About the Use of Induction Generators for Micro Hydro Power Plants

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Abstract ***- Induction machine with short circuited rotor is the simplest, robust and lowest cost electrical machine.Existing experience regarding interconnected with the general electro energetic system micro hydro plants, already established the use in such cases of simple and economic hydro mechanical, electricity generating, control and automation equipment was created by that kind of machine. This paper illustrates possibilities of the hydro energy potential utilization for hydro power plants construction on the Bihor county rivers , experiences on how to build and operate a small hydropower , induction generators use and sustainable solutions for small hydropower by in Bihor county, Romania***

Keywords ***- Power generation from renewable resources, distribution system, medium voltage, induction generators***

I. INTRODUCTION

Some of the world's biggest hydroelectric power plants, in terms of both total installed capacity and annual average power generation volume, produce millions of kilowatts and billions of kilowatt hours. At the other end of the scale are small, micro-hydro stations, up to 15 MW. Pico-hydro systems have a capacity of 50 W to 5 kW and are generally used for individuals or clusters of households[1].

In Romania are more than 200 low power hydro generators (synchronous generators) with power less than 4 MW, these hydro generators are practically equipped with the same installations as the big powers hydro generators and for good operation they are provided with automate voltage and speed control, with oil pressure groups and other devices. New electronic automation equipment , destined to the industrial technological processes made possible an integral control system for the low power hydroelectric power plants, in our county Bihor are implemented such a system at HPP Leşu [9].

River projects include turbines, storage pumps and pump-turbines of all types as well as related equipment such as speed governors and performance evaluation and testing. For now it focuses on river power[10,11].The main forces driving activity on the rivers are: new large-scale hydroelectric river projects in Bihor county, on the other, refurbishment and up-rating of existing plants Bihor, Romania. As a result, the work programme focuses on turbine runners and pump impellers, acceptance tests of hydro turbines, control systems testing, and evaluating both cavitations pitting and discharge measurement methods, as well as hydraulic turbine efficiency, vibration, stability, upgrading and rehabilitation. Particle erosion is a potential future topic for other projects[12].

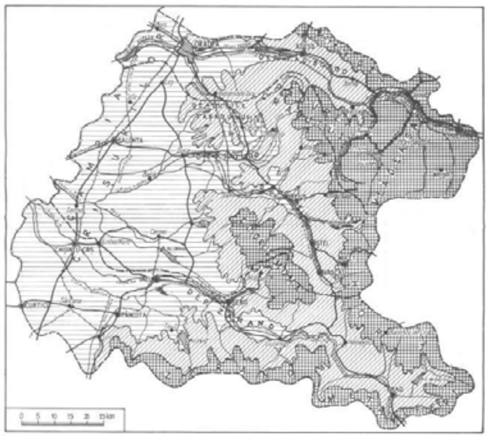

Figure1. Hydrographic reservoir Crisuri

II. RENEWABLE AND ALTERNATIVE ENERGIES

Many countries have taken an active interest in renewable and alternative energy technologies. This includes the more traditional energy sources – like hydroelectric power – as well as the newer ones covering solar photovoltaic, wind turbine systems and fuel cells. This growing interest comes from falling costs and rising yields in this area, as well as the desire to help reduce pollution [12].

Standardization helps these technologies to become marketable by providing a foundation for certification systems, promoting international trade of uniform high-quality products and supporting transfer of expertise from traditional energy systems. The very nature of the renewable energy technologies means that standardization requires a dedicated and on-going effort to keep pace with developments in the various fields[2,3].

In our county Bihor, HPP Lesu is exploited by the Cluj Hydroelectric Power Subsidiary-Electric Plant Crişuri Oradea, that hydroelectric power plant is situated near the village Remeți, Bihor, county Western Carpathians Mountains, Romania. The HPP Leşu is placed at the foot of the Leşu dam, which dam belongs to ANAR (Administratia Nationala Apele Romane) and has an installed power of 3,4 MW[11].

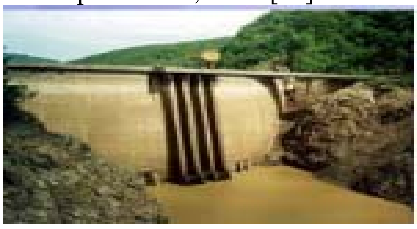

Figure 2. Hydro power plant Leşu

The development works from the Crisul Repede hzdrographical basin began in the zear 1973 on the Crisul Repede river and its left tributaries: Drăgan, Iad andSăcăieu. Seven hydropower plants have been completed so far, summing up an installed capacity of 208 MW, one pumping station with an installed capacity of 10 MW, which allows that during an average hzdrologic year it should get to an electric power generation of 423 GWh. The HPP Leşu is the first objective commissioned in that area in the year 1976. The works of HPP Fughiu are under construction, which will have an installed capacity of 10 MW. The Remeți hydropower plant has an installed power of 100 MW-2 hydropower units with a power of 50 MW each. The water from the Dran dam reaches gravitationally this plant through galleries and secondary headraces having a total length of 26 km.

