TEKA Kom. Mot. i Energ. Roln. – OL PAN, 2011, 11, 229–235

THE EFFICIENCY ANALYSIS OF AN ASYNCHRONOUS GENERATOR SUPPLYING SINGLE-PHASE RECEIVER SETS IN AN AGRICULTURAL FARM

Piotr Makarski, Marek Ścibisz

Ph.D.Eng., University of Life Sciences in Lublin, Department of Technology Fundamentals

Summary. The article presents the analysis of efficiency changes of an asynchronous generator supplying single-phase receiver sets. The laboratory stand was described as well as the methodology of investigations. On the basis of the investigation results, the influence was evaluated of the generator's size and character on the efficiency of its work.

Key words: asynchronous generator, efficiency of generator.

INTRODUCTION

A modern agricultural farm is usually highly mechanized. Some of the works are facilitated by machines and devices powered with electric energy. The network is the general source of electric energy due to the fact that almost the whole area of Poland is supplied with professional energy network. It has been systematically upgraded in urbanized areas and has been modernized to the present valid conditions. In rural areas the situation is less controlled.

The diffusion of energy consumers raises the individual costs of restructuring of energetic lines. The majority of these nets are guided by aerial lines. This fact has caused an increase of supply failures. The lack of possibility of bilateral lead supply, aiming at the continuous supply, results in the application of independent sources of energy.

The electric generator is the most often used spare source of electric energy. It is driven by a combustion engine. Thus, there has been observed the mechanical and then the electric processing of the burning energy. These changes have proceeded with definite efficiency together with the changes of added energy receiver sets. Therefore, the aim of the investigations was the description of energetic transformation efficiency depending on the generator's activity.

ASYNCHRONOUS GENERATOR

An asynchronous power generator consists of two basic pieces [5, 9]: stator and rotor (Fig. 1).

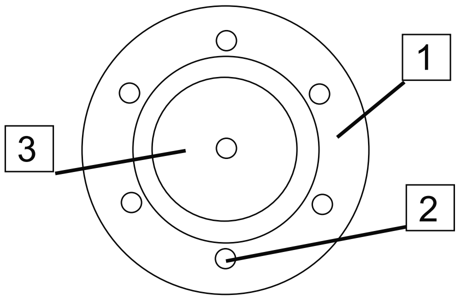

Fig. 1. The building diagram of an asynchronous machine:
1. stator, 2. stator winding, 3. rotor

Stator (1) is a motionless unit in which the winding (2) is placed. The stator winding is the source of circular whirling electromagnetic field. Rotor (3) is a movable unit placed inside the stator. From here the magnetic field influence on rotor is generated.

The magnetic field works with the speed called synchronic. It is produced due to passive energy. It is delivered to the generator from the battery of condensers.

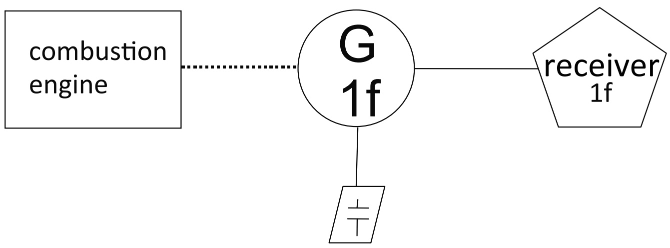

Fig. 2. The diagram of electric generator building

To be driven, the rotor needs the help of combustion engine. If the rotor of a current generator is driven with a higher speed than the synchronic speed, electric energy is generated in the winding.

LABORATORY STAND

Measurements were conducted on the laboratory stand (Fig. 3) made at the Department of Technology Fundamentals at the University of Life Sciences in Lublin. For investigations the single-phase asynchronous generator (1) was used, the type EC 2000 about the nominal power P_n = 1.7 kW, the indicative power S_n = 2 kVA, the nominal voltage U_n = 230 V and the nominal intensity of current I_n = 7.5 A.

