ABSTRACT

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"Ultrahigh-frequency drying of wood based on a single-wire line of surface waves" thesis, submitted for Doctor of Philosophy (PhD), degree specialty: 6D071900 – Radio Engineering, Electronics and Telecommunications

Relevance of dissertation research. Currently, the most promising area for the creation of drying plants for large-sized lumber is the use of a variable electromagnetic microwave field. The wide range of size of sawn timber and the variety of wood species complicate the creation of multidisciplinary drying plants. For each specific purpose of the microwave installation, it is necessary to select an electromagnetic radiation excitation device, a device for concentrating ultrahigh-frequency energy on the irradiated object, the size of the drying chamber, etc.

In order to ensure high-quality drying of wood of particularly long wood material, it is necessary to control the temperature distribution in the material. To do this, it is necessary to ensure uniform exposure of microwave energy along the entire length of the irradiated object.

In this dissertation work is proposed the possibility of using a higher-quality microwave drying of wood and large-sized lumber by developing a new tool that allows to create a uniform distribution of the electromagnetic field of the microwave range over the entire area of the wood material.

It is obvious that the creation of new methods for excitation of ultrahigh-frequency radiation, irradiation of drying objects, uniform distribution of electromagnetic radiation along the length of the irradiated material will ultimately allow to develop more efficient installations for drying wood.

The production of a productive ultrahigh-frequency plant will require the most efficient method, justified by engineering calculations, of delivering electromagnetic energy to the irradiated object, a system of uniform concentration of microwave radiation to the irradiated object, a device for excitation of the required structure of the electromagnetic field, which will ultimately lead to an increase in the feasibility of the developed unit compared to the existing ones.

From the main units forming the microwave installation, the following can be distinguished: a microwave generator (magnetron), a single-wire power transmission line to the object of drying, a system for distributing microwave energy on the object, a device for absorbing unclaimed microwave energy.

In the proposed version of ultrahigh-frequency installation, a single-wire transmission line is used, which is made in the form of a single wire coated with a thin layer of dielectric. Previously, such line is known as the Goubau line. Electromagnetic waves of the E- type propagate along such line. To optimize the number of links in the proposed version of the microwave wood drying plant, a number of problems can be solved:

- to explore the most efficient way to deliver electromagnetic field energy to a drying object.

- to determine the model of ultrahigh-frequency heating, on the basis of which the analysis of processes taking place in a single-wire line of surface waves will be carried out.

- to investigate processes of absorption of electromagnetic energy of microwave range by wood material.

- to analyze the dependence of electromagnetic field penetration depth into lumber on microwave generator frequency.

- to identify the possibility to optimize geometric dimensions of single-wire line of surface waves.

- to analyze surface wave excitation devices. E00

- to investigate methods of uniform concentration of electromagnetic field energy over the entire volume of irradiated object.

- to investigate the possibilities of controlling the propagation of the electromagnetic field in the transverse direction.

The results of the research presented in the dissertation work were carried out at the North Kazakhstan University named after M. Kozybayev, at the department of " Energy and Radio Electronics" and at the Omsk State Technical University, at the department of "Communications and Information Security".

The purpose of the dissertation work is to create new methods for irradiation of wood materials with ultrahigh-frequency energy, uniform distribution of electromagnetic radiation along the entire length of large-sized lumber, using a single-wire transmission line and a vibrator device for excitation of the E00 wave.

Subjects of study:

1. Models of ultra-high-frequency drying of wood, taking into account the main features of the effect of the electromagnetic field of the microwave range on wood material, containing a vibrator excitation device, a re-emitting vibrator antenna array, an absorbing load and a heating system.

2. Choosing the optimal frequency range in drying different types of lumber.

3. Methods of uniform distribution of microwave radiation into various types of wood material: bar, boards, veneers, plywood boards, particle boards, wood chips, chips.

4. Methods of designing absorbent loads.

5. Methods of utilization of unclaimed energy of electromagnetic field of ultrahigh-frequency range.

To achieve these objectives it is necessary to conduct a number of studies :

1. to investigate models of ultrahigh frequency irradiation of wood material.

2. to investigate the possibility of summing microwave field energy from independent magnetrons.

3.to develop methods for evenly distributing microwave power to wood objects of various lengths.

4. to develop design options for absorbing loads.

5. to develop systems for converting unclaimed microwave field energy into thermal energy.

Study objects: components that make up the E00 wave field in a single-wire transmission line. Adjustment of intensity of wave field power E00 in transverse direction. Processes of absorption and re-radiation of wave E00 objects of different structure for creation of uniform distribution of microwave radiation along length of single-wire line of surface waves.

