International Scientific – Practical Conference «INNOVATIVE INFORMATION TECHNOLOGIES»

PART 3
INNOVATIVE INFORMATION TECHNOLOGIES IN INDUSTRY AND SOCIAL-ECONOMIC SPHERE

Prague – 2014
April 21-25

К 32.97
UDC 681.3; 681.5
I 64

I 64 Innovative Information Technologies: Materials of the International scientific – practical conference. Part 3. /Ed. Uvaysov S. U.–M.: HSE, 2014, 596 p.

ISSN 2303-9728

The materials of The Third International Scientific – Practical Conference is presented below. The Conference reflects the modern state of innovation in education, science, industry and social-economic sphere, from the standpoint of introducing new information technologies.

Digest of Conference materials is presented in 3 parts. It is interesting for a wide range of researchers, teachers, graduate students and professionals in the field of innovation and information technologies.

The editorial board:

A.Abrameshin, S.Aldoshin, A.Bugaev, E.Cheremisina, Yu.Evtushenko, I.Frumin, L.Gamza, J.Halík, I.Ivanov (executive editor), M.Kagan, B.Katalinic, V. Klaban, G.Kuzaev, J.Kokes, V.Maslov(scientific editor) E.Pozhidaev, J.Prachař, G.Savin, L.Schoor, A.Shmid, P.Skalicky, V.Tihomirov, A. Tikhonov(scientific editor), S.Uvaysov(under the general editorship), V.Vasiliev, L.Verbickaya, A.Zhizhchenko

LBC 32.97
ISSN 2303-9728
© The conference organizing committee
© HSE, 2014

TEMPERATURE DISTRIBUTION IN SHEET MATERIALS IN A WAVEGUIDE MICROWAVE DEVICES

Mamontov A.V., Nefedov V.N.
Moscow Institute of Electronics and Mathematics, Higher School of Economics (MIEM HSE)

The temperature distribution calculation and measurement results for sheet dielectric materials heated up in the microwave waveguide type devices are presented. The calculation method for sheet dielectric materials' heat treatment in a waveguide type microwave devices is presented. Microwave devices, a distinctive feature of which is the rectangular waveguide narrow wall geometrical sizes' change, working mainly on the H_{10} type of wave to ensure a uniform temperature in the processed sheet dielectric material are considered.

Keywords: microwave device, waveguide, power distribution, the distribution of temperature, dielectric material, the source of microwave energy.

Microwave devices are widely used in a high-performance heat treatment for relatively thin sheet dielectric materials [1]. In such microwave devices a rectangular waveguide on the main wave type H_{10} is used as a heating element and the material is transported through the narrow slits cut along the middle of waveguide's broad wall parallel to the narrow walls. Such microwave units are called units with cross interactions [1, 2].

The transported material is thin enough and it can be assumed that the basic wave type H_{10} is propagated in a waveguide.

Let rectangular waveguide with the processed material be ideally matched with a source of microwave energy on one side, and with a water load on the other side. We assume that the heat emission in the surrounding space and the ohmic losses in the waveguide are small and they are not taken into account in calculations. The electromagnetic field energy propagates along the "z" axis, and the processed material's width is ℓ in the electromagnetic power propagation direction.

The spreading through the waveguide power fades in processed material by the exponential law:

$$P(z) = P_{вх} \cdot e^{-2 \cdot \alpha_z \cdot z} \ , \qquad (1)$$

where $P_{вх}$ is the output power of the microwave energy source; α_z - electric field amplitude decay constant in the material along the axis “z”.

The ratio for engineering calculation of constant attenuation in a waveguide with a relatively thin material, situated in the middle of the wide side parallel to the narrow, can be obtained by a generalization of the equivalent circuits method for a waveguide with a H_{10} wave type with homogeneous filling [2]. The electric field amplitude decay constant value in the material is determined by the relation [2]:

$$\alpha_z = \frac{\pi^2 \cdot d \cdot \varepsilon''}{2 \cdot a \cdot \lambda \cdot \sqrt{1 - \left(\frac{\lambda}{2 \cdot a}\right)^2}} \ , \qquad (2)$$

where ε'' - the imaginary part of the material's relative permittivity; a size of the waveguide's wide side; λ - microwave energy source wavelength; d thickness of the material.

