ANALYSIS OF FUNCTIONAL STABILITY OF THE TRIPHASED ASYNCHRONOUS GENERATOR USED IN CONVERSION SYSTEMS OF A EOLIAN ENERGY INTO ELECTRIC ENERGY

Ion Voncila, Cristian Munteanu, Razvan Buhosu, Marcel Oanca

Faulty of Electrical Engineering and Computer Science, University "Dunarea de Jos", Domneasca street, no. 111, 800008 Galati, Tel, Fax: 460182
email: ion.voncila@ugal.ro

Abstract : This paper presents a study of the influence of the main perturbation agent over the functional stability of the triphased asynchronous generator (for the two alternative: with coiled and short circuit rotor), used for the conversion systems from a eolian energy into electric energy.

Keywords : triphased asynchronous generator.

1. INTRODUCTION

Since triphased asynchronous generators are mainly used in conversion systems of a eolian energy into electric energy, their functional stability represent is of great importance. As a first step, the factors that radically affect the functional stability of these generators have been established. Thus, it was decelat the powerful influence of the capacitor bank – that provides the necessary reactive power for the magnetization of the ferromagnetic core – over the functional stability of the triphased asynchronous generator with short circuit rotor.

The functional stability is greatly influenced by the charge character (type) as well. The experimental work emphasized – through the functional features – the way these parameters influence the stability area of the asynchronous generators. As far as triphased asynchronous generators with coiled rotor are concerned, the controllable blind power was analyzed the analogy being made with the situation of the necessary controllable generating capacity for of the triphased asynchronous generator with short circuit rotor.

2. THE INFLUENCE OF THE CONTROLLABLE EXCITATION OVER THE FUNCTIONAL STABILITY OF THE TRIPHASED ASYNCHRONOUS GENERATOR

2.1 Triphased Asynchronous Generators With Coiled Rotor

The group of external features designed for R type of charge was analyzed, for two values of the generation power.

The tests were made by the help of the montage in Fig. 1 where:
V_M – magnetoelectric voltammeter (0 ÷ 600)[V];
A_M – magnetoelectric ampermeter (5 ÷ 10)[A];
A_{EM} – magnetoelectric ampermeter (0,006 ÷ 6)[A];
R_{hp} – start rheostat 11[Ω]/10[A];
R_{hc} – field rheostat 600[Ω]/1[A];
ATT – triphased autotransformer;
A_{EG} – magnetoelectric ampermeter (2 ÷ 10)[A];
V_{EG} – magnetoelectric voltammeter (75 ÷ 600)[V];
TM – checking case QN10;

This paper was recommended for publication by Dumitru CĂLUEANU

K_1, K_2 – triphased switch;
Hz – reed frequency meter (20 ÷ 100)[Hz];
R_s – triphased rheostat 220[Ω]/5[A];
M – shunt DC motor P_N = 1k[W];
GA – triphased asynchronous generator with cioled rotor .

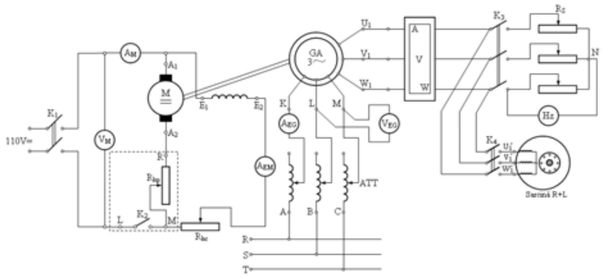

Fig. 1

The results are represented in the table below:

Table 1

U_{ex} [V]	I_{ex} [A]	U_{GA} [V]	I_{GA} [A]	n [rot/min]	P [W]
32,5	4	52	0,48		100
31,5	4	50	0,51		110
31	4	49	0,55		115
29	4	46	0,58		120
28	4	43	0,66		125
24,5	4	36	0,75		125
21	4	32	0,82	1550	115
10	4	10	1		50
37	5,2	59	0,84		215
35	5,2	55	0,88		220
33,5	5,2	52	0,95		220
27	5,2	39,5	1,1		180
22	5,2	30	1,2		175
18,5	5,2	23	1,25		120

The group of characteristics is represented in the chart below:

