MODELING OF HIGH-FREQUENCY POWER GENERATOR FOR WOOD DRYING SYSTEMS

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Vacuum tube (VT) generators are used for high-frequency wood drying. Such systems are robust, reliable, energy efficient and economically acceptable. Development and optimization of the VT generator are much more complex than that of transistor systems, especially in the higher frequency range. The development is now compelled to rely on computer modeling and simulation. For the purposes of this research, a high frequency generator of 20 kW output power based on a VT was analyzed. An appropriate model for the VT and the rest of the assembly was proposed and simulation and measurement on the real system have been made. The study allowed determining model parameters and developing an optimized system.

Keywords: high-frequency generator, vacuum tubes, modeling, simulation.

There is a great interest in wood drying processes that enable process intensification and material quality improvement, including high frequency current (HFC) drying that can be used individually or in combination with convection. The development of electronics and high technologies enabled the production of industrial HF generators, which were a precondition for further development of the theory and technology of drying on the new bases for the purposes of various industries [1].

The key element of the HFC wood drying systems is a high-frequency AC generator. Since it is usually a matter of high voltages and large powers, electronic tubes are still used due to their efficiency [2—6]. Modern, powerful transistors can be used only for small or laboratory installations [7]. In this paper, a device based on a semi-industrial high-frequency drying system is proposed, as well as the computer simulation and experimental confirmation.

HF high power generator

In the area of lower and middle frequencies, transistor generators are predominant. However, in the case of radio frequencies (1 MHz and higher), transistor generators have very limited possibilities. With larger powers (tens of kW and more), the advantage is on the side of the generator with vacuum tubes (VT). It is these requirements that are to be met when developing generators for wood drying, and they are still most often based on VT.

Each oscillator consists of a serial connection of a nonlinear active element (VT in this case) and an oscillator circuit adjusted to the desired frequency. Different configurations of oscillator circuits and feedback to the grid are possible, and in this study the Colpitts configuration was used (Fig. 1).

The active element of the generator is a GU62A triode, and the elements of the oscillator circuit are C_1, C_2 and L_2. The feedback is achieved through the C_g capacitor, and the resistor Rg generates a negative preload grid. The C_s capacitor separates the oscillator from the DC source of the anode supply, and the inductance L_1 prevents the penetration of HF energy to the source.

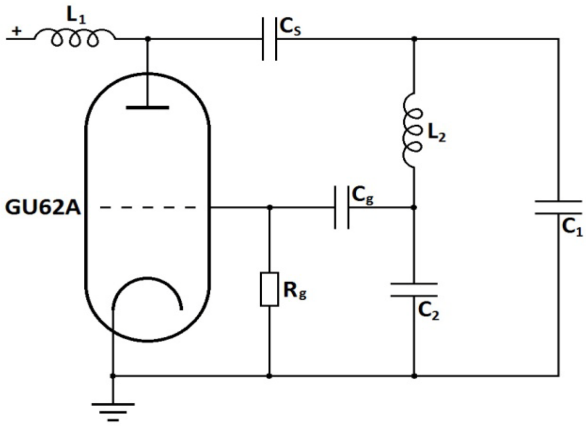

Fig. 1. Principal scheme of the Colpitts oscillator based on a VT triode

Modeling of the HF generator has been done in the PSPICE simulation software embedded in the ORCAD package [8]. The software was used to simulate the behavior of the projected HF generator. The basic scheme of the generator from Fig. 1 is supplemented by serial inductances (L3 to L8) that correspond to the real inductances of the lines. Also included in the system, the resistor R1 that corresponds to the active consumption, that is, the drying of the wood. The starting model for the active element (triode) was SV811-3 [9, 10]. The basic parameters of the model are calculated according to the recorded static characteristics of the VT, while the parasitic capacitances are taken from the manufacturer's declaration. Following the previously described, model for a specific VT was obtained.

