Study of Supply Installation for Ozonation System of Wind Generator

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Abstract – **The applications of ozone are widely used in many industries, agriculture, medicine, etc. it being obtained by ozone generator plants. The article investigates the operation of the wind generator system – a step-up transformer corona system which enables the ozone production using renewable energy sources. The analysis focuses on the coordination characteristics of individual elements providing for maximum efficiency. There are criteria for determining the parameters of Corona System and transformers to the installed Power of wind turbines and wind resource**

Keywords– **Ozone generator, wind generator, transformer.**

I. Introduction

Industrial ozone generatingplants [1,2,4] are used to produce ozone for different applications: tank and rural water treatment, grain silos cleaning and so on. The main component of the plant is the CoronaSystem [1,3,4] with power supply voltage range of 9-15kV which is provided by means of a step-up transformer.

In the system under consideration, the corona system power supply is provided by a wind turbine, thereby using a renewable energy resource for ozone production. The wind generator operates in an autonomous-source mode, directly powering a step-up transformer and an ozone generator. A direct connection between the wind turbine, the transformer and the corona system is employed. Moreover, the conventionally used frequency converter [2] has been excluded in order to simplify the design leading to a financial solution, which is a crucial criterion for the use of autonomous renewable sources. It is necessary to study the possibility of coordinating the parameters of the individual components ensuring their optimal operation. The problem in this respect is associated with the voltage provided by the wind turbine, which depends on wind speed and has no constant value. The parameter harmonisation must exclude the possibility of emergency situations such as step-up transformer overloading, breakthrough, etc.

In the present task, the direct use of renewable resource systems without conversion (inverter) and energy storage (UPS) is justified by several considerations:

- The use of an ozone generator for tank water treatment, for example, typically requires the generation of a specified quantity of ozone in a definite time interval, i.e. a definite number of hours per day. In addition, the temporary electric supply cut-off is acceptable.
- Any losses resulting from electrical energy conversion are avoided
- The initial cost of the Water Plant and the maintenance and operational cost are reduced, which contributes to the fast investment turnover

II. Analyses and Experiment

The experimental studies was based on a wind turbine with nominal parameters P=500W, U=24V, 50Hz. Fig.1 shows the record of the electrical parameters for one day, using a resistive load directly connected to the generator. For wind speed between 3 and 9 m/s, the parameters vary in the following respective ranges U = 15 ÷ 35V, I = 3 ÷12A, f = 30 ÷100Hz, with the following peaks: I = 14A, U = 43V, f = 193Hz . The preliminary measurements indicate that a standard measuring transformer 20000V/100V may be used as a step-up transformer. In the particular case investigated, the high-voltage supply in the range of 8-15kV requires the wind turbines output voltage to be doubled by means of an additional step-up transformer.

The study of the corona system is dealt with in a number of sources [1,3,4]. The corona system employed is made up of horizontal electrodes separated by glass plates. The experimental model is shown in Figure 2, and Figure 3 illustrates a wiring diagram. Both figures use the following abbreviations: WG – a Wind Generator, Tr1 – a Step-Up Transformer, doubling the voltage of the wind generator, Tr2 – a High-Voltage Measuring Transformer 20kV/100V, OG – an ozone Generator. S1, S2 – Automatic Control and Safety Switches, F - Fan.

The data obtained and indicated in tabular form (Table 1) and graphically (Figure 4) show the relation between the number of electrodes, current and voltage on the primary side of Tr2. The characteristic illustrated in Fig.4. corresponds to the wind turbines nominal voltage. An additional factor influencing the electrical parameters are the geometric dimensions of the electrodes, which should comply with the system sizing [1,4]. For the systeminvestigated, two electrodes with dimensions 0.4 x 0,4 m are used, their number being limited to 5 in order to prevent transformer overload at the peak input voltage. The one-day experimental study shows that the voltages illustrated in Fig.3 rangewithin the allowable limits U1 = 10÷40V, U2 = 20÷80V (Fig. 5), U3 = 4000÷16000V.