The amount of power transmitted through the waveguide:

$$P(z) = P_{вх} \cdot e^{-\frac{\pi^2 \cdot \varepsilon'' \cdot d}{a \cdot \lambda \cdot \sqrt{1-\left(\frac{\lambda}{2 \cdot a}\right)^2}} \cdot z}. \quad (4)$$

The value of linear power loss:

$$P_{пог}(z) = \frac{dP(z)}{dz} = P_{вх} \cdot \frac{\pi^2 \cdot \varepsilon'' \cdot d}{a \cdot \lambda \cdot \sqrt{1-\left(\frac{\lambda}{2 \cdot a}\right)^2}} \cdot e^{-\frac{\pi^2 \cdot \varepsilon'' \cdot d}{a \cdot \lambda \cdot \sqrt{1-\left(\frac{\lambda}{2 \cdot a}\right)^2}} \cdot z}. \quad (5)$$

Specific power loss is equal to the relation of linear power losses in the cross section of the material:

$$P_{уд}(z) = \frac{P_{пог}(z)}{S} = \frac{\pi^2 \cdot \varepsilon''}{a \cdot \lambda \cdot b \cdot \sqrt{1-\left(\frac{\lambda}{2 \cdot a}\right)^2}} \cdot P_{вх} \cdot e^{-\frac{\pi^2 \cdot d \cdot \varepsilon''}{a \cdot \lambda \cdot \sqrt{1-\left(\frac{\lambda}{2 \cdot a}\right)^2}} \cdot z}, \quad (6)$$

where: S is the area of the cross section of the material; b - the size of the waveguide's narrow walls.

Temperature distribution in the material in the electromagnetic power propagation direction is:

$$T(z) = T_{нач}(z) + \frac{\pi^2 \cdot \varepsilon'' \cdot P_{вх} \cdot \tau}{c_{\partial} \cdot \rho_{\partial} \cdot b \cdot a \cdot \lambda \cdot \sqrt{1-\left(\frac{\lambda}{2 \cdot a}\right)^2}} \cdot e^{-\frac{\pi^2 \cdot \varepsilon'' \cdot d}{a \cdot \lambda \cdot \sqrt{1-\left(\frac{\lambda}{2 \cdot a}\right)^2}} \cdot z}, \quad (7)$$

where c_{∂} is the heat capacity of the processed material [J/(g·°K)]; ρ_{∂} is the density of the processed material [g/cm^3]; τ - material's processing time in microwave device [sec].

For sheet materials, as a rule, microwave devices consisting of two waveguide sections, with the same design and parameters, but having mutually opposite direction of the electromagnetic field energy propagation are used [3]. In such electrodynamic systems' sections temperature in the material decreases exponentially in the electromagnetic power propagation direction. The addition of two exponential temperature distribution dependences in the material after the passage through two microwave heating device sections should ensure the temperature distribution in the material satisfying the technological process conditions.

As an example, figure 1 shows a microwave device, and fig.2 shows the calculated and experimental characteristics of the temperature distribution in the material after the passage through two sections of microwave devices, which uses the waveguide sections of constant cross-section.