Results of simulations and experiments

Fig. 2 shows simulated and measured values of the voltage of the consumer and the anode current for the designed generator. The described model was tested several times by comparing with the results of measurements on the real system, where the configuration of the wood complex, the humidity of the wood and the frequencies were changed. After obtaining high matching level of the simulation and measurement results, "experiments" were simulated in order to optimize the system parameters from the point of view of energy efficiency and other requirements.

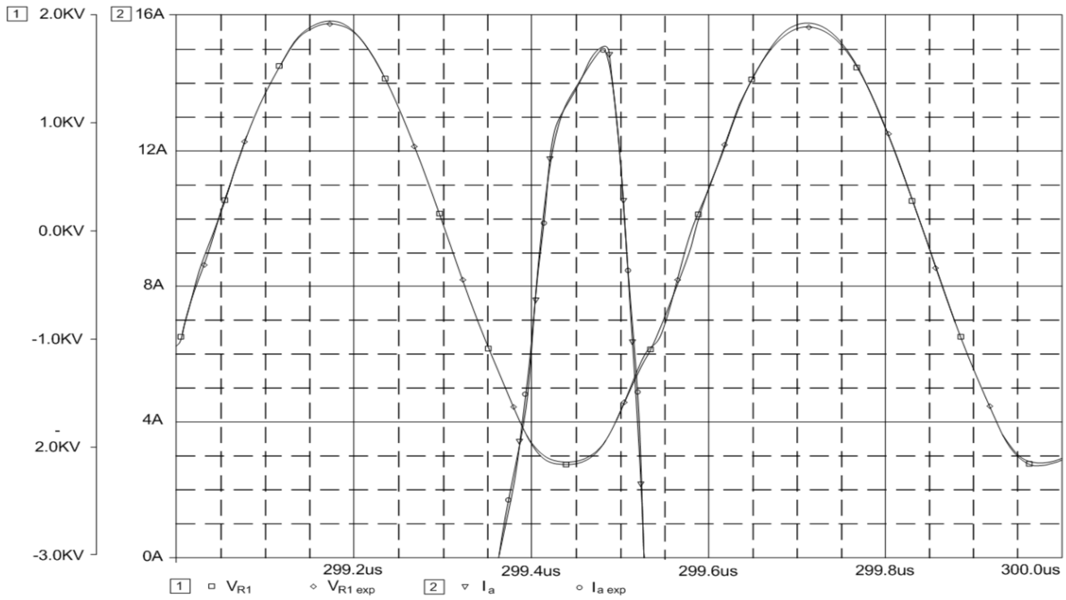

Fig. 2. Results of the measurement and simulation for the consumer voltage and the anode current

Conclusion

The HF generator based on the VT was implemented using the standard procedure. The computer simulation was performed for various frequencies, various configurations of the complex and the moisture content of the wood, while actual experiments were performed only for the optimal parameters determined by the simulation. During all experiments, high matching level of the simulation and measurement results was obtained. The measured effective value of the consumer voltage was 1.359 kV, and the result of the simulation was 1.379 kV. The measured peak value of the anode current was 15.01 A, and the result of the simulation was 15.09 A. This confirms the validity of the model and the suitability of the entire system for further research in this field.

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Моделирование генератора высокочастотной энергии для системы сушки древесины

Генераторы вакуумных труб (ВТ) используются для сушки на высоких частотах. Такие системы надежны, энергоэффективны и экономически приемлемы. Разработка и оптимизация ВТ-генератора намного сложнее, чем транзисторной системы, особенно при более высоких частотах. В настоящее время при разработке приходится полагаться на компьютерное моделирование и симуляцию. В данной работе был проанализирован ВЧ-генератор мощностью 20 кВт на основе ВТ. Предложена соответствующая модель для ВТ и других частей системы. Также были выполнены моделирование и проведены измерения на действующей системе. Исходя из этого, предложены параметры модели и оптимизированная система.

Ключевые слова: высокочастотный генератор, вакуумные трубки, моделирование, симуляция.