According to the results obtained, the wind-transformer-corona system operates properly, a transformer of power 2kW,much higher than that of the wind generator, has been deliberately selected for experimental purposes. In real operation,several small transformers connected to a common wind generator may be used (Fig. 6). This approach allows an adequate load selection depending on the available resources.

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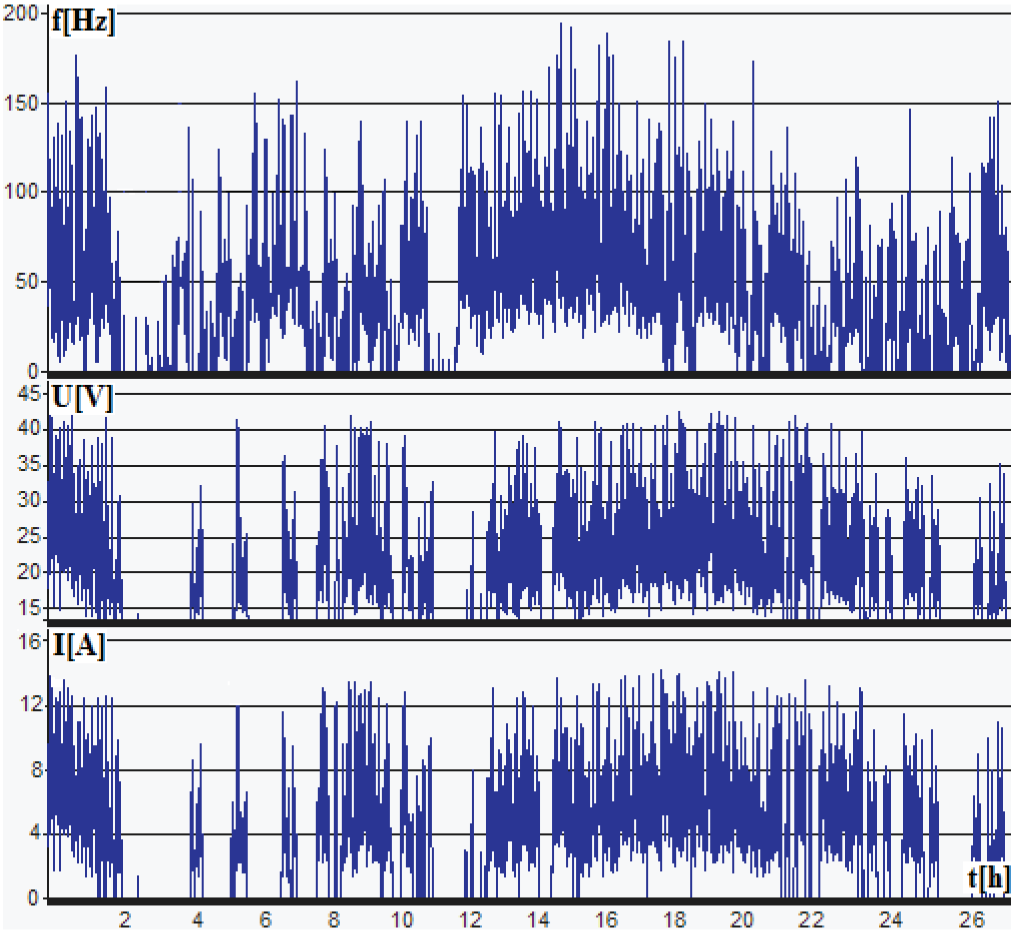

Fig. 1. Data obtained by a Wind Generator Study.

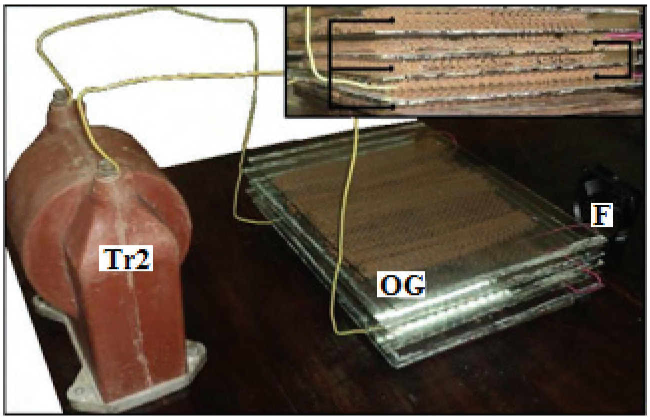

Fig.2. An Experimental Corona System Model powered by a measuring high-voltage transformer.