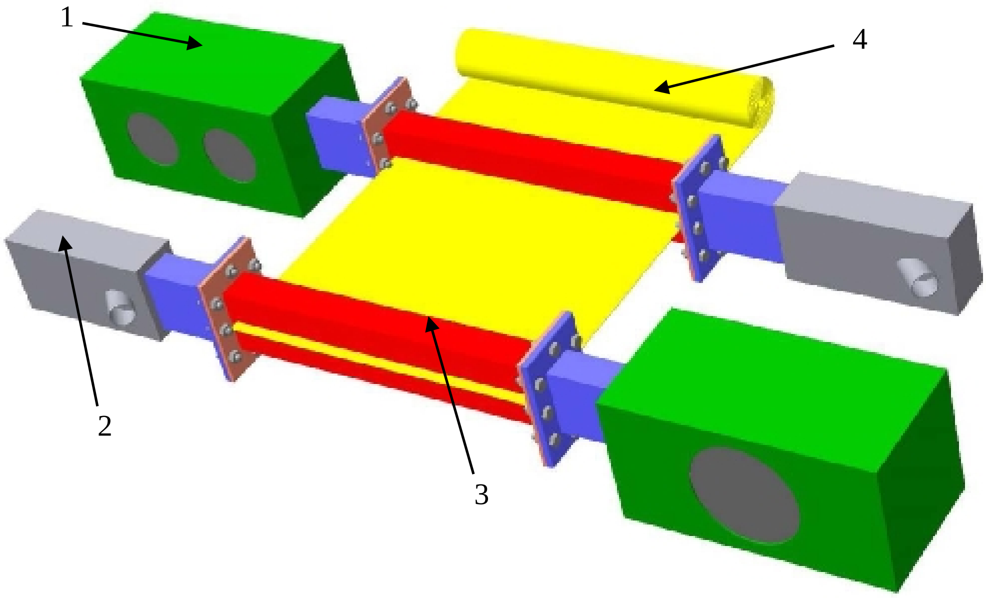

Fig. 1. MW heating device, consisting of two rectangular waveguide sections with constant cross-section: 1 - MW energy source; 2 - water load; 3 - a rectangular waveguide; 4 - processed sheet dielectric material with width ℓ.

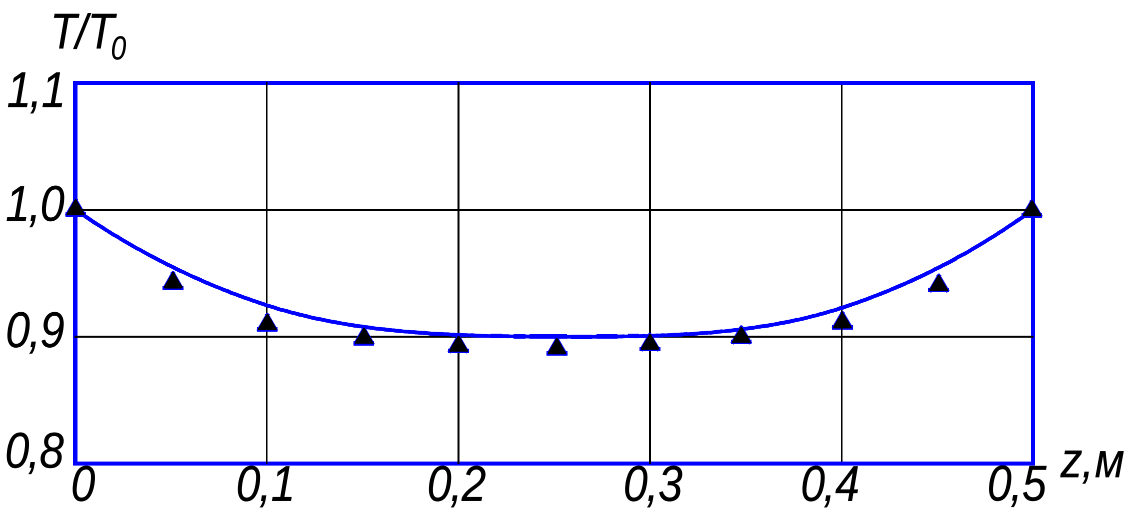

Fig. 2. The calculated and experimental characteristics of the temperature distribution in sheet dielectric material after the passage through two MW heating device sections shown on Fig.1.

Temperature deviation in the material from the nominal values of temperature after the passage of two MW heating device sections did not exceed 12%, and the discrepancy between the calculated and measured values of the temperature distribution in the material does not exceed 6%.

The electric field amplitude value in the material in the electromagnetic power propagation direction can be kept constant by changing the waveguide narrow walls size by a certain rule.

For stationary case (material standing), the constant temperature condition in the material in the microwave energy propagation direction is determined by the expression:

$$T(z) = T_{нач} + \frac{\pi^2 \cdot \varepsilon'' \cdot P_{вх} \cdot \tau}{c_д \cdot \rho_д \cdot b(z) \cdot a \cdot \lambda \cdot \sqrt{1 - \left(\frac{\lambda}{2 \cdot a}\right)^2}} \cdot e^{-\frac{\pi^2 \cdot \varepsilon'' \cdot d}{a \cdot \lambda \cdot \sqrt{1-\left(\frac{\lambda}{2\cdot a}\right)^2}} \cdot z} = const. \quad (8)$$

To satisfy the condition (8) it is necessary and sufficient that the size of the waveguide narrow walls is changed by a rule in the electromagnetic power propagation direction:

$$b(z) = b(0) \cdot e^{-\frac{\pi^2 \cdot \varepsilon'' \cdot d}{a \cdot \lambda \cdot \sqrt{1-\left(\frac{\lambda}{2\cdot a}\right)^2}} \cdot z}. \quad (9)$$

Fig. 3 shows the MW heating device, consisting of two identical waveguide sections with waveguide's narrow walls size changes according to the linear rule.

