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COMPARISON OF TACTICS MEANS EFFICIENCY FOR CREATING FIRE BARRIERS BY WATER DISCHARGE FROM THE AIRCRAFT AN-32P

The article results in values of probability in forming continuous link of two water spots resulting from successive discharges water from firefighting aircraft An-32P. The cases of using the colored and the colorless reagent, tactics of discharging along the targeted localization line as well as along the axis of the previous spot.

Keywords: a firefighting aircraft An-32P, a localization barrier, a wildfire.

Formulation of the problem. Creating a fire barrier of wetland plant material by discharging water from firefighting aircraft during the wildfire localization is a common practice. Due to random distribution of point drop coordinates of water center core it is important to solve the problem of the probability of extending continuous fire barrier in different variants of accounting of previous discharges.

On the contrary, using the colored reagent allows pilots take the next discharge more precisely with account of visualized water spots, obtained as a result of the previous discharge.

In the literature there is no theoretical neither experimental assessment of probability of forming continuous barrier only by water discharges that do not allow to compare the efficiency of the colored reagent and conclude on the feasibility of attracting only aircraft (without the support of ground forces) to confine wildfires.

Analysis of recent research and publications. In [1], it is given the probability mathematical models of forming continuous fire barrier with the application of colorless and colored reagent as well as tactics of discharge along the targeted localization line (without location of the previous spot) and along the axis of the previous spot (i.e. considering location) the application of the An-32P.

In [1] the numerical values of these probabilities have not been received, which does not allow to draw a conclusion about the possibility of the forming a continuous fire barrier only by aviation forces and to identify the most effective tactics of wildfire localization.

Statement of the problem and its solution. The aim is to compare the efficiency of creating continuous fire barrier when discharging water from aircraft An-32P when using three tactics means.

In [1] based on data obtained in [2-4] it has given the mathematical model of probability P overlapping two water spots formed by independent discharges (colorless reagent), aimed at the points located along some straight (OX axis)

$$P(d,H,\delta^*)=\frac{1}{(2\pi\sigma_{\Delta x}\sigma_{\Delta y})^2}\int\limits_{-\infty}^{\infty}\int\limits_{-\infty}^{\infty}\iint\limits_{\Omega_1} e^{-\frac{u^2+(s-d)^2}{2\sigma_{\Delta x}^2}-\frac{v^2+t^2}{2\sigma_{\Delta y}^2}}\,dsdtdudv, \quad (1)$$

where H – the height of discharge; d – the distance along the axis OX between the aiming points; δ^*- required thickness of water layer in a water spot; $\sigma_{\Delta x}$ and $\sigma_{\Delta y}$ – longitudinal and transverse standard deviation from center spot to the aiming point; Ω_1 – area around the previous spot, in which the center of the next spots hit that causes them to overlap.

In case of visual identifying the first spot its location is not accident (it is believed that the center of the spot is at the point $(x_1;y_1)$), the likelihood of overlapping the two spots in the case of prolonging localization line along the axis OX will be set by [1] expression

$$P(x_1,y_1,d,H,\delta^*)=\frac{1}{2\pi\sigma_{\Delta x}\sigma_{\Delta y}}\iint\limits_{\Omega_1}\exp\left(-\frac{(s-x_1-d)^2}{2\sigma_{\Delta x}^2}-\frac{(t-y_1)^2}{2\sigma_{\Delta y}^2}\right)dsdt. \quad (2)$$

An alternative to this tactic is discharge of other spot not along the OX line but along the line $y = y_1$, that is, prolonging the first spot. In this case, the probability of overlap will be set by [1] expression

$$P(x_1,d,H,\delta^*)=\frac{1}{2\pi\sigma_{\Delta x}\sigma_{\Delta y}}\iint\limits_{\Omega_1}\exp\left(-\frac{(s-x_1-d)^2}{2\sigma_{\Delta x}^2}-\frac{t^2}{2\sigma_{\Delta y}^2}\right)dsdt. \quad (3)$$

Repeat of discharge procedure creates a fire barrier. The probability that it will be continuous can be found after calculation (1), (2) and (3). Fig. 1 shows the result of calculating the probability of (1) creating a continuous link with two consecutive discharges of water depending on the distance d between the aiming points and thickness in spots of water at different values of the altitude discharge H.