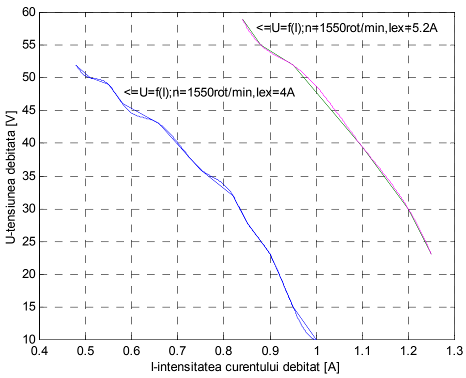

Fig.2 $U = f(I)$ The group of external characteristics of the asynchronous generators with coiled rotor

2.2 Triphased asynchronous generator with short circuit rotor

The montage used in this case is represented in *Fig.3*, where:
ACS 200 – frequency converter ABB;
C – condensator battery;
TM – checking case K505;
Hz – reed frequency meter (20 ÷ 100)[Hz];
R_s – load triphased rheostat 220[Ω]/5[A];
GA – triphased asynchronous generator with short circuit rotor;
MA – triphased asynchronous motor with phase-wound rotor;
K_1, K_2 – triphased switch.

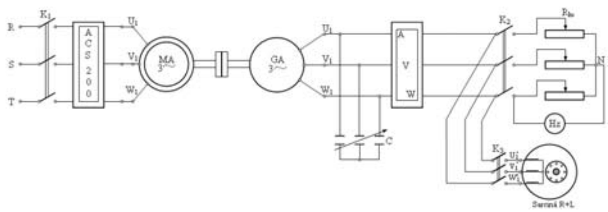

Fig.3

The test results for two values of the generating capacities, Cf = 34 [μF], Cf = 40 [μF] for a arbor speed equivalent to the supply of the primary engine (a triphased asynchronous engine) from a triphased system with f = 50[Hz] frequency. (by the help of a frequency converter ACS – 200) and R type given power are represented in the table below:

Table 2

U [V]	I [A]	P [W]	n [rot/min]
244	1,25	315	1180
230	1,375	320	1170
218	1,5	330	1167
206	1,625	330	1176
196	1,75	330	1195

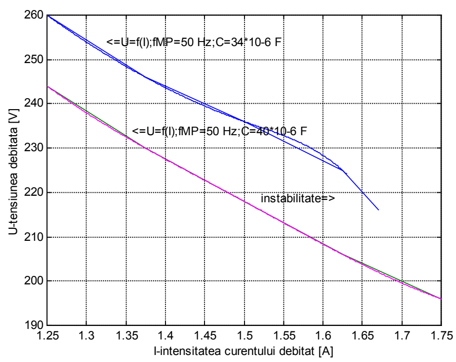

Fig.4 The group of external characteristics of a triphased asynchronous generator with short-circuited rotor for $f_{MA} = 50[Hz]$

If the charge remains the same, but the primary engine's supply frequency is f = 48[Hz], for the two capacity values above, the test results are modified as follows:

Table 3

U [V]	I [A]	P [W]	n [rot/min]
258	1,275	330	1252
248	1,375	340	1245
232	1,5	350	1243
216	1,625	355	1250

$C_f = 34[\mu F],\ U_0 = 330[V],\ n_0 = 1280[rot/min];$

In this case, the group of external characteristics is represented in the chart below:

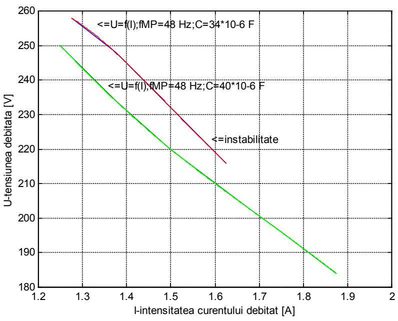

Fig.5 The group of external characteristics of a triphased asynchronous generator with short-circuited rotor for $f_{MA} = 48[Hz]$

3. THE CHARGE'S INFLUENCE OVER THE FUNCTIONAL STABILITY OF THE TRIPHASED ASYNCHRONOUS GENERATOR

One of the fundamental conclusions of this study is that the type of the charge connected to the asynchronous generator's borne may also radically influence the functional stability of this type of generator, through the modification of the reaction field.

