ELECTRODYNAMICS, MASS AND HEAT TRANSFER LIMIT PROBLEM FOR MICROWAVE SISTEM

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Abstract: The paper describes the general formulation of the problem of mass and heat exchange in the high and super high frequency electromagnetic field, which solves a wide range of applicative problems related to thermal treatment and drying of materials.

Key words: Maxwell's equations, mass and heat transfer.

Introducere

The process of heating and dewatering in microwave installations is described by the equations system of Maxwell and Lykov. In most cases we can take the dependence of the electric induction vector D from the E tension and the magnetic induction B from H, for an isotropic environment, the equation (1) of mathematics can be written as:

$$D = \varepsilon E;\ B = \mu H;\ j = \sigma E \tag{1}$$

Where:

ε, μ – permeability of the dielectric and magnetic environment;

σ – conductivity of the environment;

j – current density of conduction.

Development of equation systems

In microwave installations, applicators are typically used to process imperfect dielectrics, where structural heterogeneity is less than the wavelength in the environment, which allows the hypothesis of homogeneity of the object. In product processing, relative dielectric permittivity ε' and $tg\ \delta$ (dielectric loss angle) depend on the temperature. From the well-designed device account, the heat treatment takes place considerably uniform throughout the volume. Thermo physical parameters within a narrow range can be considered permanent. Then the system of equations (2 – 9) of transferred heat mass and electrodynamics can be written as:

$$\frac{\partial T}{\partial \tau} + v\nabla T = a\nabla^2 + \frac{\varepsilon 2}{c}\frac{\partial u}{\partial \tau} + \frac{Qv}{c\rho} \tag{2}$$

$$\frac{\partial u}{\partial \tau} + v\nabla u = a_m\nabla^2 u + a_m\delta_T\nabla^2 T + \varepsilon\frac{\partial u}{\partial \tau} \tag{2}$$

$$\frac{\partial p}{\partial \tau} + v\nabla p = a_p\nabla^2 p + \frac{\varepsilon}{c_b}\frac{\partial u}{\partial \tau} \tag{3}$$

$$rotH = j + \frac{\partial D}{\partial \tau} \tag{4}$$

$$rotE = -\frac{\partial B}{\partial \tau} \tag{5}$$

$$divD = 0 \tag{6}$$

$$divB = 0 \tag{7}$$

where:
T – the environment temperature, [°*C*]; *u* – moisture content, [*g/cube*]; *v* – the transportation speed of the object, [*m/s*]; *a* – thermal conductivity, [m^2/s]; a_m – mass conductivity, [m^2/s]; a_p – the convective filter diffusion coefficient; c_b – capillary-porous body capacity in relation to wet air; *c* – the specific heat of a substance, [*J/Kg·°K*]; *ρ* – density, [*kg/cube*]; p – water vapor pressure in the material, [*Pa*];

$$Q_v = 0{,}5w\varepsilon_0\varepsilon' tg\left|\dot{E}\right|^2 \tag{8}$$

Where:
w – angular frequency, ε_0 – dielectric permeability in vacuum.

Calculus solution

Electromagnetic fields in some areas are interfaced (9):

$$\begin{gathered}[H_2 - H_1, n] = 0 \;\; ; \; [n, E_2 - E_1] = 0 \\ n(D_2 - D_1) = 0 \;\; ; \;\; n(B_2 - B_1) = 0\end{gathered} \tag{9}$$

n – the unity vector, guided from one medium to another

The limit condition for heat transfer can be written as follows:

$$\begin{gathered}\lambda\nabla T|_n + q(\tau) + 2j_n(\tau) = Q \\ \lambda_m \nabla u_n + \delta_T \nabla T_n + \delta\nabla p_n + j_n(\tau) = 0 \\ p_n = 0\end{gathered} \tag{10}$$

q, j_n – density of heat and mass flow.

Conclusion

Thermal processes in a heated environment can be described by solving the limit value issue (1), (2), (3) and (9). And the electromagnetic field can be calculated from solutions (4) - (7) and (8). The problem of the declared limit value can be considered correct.

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