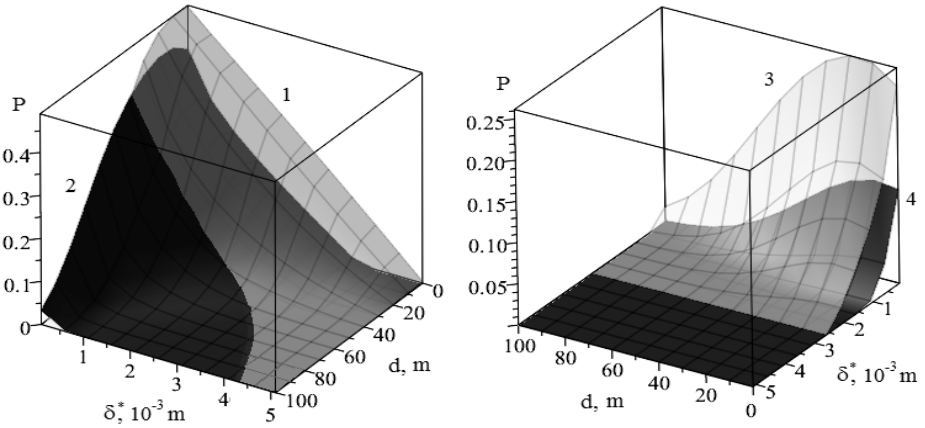

Fig. 1. Graph of dependency at H: 1 – 40 m; 2 – 50 m; 3 – 60 m; 4 – 70 m

The analysis of graph shows that the maximum probability does not exceed 0,5 (at H = 40 m). With increasing distance d the probability slightly increases (for d = 10-20 m) and then falls to 0. Also there is a monotonic decrease with an increase in the required thickness of water.

Fig. 2 shows a graph of (2) (with designation $x = x_1, y = y_1$) at different values of the altitude discharge H and thickness of water depending on the coordinates of the drop point center of the first spot. It is evident that there is symmetry dependence, due to the symmetry of the field Ω.