In this case, the analysis was made for two types of charge:

- Purely ohm charge (RS - Symmetrical triphased rheostat 220[Ω]/5[A]);
- Ohm-inductive charge (represented by the stator winding of a asynchronous engine with short circuit rotor having PN = 0,55[KW]).

3.1 Triphased asynchronous generator with coiled rotor

The results experimental obtined for triphased asynchronous generator with coiled rotor are synthesized in the tables below:

- Table 4 - constant wind and charge R-type variable;
- Table 5 - constant wind and charge R-L - type.

Table 4

$U_0 = 64[V],\ I_E = 4[A],\ n_0 = 1600[rot/min];$

n [rot/min]	U [V]	I [A]	P [W]	f_{GA} [Hz]	TIP SARCINĂ
1600	50	0,73	120	85	**R = var.**
	45	0,73	130		
	34	0,71	118		
	29	0,66	100		

Table 5

$U_0 = 64[V],\ I_E = 4[A],\ n_0 = 1625[rot/min];$

n [rot/min]	U [V]	I [A]	P [W]	f_{GA} [Hz]	TIP SARCINĂ
1625	60	0,1	20	85	**R - L(MA)**

For experimental date obtined, scribe external characteristic of the asynchronous generators with coiled rotor:

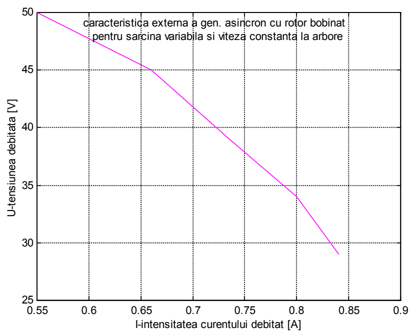

Fig.6 $U = f(I)$ External characteristic of the asynchronous generators with coiled rotor for variable charge (R) and constant speed a wind

3.2 Triphased asynchronous generator with short circuit rotor

The same tests were done for the triphased asynchronous generator with short circuit rotor. The results for the two values of the bank of capacitors (Cf = 34[μF], Cf = 40[μF] when the speed of the primary engine's arbor was kept at a constant value where the frequency of the values supplied by the generators is 50[HZ], are synthesized in the tables below:

- Table 6 – R - type controllable charge and Cf = 34[μF];
- Table 7 – R - L type controllable charge and Cf = 34[μF];
- Table 8 – R - type controllable charge and Cf = 40[μF];
- Table 9 – R - L type controllable charge and Cf = 40[μF];

Table 6

$C_f = 34[\mu F],\ U_0 = 122[V],\ n_0 = 1085[rot/min],\ f_{GA0} = 54,5[Hz];$

n [rot/min]	U [V]	I [A]	P [W]	f_i [Hz]	f_{GA} [Hz]	TIP SARCINĂ
1034	146	0,73	106	50	50	**R = var.**
	136	0,73	100			
	128	0,71	89			
	106	0,66	70			
	84	0,615	59			
	64	0,43	28			

Table 7

$C_f = 34[\mu F],\ U_0 = 122[V],\ n_0 = 1085[rot/min],\ f_{GA0} = 54[Hz];$

n [rot/min]	U [V]	I [A]	P [W]	f_i [Hz]	f_{GA} [Hz]	TIP SARCINĂ
1034	124	0,26	10	50	51,5	**R - L (MA)**

Table 8

$C_f = 40[\mu F]$, $U_0 = 132[V]$, $n_0 = 1085[rot/min]$, $f_{GA0} = 54,5[Hz]$;

n [rot/min]	U [V]	I [A]	P [W]	f_i [Hz]	f_{GA} [Hz]	TIP SARCINĂ
1057	198	0,9875	195	50	50	**R = var.**
	180	1,1125	200			
	160	1,175	185			
	140	1,2625	160			
	120	1,025	130			
	98	0,9	87,5			
	78	0,79	66			

Table 9

$C_f = 40[\mu F]$, $U_0 = 132[V]$, $n_0 = 1085[rot/min]$, $f_{GA0} = 54[Hz]$;

n [rot/min]	U [V]	I [A]	P [W]	f_i [Hz]	f_{GA} [Hz]	TIP SARCINĂ
1057	118	0,36	10	50	52,5	**R - L(MA)**

In this case a graph representing the external features is necessary for a better representation of the triphased asynchronous generator with short circuit rotor functioning, in the conditions described above.