Figure 3. Hydro power plant Remeți

The Dragan dam located on the river with the same name is a 120 m and 442 m wide high arched double curved concrete dam, its width being the largest in Romania, this dam allows the storage of a volume of about 112 million m^3 of which a contribution of 40% comes from the secondary catchments from the hydro graphic basins of the lad, Dragan and Sacaieu rivers. The HPP Munteni I is an underground power placed on the right bank of the Iadului Valley and it has an installed power of 2x29MW, of which precincts there is also a micro hydropower plant Munteni II, with an installed power of 0,63 MW.

The HPP Lugasu is located on the right bank of the Crişul Repede river and has an installed power of 2x9MW, it uses the water stored in the Lugasu lake, of which volume is about 63,5 million m^3. The Lugaşu dam is a 36.5 m high reinforced concrete spillway dam. The HPP Tileagd is located on the right bank of the Crişul Repede river and has an installed power of 2x 9MW and it uses the water stored in the Tileagd lake, of which volume is about 52,9 million m^3 and the dam is a 36,5m high reinforced concrete spillway.

The Lugaşu and Tileagd lakes represent an important reserve of water for regulation of the flow discharge on the Crişul Repede river and for supply of the drinking and industrial water of the Municipality of Oradea.

The HPP Săcădat is a diversion power plant and is located on the Crişul Repede river, it has an installed power of 2x5 MW.

III. INDUCTION GENERATORS FOR MICRO HYDRO POWER PLANTS

For the specific aspects of induction generation operation at micro HPP connected to the National Power System a several studies was undertook , like: excitation reactive energy compensation, self-excitation, load loss racing, plant connection to national electroenergetical network[3,5].

If the system conditions impose it, the required compensation of load reactive energy must be assured by connecting condensers at the induction generator terminals. The most restrictive condition in the sizing of condensers is to avoid the appearance of dangerous voltages, due to load compensation condensers at induction generator disconnection from national system.

TABLE1. Micro hydro power station in function, in Bihor county and neighboring counties

Crt. No.	NAME	RIVER	Pi (KW)
BIHOR			
1	Astileu I	Crisul Repede	2.800
2	Astileu II	Crisul Repede	1.040
3	CET Dam	Crisul Repede	680
4	CET Restitution	Canal CET	215
5	Boga 2	Boga	778

6	Piatra Bulz	Boga	1.754
7	Budureasa	Nimaiesti	731
8	Nimaiesti 4	Nimaiesti	1.180
CLUJ			
9	Manastirea Dej 1	Somesul Mic	378
10	Manastirea Dej 2	Somesul Mic	366
11	Huza 1	Huza	200
12	Huza 2	Huza	400
13	Somesul Rece 2	Somesul Rece	280
14	Salasele 1	Salasele	25
15	Salasele 2	Salasele	25

The calculations made from the case study of hydroelectric plant, show that there can be allowed compensation condensers which only partially compensate the necessary reactive. So if the limit conditions are: maximum allowed over speed 1.5 n_{nom} and maximum.

Allowed over voltage 1.5 U_{nom} compensation condensers can improve the factor to values of about 0.92 in rated operation conditions. The local compensation of the required reactive energy in rated operation conmditio0ns can be made if at load loss by disconnection from the system, the electrical method is adopted.

Self-excitation of autonomous induction machine with capacitive character load is theoretically well known. The steady-state voltage, at induction generator disconnection from national electroenergetical network depends on the generator characteristics, load and drive speed. The voltage value is as much greater as the drive speed is greater, the non-reactive load and inductive load are smaller and the capacitance is greater, the parameters of steady state regime, without resistive load for laboratory studied induction generator are presented .

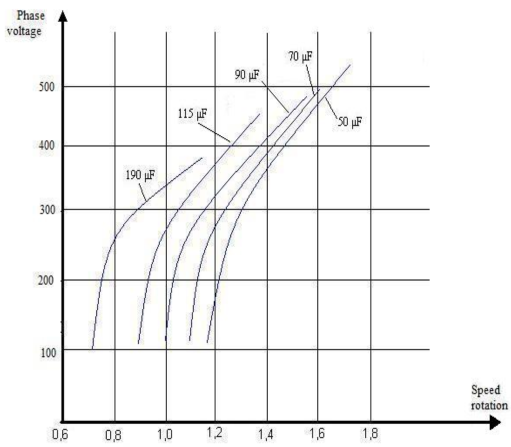

Figure4. Phase voltage-speed rotation

An economic solution for plant's connection is the use of induction generator with rated voltage of 0,4 kV , eliminating thus the 6kV equipment.

As in Romanian induction machines production machines production there aren't induction machines of 0,4 kV for all necessary powers , there is proposed that the stator winding of induction machines , meant initially for 6kV , to be wind to 0,4 kV.

The generator operates electric scheme for HPP Leşu, a step-up transformer, 6.3 MVA, 6.3/20 kV allows the energy evacuation to the local grid. Two aerial electrical lines of 20 kV achieve the link with the grid. The auxiliary services are mainly provided from the generator terminals, by means of a step-down transformer, 6.3/0.4 kV; as a reserve, they may be provided from the local grid by means of a 20/0.4 kV transformer .