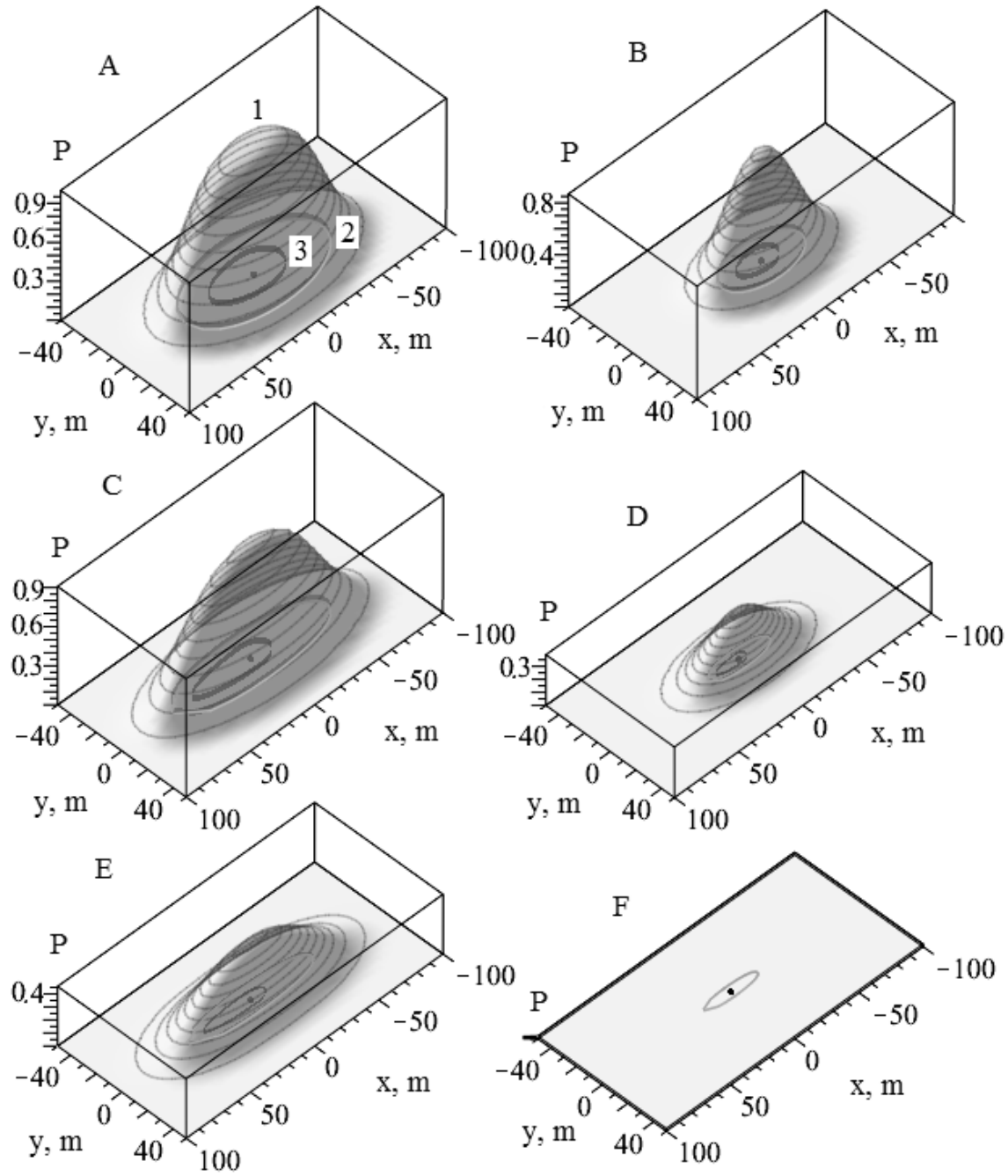

Fig. 2. The graph of $P(x, y)$ (surface 1) for the expression (2). Line 2 – the border of field Ω; line 3 – contour $L_1(x, y) = 0$. Values: A – H = 40 m; B – H = 40 m; C – H = 50 m; D – H = 50 m; E – H = 60 m; F – H = 60 m

From the analysis of graphs it follows that, for example, when aiming within a water spot (Fig. 2-A) continuous link two spots (P value close to 1) is almost reliably formed, but with increasing the required thickness of water the probability decreases. Also, the probability significantly reduces with increasing the altitude discharge.

Fig. 3 shows a graph of the expression (3). It should be noted that the expression (3) is formed from (2) when substituting $y = 0$. Accordingly, the graphics shown in Fig. 3 are the result of overlapping the graphs which shown in Fig. 2 by plain $y = 0$.

Analysis of Fig. 3 shows that the discharge from a height of 40-50 m reliably leads to the formation of continuous links from two spots if the thickness of water is negligible ($\delta^* = 0.1\text{mm}$) even when the distance between the center point of the previous spot and aiming point for the next spot is to 50 m.

