INFRARED DETECTORS FOR SAFETY-CONTROL OF POSOFFICE MESAGES

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Abstract

It is proposed a simultaneous method for treatment and control of potentially dangerous objects like viruses or explosives. Those methods are based on the prophylaxis irradiation and post irradiation IR-control.

Key words: plastic explosives, viruses, low-contrast objects, radiation – induced heating.

Introduction. One of the reasons of the modern world vulnerability is high organization and mass character of its industrial, commodity and transport lines. Unfortunately one of the most unsafely items is mail because of the following reasons: high speed of delivery, integration into the WorldNet, the sender's actual anonymity, and identification of the addressee. To possible minuses of this channel usage for mailing items of provocative character is their restricted carrying capacity, therefore the subject of dangerous immersions can be, as it is already known, bacteria and viruses culture or plastic explosive, that took place even before the peak of terrorist activity.

Reflecting on solutions of the problem of possible dangerous immersions revealing and neutralization in mail items our author's collective has turned to existing civil and special experience. In particular, we have turned to making of sterilization sections for disposable medical production and to detection and identification of objects by indirect temperature-contrasting imagining. With reference to a problem of mail items safety by our opinion these two methods can successfully supplement each other especially while using modern developments in nanotechnologies.

For preventive bactericidal treatment of mail items it is expedient to use the method of radiative sterilization, which is widely spread all over the world for processing of medical production. The value of the absorbed dose 15-25 kGr can kill the vital activity of pathogenic microorganisms. Estimated cost of such treatment can be received proceeding from the calculation that for processing of 15 kg of envelopes it is necessary to apply electric power equal to 1 KWatt-hour.

Besides the preventive treatment there is also a problem of revealing of envelopes with suspicious immersions. Here we should return to values of the sterilizing absorbed doses of ionizing radiation. It is known, that at radiation passing through the substance the part of the absorbed energy is spent for temperature increasing of irradiated object. Thus the object absorbing ability depends on its density and geometrical sizes, in particular thickness of an immersing layer.

Deconmination and Control of postoffice message. The processing of mail is supposed to be made as well as in case of medical production by conveyor method (fig. 1). Taking into account that we initially guess homogeneity of the processed massflow objects, which are in the area of irradiation, will immerse the radiation field with equal intensity and according to this their temperature will raise on some given quantity. If in a post envelope there is a unauthorized immersion (for example the plastic explosive), the radiation field will be immersed more intensively and the temperature on an irradiation zone output will differ from a background temperature. Radiation induce heating of polymers materials determined by the formula:

$$\Delta T = \frac{D \pm E}{c}, \tag{1}$$

D – absorbed dose, kGr, c – heat capacity, kJ/(kgK), E – energy, which adsorbed as result of chemical reactions.

The task of revealing of object with boosted temperature and fixing of more intensive absorption of a radiation field appears.

One more indication of the unauthorized immersion presence can be the change of a radiation field after passing through the irradiated object. For controlling the radiation field it is offered to use the screen that is made of a thin foil. The change of a radiation flow also will cause a change of its surface temperature.

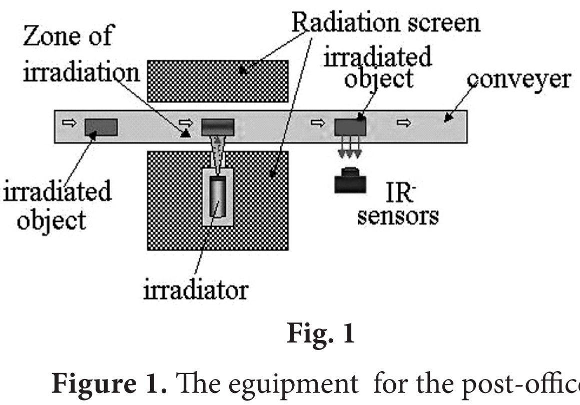

Fig. 1

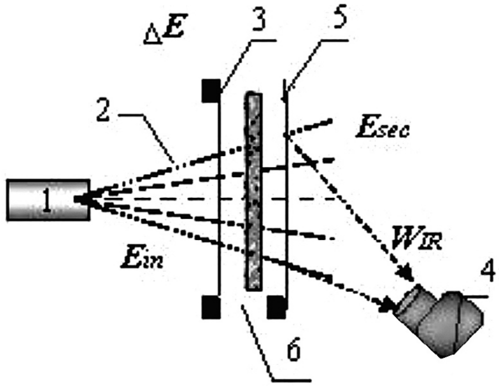

Fig. 2

Figure 1. The eguipment for the post-office processing and control.