Research methods. In the process of performing dissertation work, the positions of classical electrodynamics, electromagnetic field theory, antenna and

radio wave theory were used, including the theory of the dielectric heating process and the basic laws of geometric optics. The experimental studies presented in the work were carried out in laboratory conditions on a specially manufactured plant.

The scientific novelty of the study is as follows:

1. Method of irradiation of wood material with ultrahigh-frequency energy is developed by means of single-wire transmission line, on wire of which antenna array of re-emitting vibrators is located.

2. Method of uniform distribution of electromagnetic field energy over the whole volume of large-size lumber is developed.

3. A method of summing up powers from independent low-power magnetrons in the form of heat in a drying object has been developed.

4. Versions of structures of absorbing loads and methods of redistribution of unused power supplied from ultrahigh-frequency generator are proposed.

Practical value of the work. By performing microwave irradiation of wood materials using a single-wire transmission line, and using the effects associated with the structure of the surface wave field E00, as well as taking into account the properties of elliptical and parabolic reflectors, it was possible to significantly increase the uniformity of the energy distribution of the electromagnetic field throughout the volume of large-sized lumber, as well as reduce the overall size and metal consumption of microwave dryers.

Protection provisions:

1. Method of ultrahigh frequency irradiation of wood materials.

2. Method of uniform distribution of ultrahigh-frequency radiation by volume of wood material

3. The addition of ultra-high-frequency powers from low-power magnetrons in wood material.

4. Creating absorbent load designs to redistribute unused power.

Testing the work. The main results of the study were reported and discussed at the International Scientific and Practical Conference "Kozybayev Readings-2018: Eurasian potential and new development opportunities in the face of global challenges "(Petropavlovsk, November 16, 2018), VI international practical conference" Youth and Science-2019, "dedicated to" Jastar jyly "(Petropavlovsk, April 12, 2019), LXVII International Scientific and Practical Conference" Technical Sciences - from Theory to Practice "(Russia, Novosibirsk, February 27,2019

Implementation of performance. The results of the research are approved for implementation into the production process of LLP"Foundation" in Petropavlovsk, and the implementation of KazLes LLP in Nur-Sultan is also planned.

Publications. According to the results of the dissertation study, 14 publications have been published, including 5 in scientific publications recommended by the Committee on Quality Assurance in the Field of Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan. 2 articles are published in the international reviewed scientific magazines having in the Scopus database an indicator a percentile on Cite Score (SaytSkor) not less than 35; 4 - in the materials of conferences, including 1 -

foreign; 1 in the regional periodical. The results of the study are reflected in two patents for a useful model.

Personal contribution of the author.

The main results of theoretical and experimental studies were obtained by the author independently. In printed works, which are co-authored, the applicant has a leading role in the synthesis and analysis of the results.

The structure and scope of the dissertation.

Dissertation work consists of an introduction, four chapters, a conclusion and a list of literature. The work is described on 114 pages of 59 figures and 7 tables. The bibliographic list consists of 125 names, including 20 in English.

The introduction justified the relevance of dissertation research, defined the purpose and tasks of dissertation work, presented methods, subjects and objects of research. Scientific provisions are submitted for defense and a brief description of each chapter of the dissertation is given.

The first chapter discusses the main methods of drying wood. Advantages and disadvantages of ultrahigh frequency, infrared and induction effects on wood material for heating and drying purposes are indicated. The effect of electromagnetic microwave energy is considered to be the most efficient and promising method of drying wood.

Also in this chapter two models of irradiation of materials using microwave electromagnetic fields are analyzed. It is shown that ultra-high-frequency drying of wood is carried out as a result of its resolution in the near irradiation zone.

The second chapter is devoted to the analysis of the effects of electromagnetic energy of the microwave range on wood material. A number of dependencies of dielectric properties of wood at different density, temperature and humidity of wood material are analyzed. Using the experience of previous studies (publications, monographs, textbooks, dissertations) in the field of ultrahigh-frequency drying of wood, an analysis of the propagation of ultrahigh-frequency radiation in large-sized wood lumber was carried out.

The third chapter analyses the structure of the E00 wave field in a single-wire transmission line. Disclosed is a version of excitation of electromagnetic field of E00 wave by means of excitation system consisting of three half-wave vibrators.

Also, this chapter proposes versions of the structures of absorbing loads that serve to absorb the unused energy of the electromagnetic field of the wave E00

As a result of the research, a model of a microwave plant for drying wood and large-sized lumber was proposed.

The fourth chapter deals with methods of uniform irradiation with ultrahigh-frequency energy of wood materials of various configurations. It is proposed to use parabolic and eidetic reflectors properties to ensure required intensity of E00 wave field on surface of irradiated wood material.

The conclusion summarizes and reflects the main results of the dissertation study.

Papers published on the topic of the dissertation

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