The analysis shows that this operation is technically realistic, economic and accessible. The winding for 0,4 kV implies:

- better use of the slot , by the increase of the available space for the copper and reduction of insulation
- winding working temperature reduction by a better evacuation of the heat through insulation
- safety increase
- winding mechanical rigidity increase

To compensate the reactive power taken from grid, capacitor batteries, mounted in parallel at the generator terminal , are used. The capacitors are power capacitors impregnated with synthetic chlorinated oil,standard type.

The value of maximum over-voltage due to self-excitation , which occur in the capacitors in case of group racing , when the generator is disconnected from the grid for different reasons , and the water intake to the turbine continues , is limited at 3,5 times the rated voltage , assuring the compensation of the power factor at about 0,85 for generators of 300-500 rpm , respectively 0,9 for generators of 750-1000 rpm.

The standard type induction generators are provided with a thermal-control system , especially conceived to assure the automatic supervision of the thermal state of microhydrounit and of the signalizing and transmission of any pre-emergency state due to thermal causes. For temperature sensing ten transducers are used , placed in different machine parts. As a result of shown above standardization , the provision with materials and the fabrication technologies of these machines are simplified and their prices are reduced.

By the design of a relatively reduced number of standard dimensions, the covering of a large range of power and speed, imposed by the specific hydraulic requirements of the micro hydro plants, was achieved[6,7].

The fabrication of a standard type induction hydrogenerators range is the answer to the urgent need of the national economy to capitalize completely and with minimum investments the hydroenergetical potential, an important renewable energy source[8].

IV. CONCLUSIONS

The growing importance of preserving the environment and the role electrotechnical standardization has to play to foster sustainable development. It is our responsibility to contribute actively to the evolving standards framework for the benefit of the environment. For this purpose, with respect to product-related standards, we must continuously assess and improve new and existing standards in view of reducing adverse environmental impacts over the whole life-cycle of products.

It also has to do with electrical energy efficiency, ensuring efficient production, transmission, distribution and use of electrical energy brings positive results. In terms of electricity generated from burning fossil fuels or coal, it diminishes the overall impact on the environment. In terms of consumers, it helps to keep energy costs down. The technical – economic premises to a wide introduction generators in micro hydro power plants connected to the grid , do exist. The theoretical and experimental study allowed the establishment of technical conditions necessary for a normal operation of a induction generator in hydropower stations.From economic and reliability reasons it is recommended to use in hydropower plants induction machines of 0.4 kV.The real-case example presented in this paper has shown that it is possible to obtain significant reductions in the electric power generation in hydropower plants. These results can be associated to the knowledge of the power flow solutions in order to establish sound criteria for selecting the best radial configuration according to a specified objective function.

REFERENCES

[1] Helga Silaghi , *"Contributions Regarding the Power Flows in Electrical Drive Systems with Induction Machine and Their Effect on Energy Quality ," Ph.D. thesis ,* University of Oradea, Romania 1999.

[2] H.Andrei, M.A.Silaghi, G.Chicco, N.Coroiu and M.Popa, *"Investigating on the Possible Radial Structures of a Real Medium Voltage Distribution System ," 7th WSEAS International Conference on Systems Theory and Scientific Computation (ISTASC'07), Athens, Greece*, pp. 306-309, 2007

[3] Helga Silaghi, *"Energy Quality in Electrical Drive Systems with Induction Machine,"* Treira Publishing, Oradea, 2000.

[4] Helga Silaghi and M.A. Silaghi, "*Electrical Drive Systems with Induction Machine. Data Acquisition and Informatic Techniques,"* Treira Publishing, Oradea, 2000.

[5] R.J. Sarfi, M. M. A. Salama, and A.Y. Chikhani, "*A survey of the state of the art in distribution system reconfiguration for system loss reduction*," *Electric Power Systems Research* , vol. 31, pp.61-70, 1994

[6] M. E. Baran, and F. F. Wu, "*Network reconfiguration in distribution systems for loss reduction and load balancing*," *IEEE Trans. on Power Delivery* vol. 4, pp. 1401-1407, 1989

[7] V. Parada, J.A. Ferland, M. Arias, and K. Daniels, *"Optimization of electrical distribution feeders using simulated annealing," IEEE Trans. on Power Delivery*, vol. 19 (3), pp. 1135-1141, 2004

[8] H.Andrei**,** F.Spinei, C.Cepisca, M.A.Silaghi, V.Dogaru, Helga Silaghi, M.Popa, *"A method for Optimization of the Power factor for Nonlinear Receptors ," Proceedings of 6th RSEE, Annals of University of Oradea, Romania, 2006*, pp. 132-135, ISBN 1841-7221

[9] Hydro Universe IV, 3(15) July-September 2006, Romania

[10] River Basins Management Plans – National Report 2004 Romania – River basin characteristics

[11] http://www.rowater.ro

[12] http://www.europa.eu.int