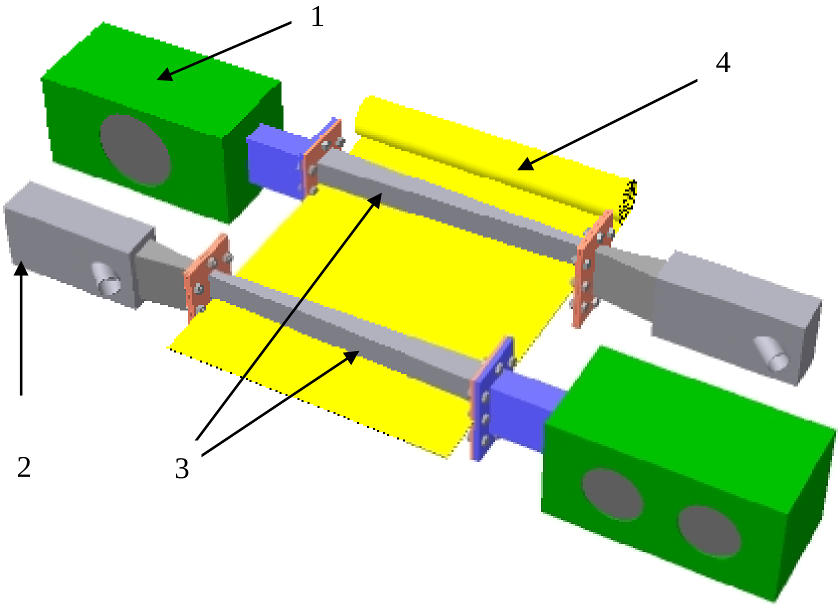

Fig. 3. Microwave device, consisting of two sections with the waveguide narrow walls size linear change. 1 - microwave energy source; 2 - water load; 3 - a rectangular waveguide; 4 - processed sheet material.

Fig.4 shows the calculated and the experimental temperature distribution characteristics in material after the passage through two sections of microwave devices with the waveguide narrow walls size linear change in the electromagnetic power propagation direction.

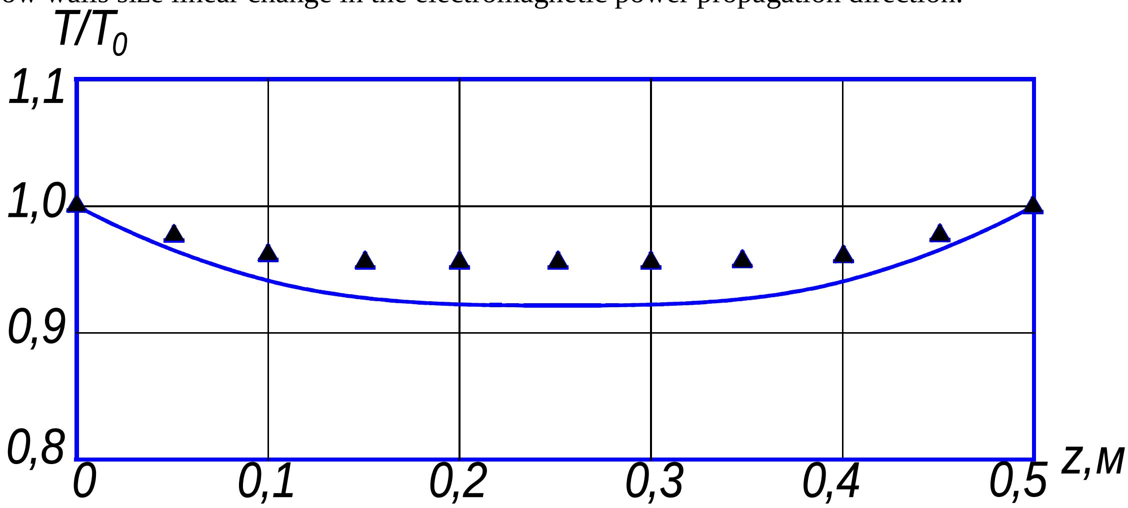

Fig. 4. Temperature distribution in the material after the passage through two microwave devices' sections, shown in Fig. 3.