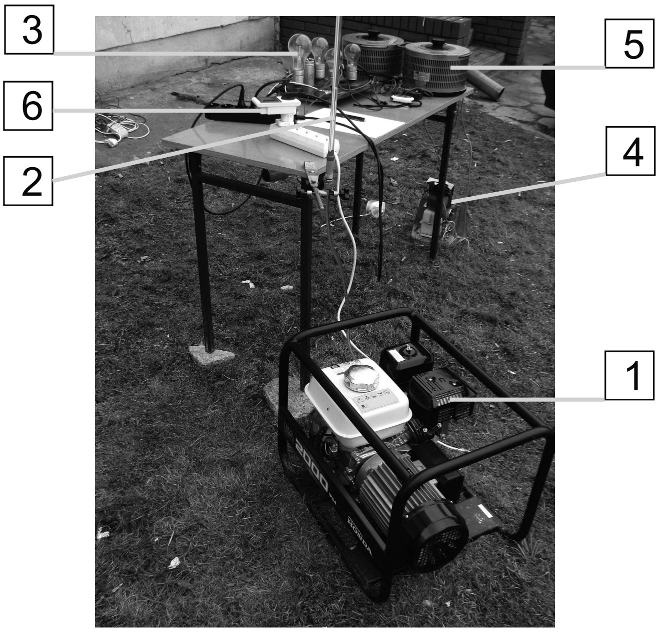

Fig.3. The laboratory stand to measure the efficiency of power generator:
1. power generator, 2. arrangement of fuel measurement, 3. the resistor duty,
4. the inductive duty, 5. autotransformers, 6. the measure of power net parameters

The fuel arrangement in the engine was modified, reinforcing the carburettor across the scaled burette (2). This allowed for the measurement of definite doses of fuel. The time of burning of the tested gob of fuel was measured using the stopper. Resistor (3) was used during the work of the generator (heating spiral casings 1000W and 1200W, bulb about power 200W, 150W, 75W and 40W) and inductive units (4) (throttles from lamps 125W and 250W). The autotransformers (5) were applied for the adjustment of the resistor and inductive work. The versatile power net measurement parameters were used for the measurement of the generator's work.(6).

METHODOLOGY

For the assessment of the efficiency of processing, the quantity of thermal energy (Q_p) received after burning the dose of fuel and the quantity of electric energy (W_p) produced in the power generator were taken into consideration. The thermal energy was evaluated on the basis of the volume (V) of the used fuel as well as the fuel's value (c_p):

$$Q_p = V * c_p, \text{ [J]}. \quad (1)$$

The quantity of electric energy W_p was marked on the basis of the measured power (P) and the time of burning (t_s) of the definite quantity of fuel (V):

$$W_p = P * t_s, \text{ [J]}. \quad (2)$$

The efficiency of processing was marked on the basis of the dependence:

$$\eta = Q_p / W_p. \tag{3}$$

The unleaded petrol Pb95 was used in the investigations. The fuel value depends both on the manufacturer and the distributor of fuel and it remains in the range of 29-38 MJ/m^3 [11, 12, 13, 14].

The fuel value was accepted as 32 MJ/m^3 [6]. It was analyzed during the burning of 5 cm^3 of the fuel.

THE RESULTS OF INVESTIGATION

In the first phase of investigations the generator was put under resistance load. The work was altered from idle state to 1.07 of the nominal power of the generator. The results of investigations are presented in Table 1.

Table 1. The investigations results of asynchronous generator put under resistance load

P, W	t_s, s	W_p, J	Q_p, J	η, -
0	27.4	0	160000	0.000
200	26.3	5267	160000	0.033
396	24.5	9681	160000	0.061
587	22.4	13129	160000	0.082
857	20.7	17718	160000	0.111
1130	18.9	21351	160000	0.133
1384	18.7	25887	160000	0.162
1709	16.0	27344	160000	0.171
1825	15.0	27441	160000	0.172

Then the resistor-inductive duty was added to the generator. It was provided with the stable value of power in the circuit circa 1000 W as well as circa 500 W and the inductive duty was altered.

The results of measurements were introduced in Tables 2 and 3.

Table 2. The investigations results of asynchronous generator for resistor - inductive duty for P≈1kW

$\cos\phi$, -	t_s, s	W_p, J	Q_p, J	η, -
0.87	20.7	21901	160000	0.137
0.90	19.9	21063	160000	0.132
1.00	18.9	19477	160000	0.122

Table 3. The investigations results of asynchronous generator for resistor - inductive duty for P≈0,5kW

$\cos\phi$, -	t_s, s	W_p, J	Q_p, J	η, -
0.50	16.0	8405	160000	0.053
0.55	18.5	9780	160000	0.061
0.65	18,9	10345	160000	0.065
0.85	20.7	11332	160000	0.071
1.00	22.4	11862	190000	0.074

THE ANALYSIS OF INVESTIGATION RESULTS

The results of the performed analysis are shown on the graphs of efficiency (η) changes due to the changes of power (P) duty or due to the changes of coefficient power ($\cos\phi$).