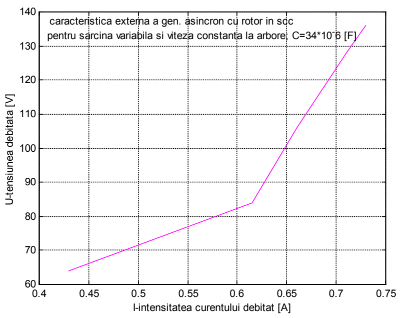

Fig.7 $U = f(I)$, $C_f = 34[\mu F]$ The triphased asynchronous generator with short circuit generator's external feature for R - type controllable charge and constant wind speed

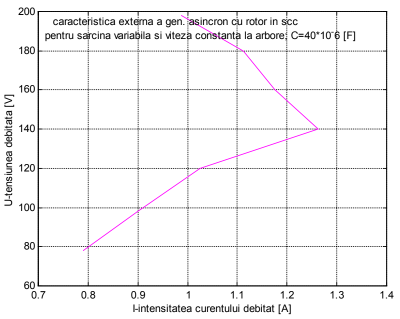

Fig.8 $U = f(I), C_f = 40[\mu F]$ The triphased asynchronous generator with short circuit generator's external feature for R - type controllable charge and constant wind speed

4. CONCLUSION

The following conclusions may be drawn from this test:

1) In the case of the triphased asynchronous generator with coiled rotor, when the intensity of the generation power is increased, the area of stability narrows, although the system's potentiality also increases (the tension and power value are higher, therefore the power supplied to the charge is higher);

2) In the case of the triphased asynchronous generator with short circuit rotor, for a better functional stability, the proper dimensioning of the bank of capacitors (for a certain supplied power) is necessary, as well as the dynamic changing – over of the bank of capacitors in the case of charge fluctuations;

3) For the almost constant (given generation power) reactive power supplied to the asynchronous generator with short circuit rotor, the stability area narrows once the arbor speed decreases (with a decreased wind speed);

4) A temporary rise of the speed of the primary motor's arbor appears with the loss of functional stability

5) The triphased asynchronous generator with coiled rotor is more or less influenced by a controllable charge that influences to a greater extent the triphased asynchronous generator with short circuit rotor;

6) Within the external features there are inflexion points representing the limit value above which the generator functions totally different.

5. REFERENCES

D.M. Eggleston, F.S. Stoddard – *Wind turbine engineering design,* Van Nostrand Reinhold Company New York 1986;

V. Ilie, L. Almaşi, şa – *Utilizarea energiei vântului,* Ed. Tehnică, Bucureşti, 1984;

Kovacs Pal – *Analiza regimurilor tranzitorii ale maşinilor electrice,* Ed. Tehnică, Bucureşti 1980 ;

R.J. Harrington, F.M.M. Bassiouny – *New Approach to Determinate the Critical Capacitance for Self - Excited Induction Generators,* IEEE Trans. on Energy Conversion, vol. 13, no.3, sept. 1998, pp.244 - 250;

Colliez, C., Tounzi, A., Piriou, F. – *Vector Control of a Autonomous Induction Generator connected to a PWMRectifier.* EPE `97, Trondheim, Norvegia, vol. 2, pp. 711-716;

Alan, I., Lipo, A. T. – *Control of a Polyphase Induction-Generator/ Induction- Motor Power Conversion System Completely Isolated from the Utility.* IEEE Trans. On Ind. App., vol.30, no.3, may/june 1994, pp. 636-647;

Florin Iov – *Stadiul actual în conversia energiei eoliene (Referat nr.1 – în cadrul pregătirii tezei de doctorat)* martie 1998;

Florin Iov – *Studiul ansamblului turbină eoliană – generator asincron autoexcitat (Referat nr.2 – în cadrul pregătirii tezei de doctorat)* iunie 1999;