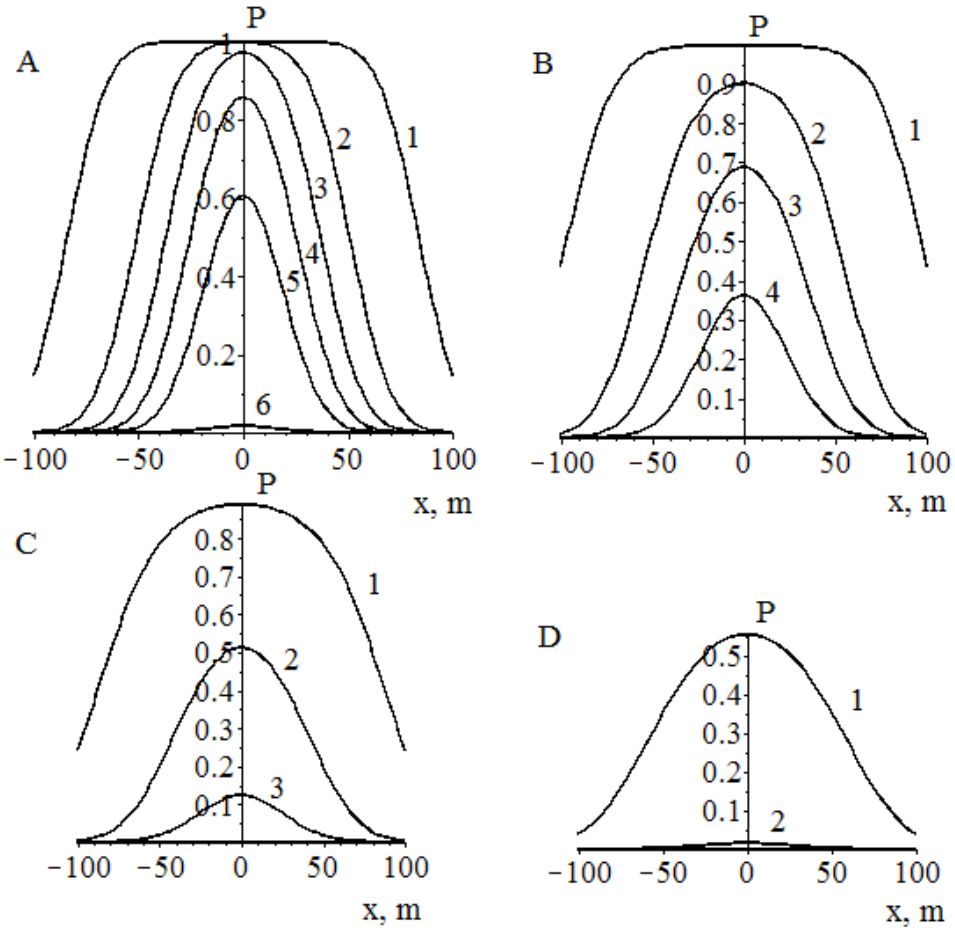

Fig. 3. Graphs of $P(x)$ for the expression (3) in the case of: A – H = 40 m; B – H = 50 m; C – H = 60 m; D – H = 70 m. Line 1 – $\delta^* = 0.1$ mm; 2 – $\delta^* = 1.1$ mm; 3 – $\delta^* = 2.1$mm; 4 – $\delta^* = 3.1$mm; 5 – $\delta^* = 4.1$mm; 6 – $\delta^* = 5.1$mm

Comparing all three cases demonstrates the superiority of the latter tactics, since the probability of forming a continuous link of two spots at the same time will be the highest. At the same time, the use of this tactic leads to

accidental deviation of formed fire barrier from the intended line localization (random walk [1]), which is unacceptable in terms of efficiency localization.

Conclusions. Tactics of discharging colored reagent along the intended line of localization is the most effective, but creates a continuous barrier only in the case of low required thickness of water. At the same time a thin layer of water is able to stop only low-intensity fires to which use of aircraft is not an appropriate for economic reasons and therefore we can conclude that nevertheless discharges are made with colored reagent during the wildfire localization by the aircrafts AN-32P a need to employ ground forces fire has arisen.

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Порівняння ефективності тактичних прийомів створення безперервного протипожежного бар'єру скидами води з літака Ан-32П

Отримано значення ймовірностей створення безперервної ланки з двох водяних плям, які є результатом послідовних скидів води з пожежних літаків Ан-32П. Розглянуто випадки використання підфарбованого і непідфарбованого реагентів, тактика скидання уздовж наміченої локалізаційної лінії, а також уздовж осі попередньої плями.

Ключові слова: пожежний літак Ан-32П, локалізаційний бар'єр, природна пожежа.

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Сравнение эффективности тактических приемов создания непрерывного противопожарного барьера сбросами воды с самолета Ан-32П

Получены значения вероятностей создания непрерывного звена из двух водяных пятен, которые являются результатом последовательных сбросов воды с пожарных самолетов Ан-32П. Рассмотрены случаи использования подкрашенного и неподкрашенного реагентов, тактика сброса вдоль намеченной локализационной линии, а также вдоль оси предыдущего пятна.

Ключевые слова: пожарный самолет Ан-32П, локализационный барьер, природный пожар.