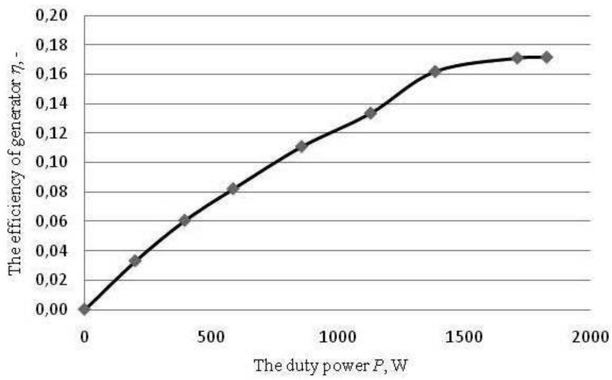

Fig. 4. Graph of efficiency changes of the generator due to the change of duty power

The growth of the generator duty causes the growth of efficiency of energy processing. The maximum efficiency 17.2 % was reached for the duty of nominal power 1.7 kW. The efficiency of energy processing (η) has grown in approximation linearly in the range of power (P) from 0 to about 1400W.

The further growth of power causes the already insignificant growth of efficiency. The change of efficiency in function of duty power for the power aggregate runs along with the efficiency of standalone electric generator in function of duty power.

For a typical generator, efficiency initially grows rapidly with duty power, however, in the wide range of duties it stays practically on the same level [2, 4]. The efficiency of the power aggregate in function of the duty moment is dominated with efficiency of combustion engine. The efficiency of combustion engine grows in function of the duty moment, initially slowly, and then after the achievement of maximum, it drops slightly [1, 7].

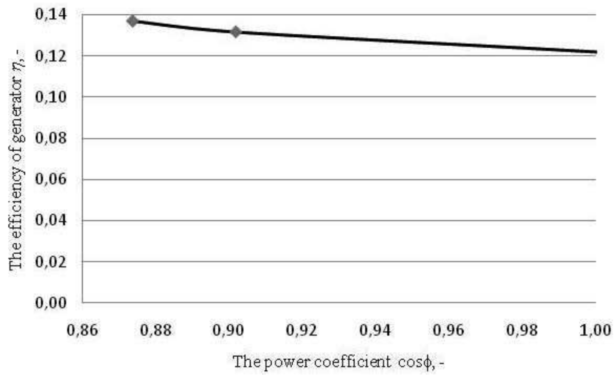

Fig. 5. The graph of efficiency changes of the generator due to change of power coefficient for duty the P ≈ 1000 W

Fig. 5 represents the change of the power efficiency of aggregate in function of power coefficient, for solid power put under load generator, even 1000W.

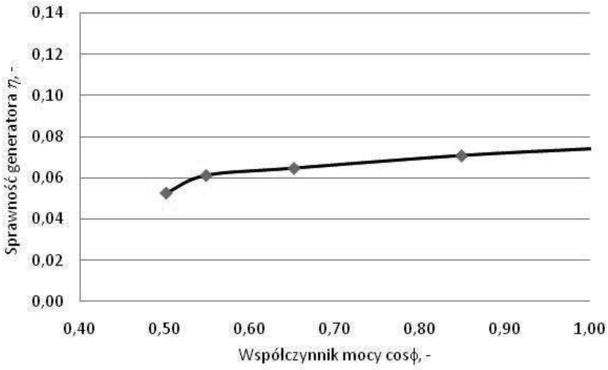

Fig. 6. The graph of efficiency changes of the generator due to change of power coefficient for duty P ≈ 500 W

The efficiency of generator grows up along with the value of power coefficient. With the growth of the *cos*ϕ from 0.5 to 1.0, the power efficiency of the aggregate grows up from 5.3 % to 7.4 %. This results in the fact, that together with the growth of power coefficient, with stable circuit power, the value of passive current diminishes, which causes the decrease of the duty losses.

CONCLUSIONS

The conducted investigations have shown that the efficiency of single-phase generator of small power is low. The maximum value reached was 17.2 %.

The most effective use of energy contained in the fuel is possible by supplying sets of resistor character. So the power generator can be used for the supplying of heat lighting or convective heating devices.

The generator efficiency is the highest by supplying duty approximate to indicative power of the generator. Therefore, from the point of view of efficiency, the power of electric aggregate needs to be correlated with the power of supplying receiver sets, so as to set the work from approximate to indicative power. However, this involves a release of pollution to the environment [3, 8, 10].

The supplying of the receiver sets with the resistor - inductive (the RL character) promotes the work efficiency of the electric generator and reduces the power coefficient. It was purposeful to use the arrangements for passive power compensation.

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ANALIZA EFEKTYWNOŚCI GENERATORA ASYNCHRONICZNEGO ZASILAJĄCEGO ODBIORNIKI JEDNOFAZOWE W GOSPODARSTWIE ROLNYM

Streszczenie. W artykule przedstawiono analizę zmian sprawności generatora asynchronicznego zasilającego odbiorniki jednofazowe. Opisano stanowisko badawcze i metodykę badań. Na podstawie przeprowadzonych pomiarów dokonano oceny wpływu wielkości i charakteru obciążenia na efektywność pracy generatora.

Słowa kluczowe: generator asynchroniczny, sprawność generatora.