Figure 2. Method of thermal-and-vision control / measuring.

1 – source of the accelerated electrons beam; 2 – beam of the accelerated electrons; 3 – the sounding screen for definition of irradiation doses (is erected in a frontal plane of the object irradiation zone); 4 – thermovisor; 5 – the sounding screen for definition of absorbed doses; 6 – irradiated object; E_{in} – energy of initial electrons; ΔE – energy of electrons absorbed by the screen; E_{sec} – energy of electrons, past through the screen; W_{IR} – energy of Infrared radiation.

The temperature T_S – of the irradiated screen surface element ΔS can be determined guessing that the main losses are the losses of radiation in an Infrared range of a radiation spectrum. The value is defined by a Stefan-Boltzmann law. Under the steady conditions the energy of the accelerated electrons bundle immersing by the element S is equal to energy of Infrared radiation increase W_{IR} concerning energy of an element radiation at a temperature of an external environment, i.e. at $T_S = T_{en}$

$$\Delta E = W_{IR} = \varepsilon\sigma(T_S^4 - T_{en}^4)\Delta S. \qquad (2)$$

Temperature of the irradiated surface element ΔS is defined from the expression

$$T_S = (\Delta E/\varepsilon\sigma\Delta S_{ir} + T_{en}^4)^4, \qquad (3)$$

where:

T_{en} – temperature of an external environment, (K);

$\Delta S_{ir} = \Delta S/2$; ε – coefficient of screen surface irradiation;

σ – Stefan–Boltzmann constant, ($5{,}67 \cdot 10^{-8}$ Watt/m^2 K^4).

The time of T_{en} establishment transient τ_{tr} is determined as

$$\tau_{tr} = (T_S - T_{en}),/\Delta T_v, \qquad (4)$$

where:

$\Delta T_v = \Delta E/C_p\Delta m$ – speed of element ΔS temperature increase,

(K/sec); C_p – heat capacity of screen substance (material), (J/kg K); Δm – element ΔS mass, (kg).

It is possible to estimate the spatial (linear) resolution δ_{sp} of the method proceeding from calculation of temperature gradient ∇T that appears due to a difference of temperature between the element ΔS and contiguous to it screen surface, and values of temperature sensitivity T_ω and thermovisor linear resolution δ_{sp}:

$$\nabla T = q/\lambda = \Delta E/\lambda l_p d, \qquad (5)$$

where:

$q = \Delta E/\Delta S_p$; λ – screen substance heat conductivity, (Watt/m K); q – heat flow density, (Watt/m^2); ∇T – temperature gradient along the screen surface, (K/m); $\Delta S_p = l_p d$, ΔS_p – element profile area ΔS on its perimeter, (m^2); l_p – element perimeter ΔS.

For ΔS that is a quadrate with the side l under condition of $\nabla T l = T_\omega$ and $l > \delta_{sp}$,

$$\delta_{sp} = T_\omega / \nabla T. \qquad (6)$$

The value (density) of radiation energy E_{in} that effect on the element ΔS is determined by the measuring data of the element temperature T_S:

$$E_{in} = T_S/f(\Delta S, \Delta E, p_1, p_2), \qquad (7)$$

where:

$f(\Delta S, \Delta E, p_1, p_2)$ – function (coefficient) of element radiation temperature conversion ΔS to the energy characteristics of the electrons bundle influencing on ΔS; $p_1, p_2, \ldots$ – functional parameters of the sounding screen pointing out on its thermal-and-physical, radiation and constructional characteristics.

Method sensitivity estimation. The dependence of screen element temperature increase ΔS from absorbed energy ΔE and screen irradiation coefficient ε, which is calculated by formula (2), is shown on fig. 3. The ultimate value of depending on value of ε, fig. 3.