Temperature deviation in the material from the nominal values of temperature after the passage through two MW heating device's sections does not exceed 9% , and the discrepancy between the calculated and measured values of the temperature distribution in dielectric sheet materials heated from 20°C to 180°C does not exceed 6%.

Section of microwave devices and material are characterized by the following parameters:
- electromagnetic field oscillations operating frequency, MHz …………………. 2450
- voltage standing wave ratio in the frequency range of 100 MHz, not more than..... 1,3
- standing wave ratio at the operating frequency ………………………………. 1,17
- microwave energy power source output, kW …………………………….. …0,6
- the length of the waveguide section ℓ, mm…………………………………..… 500
- the size of the wide side of the waveguide, mm …………………………………72
- the size of the narrow wall at the beginning of the waveguide, mm ....… 34
- the size of the narrow wall at the end of the waveguide, mm …………………. . 15
- temperature of material T_{κ}, °C ……………………………………………… .180
- the relative dielectric constant value of the material, ε'' ……………….............. 0,15
- heat capacity of the material c_{∂}, J/(g·°K) …………………………...…………..... 0,8
- the density of the material ρ_{∂}, g/cm^3... 2,4
- material thickness d , mm …………………………………………..……………6,0

It is clear that temperature distribution in the material is more uniform when the waveguide narrow walls linearly change from 34 to 15 mm at 500 mm length in comparison with constant cross-section waveguide.

The obtained results can be used in practical elaborations.

This study (research grant No 12-01-0136) was supported by The National Research University–Higher School of Economics' Academic Fund Program in 2013- 2014.

References

1. Microwave power engineering. Edited by Ernest C. Okress. Volume 2. Applications. Academic press New York and London. 1968

2. Yu.S. Arkhangelsky, I.I.Devyatkin, Microwave-heating installation for intensification of technological processes. Saratov: Publishing house of Saratov University. 1983.

3. A. V. Mamontov, I.V. Nazarov, V.N. Nefedov, T.A. Potapova. "Microwave technology", M: GNU «NII PMT», 2008.

FEATURES OF INFORMATION TECHNOLOGY IN THE MANAGEMENT OF QUALITY

Alshanskaya T., Kostileva N.
Togliatti, Volga Region State University of Service

Abstract: Quality control process is accompanied by a sharp increase in the number of issues papers, the difficulty finding the necessary information, the complexity of service data flows and processes in modern management systems. Therefore, this article highlights the important issues of information support of the product life cycle and use of information technology in management processes, marked signs of the classification of information tools and technologies to manage quality processes.

In the view of intensive globalization of world economy, targeting the activities of organizations in the consumer requests a process approach is particularly relevant, as the main element of management in the organization.

Implementation of the analysis of the main indicators of the processes with a corresponding adjustment is an essential tool for identifying effective ways to improve processes.

Directions for improving the quality of processes can be achieved with due speed and quality of dissemination of information to all personnel involved in the processes that become possible with the systemic use of information technology to facilitate the mapping and process modeling, automation, product life cycle (PLC) support of products, goods and services.

The main purpose of the automated information technology (IT) to get through the processing of raw data of a new quality information on which to base management decisions are produced, representing a process consisting of well-regulated rules of operations over the information circulating in the information system.

At each stage of the life cycle it is generated by a specific set of decisions and reflects their documents, and for an appropriate stage in the original documents and decisions are made at the previous stage.

Consider the classification of information technology, used for quality control processes on the basis of features provided by V.K. Fedyukin [4] (Figure 1).

So for the modeling of processes and quality management process modeling now developed quite a number of software tools (methodology in the Guidelines of State Standard R 50.1.028-2001) [1]

Materials of

the International Scientific - Practical Conference

INNOVATIVE INFORMATION TECHNOLOGIES

Part 3

Edited by S.U. Uvaysov;
Executive editor I.A. Ivanov

Printed in author's redaction

Computer layout:
S.S. Uvaysova, A.S. Uvaysova,
S.M.Lishov, R.Yu.Pashev, D.S.Panasik
Cover design: R.Yu.Pashev

Signed to print 08.04.1014
Format 60x84/16. Paper «Pioneer»
Conventional quires 2.3 Print run 500 copies Order № 51
HSE
109028, Moscow, B.Trehsvyatitelsky lane, 3.