentious loads. The inverter on the main winding is used to transfer the active power and also the reactive power required for generator magnetization at low speeds, when the capacitor could not provide enough reactive power. A method to determine the saturated inductance of the dual stator windings induction generator was also developed. Digital simulations and experimental results, in good correspondence, prove the validity of the theoretical considerations.

It is then briefly presented the research directions (existing or some new ones) that I want to address after obtaining the attestation certificate, together with the research teams I belong to and where I will integrate the future PhD students. The references list contains 185 papers, books or invention brevets where at 114 I am coauthor (at the 68 first author).