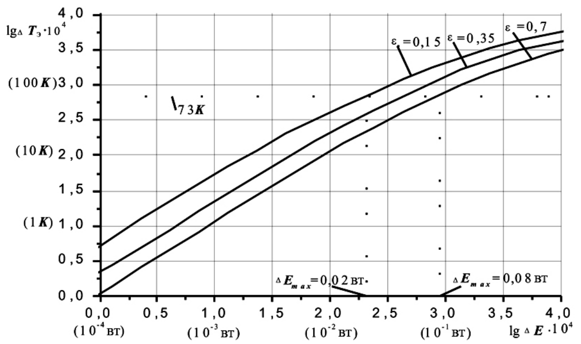

Fig. 3

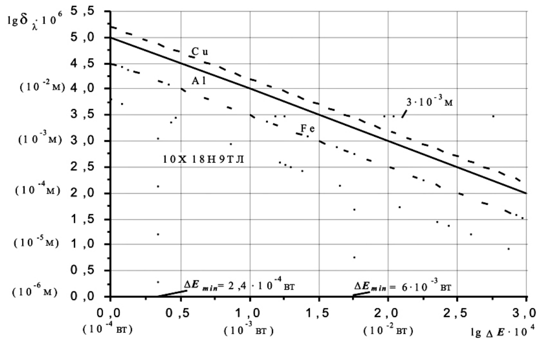

Fig. 4

Figure 3. Dependence of screen element ΔS temperature increase [K] from the absorbed energy ΔE [Watt/cm^2](at T_{en} = 300K). $\Delta E_{max} < (2 \cdot 10^{-2} \div 8 \cdot 10^{-2})$[Watt/cm^2] – the area of maximum values of the absorbed energy (depends on value ε of the screen), at which the screen element temperature achieves 373 K (~100°C).

Figure 4. Dependence of spatial (linear) resolution δ_{sp} of the method from the sounding screen substance (Cu; Al; Fe; alloy 10Х18Н9ТЛ). T_{en} = 300K; screen thickness d = 10^{-5}m; $\Delta E_{min} > (\ 2.4 \cdot 10^{-4} \div 6 \cdot 10^{-3}\ )$ Watt/cm^2 – the lower threshold of the absorbed energy value ΔE_{min}, at which $\delta_{sp} < 3 \cdot 10^{-3}$m.

In a fig. 4 the calculation data δ_{sp} of the sounding screen made of a foil with a thickness of 10 microns for various metals (Fe; Al; Cu; corrosion-proof steel 10Х18Н9ТЛ10-4) are given. From the diagrams we can see that, for example, for maintenance of $\delta_{sp} \leq 3$ mm the absorbed energy lower threshold should be not less than $(2.4 \cdot 10^{-4} \div 6 \cdot 10^{-3})$ Watt/sm^2 for the specified materials. Usage of thinner foils and alloys of iron, aluminum, copper, aluminumated polymeric (lavsan) film that have small values of a thermal conductivity λ allows to increase the resolving ability δ_{sp} up to 100 microns. The estimation of the electrons energy measuring E_{in} ratio error ξ_E can be made proceeding from a selection of an optimum range of screen temperature values T_{en}, in the limits of which the minimum value of the ratio error of temperature ξ_T measuring is provided. For values T_{en} = (310 ÷ 350)K, T_{en} = 300 K, and T_ω = 0,1K, at a level of the absorbed energy $\Delta E = 5 \cdot 10^{-3}$ Watt/sm^2, the error of taking temperature ξ_T is (0,2 ÷ 1)%, that meets the measuring of the absorbed energy with precision of $(10^{-5} \div 5 \cdot 10^{-5})$ Watt/sm^2. At maintenance of stability of (electrons) absorption coefficients and radiation (Infrared radiation) of the sounding screen the estimation of the ratio error ξ_E of electrons energy measuring E_{in} can be made based on a selection of an optimum range of screen temperature values T_{en}, in the limits of which the minimum value of temperature measuring ratio error ξ_T is provided. Under the above-mentioned conditions the ratio error ξ_E of electrons energy measuring E_{in} can be equal to ~0,5%.

Conclusion. It is proposed the simultaneous methods of treatment and control of potentially dangerous objects. This methods are based on the prophylaxis irradiation and post irradiation IR-control.

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