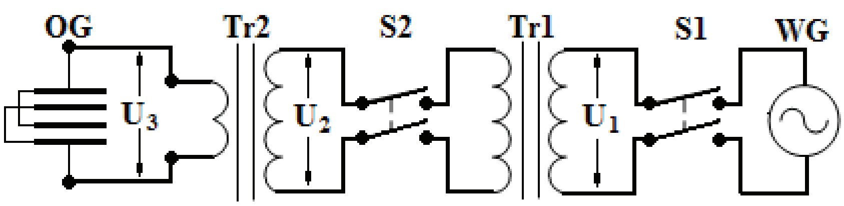

Fig.3 A Corona System Power Supply incl. a transformer and a wind generator.

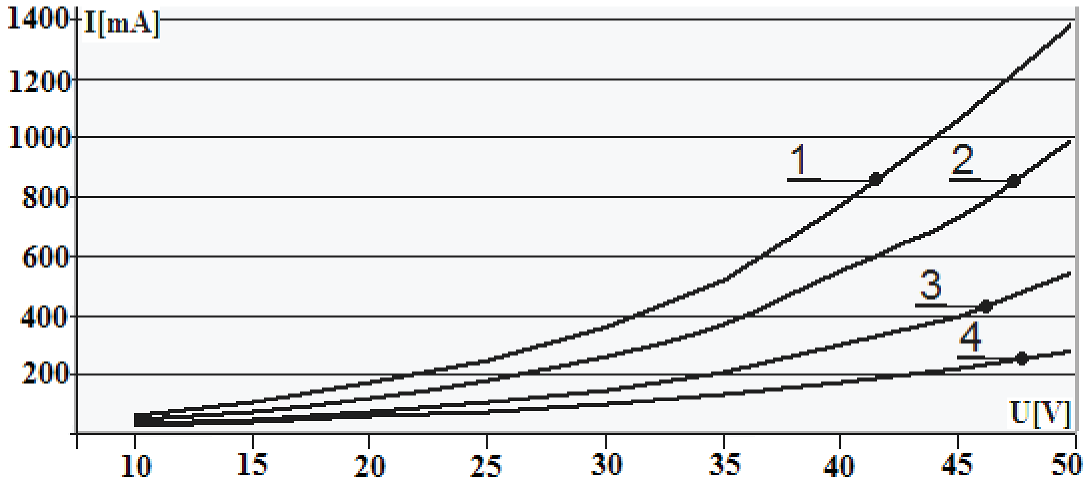

Fig.4 Data obtained according to the different number corona system electrodes used.
Graphs 1÷4 resp. 5÷2 electrodes.

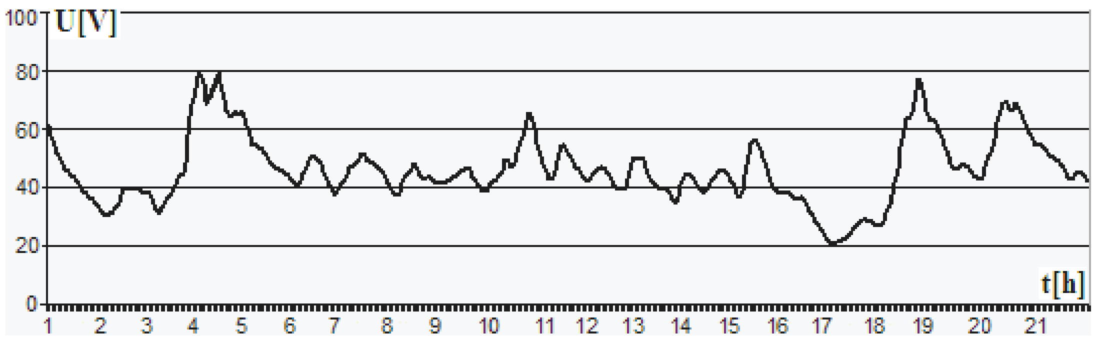

Fig.5. Step-up Transformer Low-Voltage side (Tr2, fig.3).

