EXPERIMENTAL DETERMINATION OF THE VERTICAL SPEED OF A PRACTICAL AVIATION BOMB, FORCEFULLY SEPARATED FROM THE AVIATION ARMAMENT MOUNT

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Abstract: *The article depicts the determination of the the initial vertical velocity of an aviation bomb using a high-speed camera and a stand.*

Keywords: *air bomb, beam support, mathematical expectation, standard deviation, forced separation, aviation armament installation.*

1. INTRODUCTION

The issue of aviation bomb detachment has not yet been resolved in full. This problem concerns the safety of the separation and the accuracy of the bombing. The safety of the separation is achieved by the formation of such initial flight conditions of aviation bombs, which exclude the possibility of collisions of the bombs with the elements of the airplane structure, the beam supports and the loads hung on them. The forced detachment of aviation bombs provides separation safety and reduces technical dissipation.

At present, there is no quantitative information on the vertical initial velocity of forcibly ejected aviation bombs. To calculate the technical dissipation, it is necessary to determine this speed.

2. DETERMINATION OF THE VERTICAL INITIAL VELOCITY OF A PRACTICAL AVIATION BOMB P-50-75, SUSPENDED ON SUPPORT MBD2-67U

Based on the methodology [1], an experiment was conducted (aground) to determine the initial vertical velocity of a practical aviation bomb.

The experiment was carried out on a MiG-21 aircraft, a beam support BD3-60-21, a multi-beam girder holder MBD2-67U, a PPP (10 pcs.), A stand and a high-speed camera.

When the first and second laser beams intersect, the signals are fed to a microcontroller with a working frequency of 16 MHz. The controller measures the motion time of the bomb between the two laser beams. From the known formula:

$$h_3 - h_2 = V_{уп} t_{изм} + \frac{g t_{изм}^2}{2}, \qquad (1)$$

the forced vertical velocity $V_{уп}$ is determined:

$$V_{уп} = \frac{\left(h_3 - h_2 - \frac{gt_{изм}^2}{2}\right)}{t_{изм}}. \qquad (2)$$

The plan for placing of the practical bomb and the laser sensors is shown in Fig. 1.

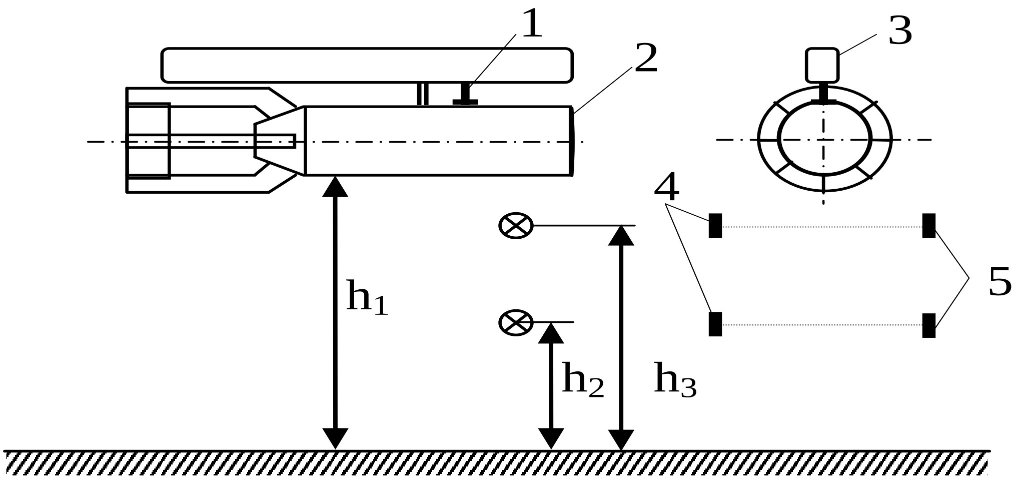

FIG. 1 Scheme of the experiment
1 - piston; 2 - practical bomb; 3 - beam supports; 4 - laser; 5 - laser sensor;
h1 = 910 mm - distance from the practical bomb to the ground;
h2 = 500 mm - distance from the second laser to the ground;
h3 = 810 mm - Distance from the first laser to the ground.

Table 1 shows the values of the forced vertical speed $V_{уп}$ and the time $t_{изм}$ for 10 attempts.