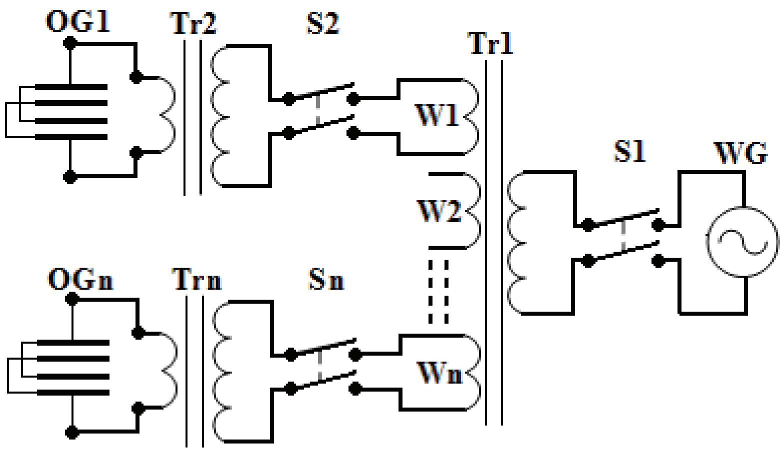

Fig.6 Supply Multiple Corona System.

TABLE 1.

U [V]	Number of Electrodes [mA]			
	2	3	4	5
10	28,59	31,03	44,31	61
15	42,61	49,31	75,42	105
20	59,41	73,64	119,33	172
25	76,56	107,91	181,12	250
30	104,23	147,25	260,51	360
35	134,34	210,04	370,17	520
40	174,77	301,06	550,91	770
45	220,12	405,43	732,45	1060
50	280,03	555,32	1000,34	1400

III. CONCLUSION

From the studies conducted, it can be concluded that the autonomous use of renewable energy sources is appropriate for generating ozone by means of an ozone generating plant. The parameters of the wind generator – step-up transformer – corona system can be harmonised so as to enable direct connection between them (Fig. 3). It is necessary to ensure acceptable mode of operation of the installation, excluding emergency situations of overloading and insulation breakthrough. This can be achieved by following the sequence proposed in the present paper:

- A precondition for proper parameter harmonisation is the use of available data from a prior research (Figure 1) on the operation of the wind turbine. It is due to the variable output voltage depending on wind speed.
- It is necessary to ensure the input voltage allowable range for the high-voltage step-up transformer (Tr2). In the particular research, this is achieved by means of an intermediate step-up transformer (Tr1), but in other cases it may be a step-down one.
- Finally, the overall experiment (Fig.4, Fig.5) should confirm acceptable modes of operation of the system components.

An additional option is to use multiple corona systems fed by a common wind generator (Fig. 6).

REFERENCES

[1] Блинов И.В., Ваняев С.В., Кузнецов К.Ю. Анализ энергетических процессов в высокочастотном озонаторе. Межвузовский сб. научн. трудов Электрооборудование промышленных установок. НГТУ, Н. Новгород, 2006г.

[2] Кузнецов К.Ю., Ларионов Н.П., Блинов И.В. Источники питания промышленных озонаторов. XXII научн.-техн.конференции «Актуальные проблемы электроэнергетики» Тезисы докладов/ НГТУ, 2003 г – с. 67-69.

[3] Панайотов М, Б. Димитров. Изследване на конструктивните и технологични отклонения в озон генераторните станции Международна научно-техническа конференция Електроенергетика 2010. стр. 301-306

[4] Пузиков Н.А., Блинов И.В., Кузнецов К.Ю., Махин Ю.И. Снижение энергозатрат озонных технологий. Тезисы докладов межд. Конгресса «Великие реки 2005», том 1. Н.Новгород. -ННГАСУ, 2005. т.1 – с. 196-198.