Table 1

n	1	2	3	4	5
$V_{уп}$ [m/s]	0,97	1,05	1,13	1,08	1,15
$t_{изм}$ [s]	0,1713	0,1662	0,1613	0,1644	0,1602

n	6	7	8	9	10
$V_{уп}$ [m/s]	0,97	1,13	0,95	0,97	1,05
$t_{изм}$ [s]	0,1713	0,1613	0,1726	0,1713	0,1662

Mathematical expectation and average quadratic deviation of forced vertical velocities $V_{уп}$:

$$M[V_{уп}] = \frac{\sum_{j=1}^{n} V_{уп_j}}{n} = 1{,}0450 \ \text{m/s};$$

$$\sigma_{V_{уп}} = \sqrt{\frac{\sum_{j=1}^{n}\left(V_{уп_j} - M[V_{уп}]\right)^2}{n-1}} = 0{,}0765 \ \text{m/s}. \qquad (3)$$

The confidense interval I_β of the mathematical expectation $M[V_{уп}]$ determined with a confidence probability β=0,95, is calculated by [4]:

$$I_\beta = \left(\tilde{m} - t_\beta \sqrt{\frac{D_{V_{уп}}}{n}}; \quad \tilde{m} + t_\beta \sqrt{\frac{D_{V_{уп}}}{n}}; \right), \tag{4}$$

where t_β=1,96.

The half length of the confidence interval ε_β is determined by:

$$\varepsilon_\beta = t_\beta \sqrt{\frac{D_{V_{уп}}}{n}} = 0{,}0474. \tag{5}$$

From Form. (3 and 4) - the confidence interval I_β of mathematical expectation $M[V_{уп}]$: I_β=(0,9976; 1,0924).

The confidence interval, $I_{D\beta}$ dispersion $D_{V_{уп}}$, vertical speed $V_{уп}$, determined with confidence probability β=0,95, are calculated using formulas [4]:

$$I_{D\beta} = \left(D_{V_{уп}} - t_\beta \sqrt{\frac{2}{n-1}} D_{V_{уп}}; \quad D_{V_{уп}} + t_\beta \sqrt{\frac{2}{n-1}} D_{V_{уп}} \right); \tag{6}$$

$$I_{D\beta} = \left(4{,}4488.10^{-4}; \quad 0{,}0113 \right),$$

or the confidence interval $I_{\sigma\beta}$ of the square quadratic deviation $V_{уп}$:

$$I_{\sigma\beta} = \left(0{,}0211; \quad 0{,}1061 \right).$$

It is clear that the mathematical expectation $M[V_{уп}]$ and the average square deviation $\sigma_{V_{пу}}$ of $V_{уп}$ are within the confidence limits of I_β and $I_{\sigma\beta}$.

The vertical speed $V_{уп}$ was also determined by a high-speed camera at 25,000 frames per minute.

The reading starts from the firing of the pyrocartridge PPL and ends with the fall of the bomb on the ground.

From the formula:

$$V_{уп} = \frac{\left(h_1 - \frac{g t_{изм}^2}{2} \right)}{t_{изм}},$$

the following results are obtained:

Table 2

n	**1**	**2**	**3**	**4**	**5**
$V_{уп}$ [m/s]	1,4282	1,4595	1,4604	1,5051	1,3995
$t_{изм}$ [s]	0,3091	0,3069	0,3069	0,3038	0,3111
n	**6**	**7**	**8**	**9**	**10**
$V_{уп}$ [m/s]	1,4661	1,5002	1,3805	1,4715	1,4928
$t_{изм}$ [s]	0,3065	0,3041	0,3124	0,3061	0,3046

The mathematical expectation and the average quadratic deviation of the forced vertical velocities $V_{уп}$:

$$M[V_{уп}] = 1{,}3544\ \ m/s;\ \ \sigma_{V_{уп}} = 0{,}0418\ \ m/s.$$

The calculated values of the forced vertical velocity $V_{уп}$ in both methods show the convergence of the results. Differences in mathematical expectations

$$\Delta M[V_{уп}] = M[V_{уп}]_{и} - M[V_{уп}]_{к} = 1{,}045 - 1{,}3544 = -0{,}3094 m/s$$

and the average square deviations

$$\Delta\sigma_{V_{уп}} = \sigma_{V_{уп_{И}}} - \sigma_{V_{уп_{К}}} = 0{,}07 - 0{,}04 = 0{,}03\ m/s$$

of $V_{уп}$ are determined by the inaccurate determination by the high-speed camera of the moments of the beginning of the separation and the fall of the practical bomb P-50-75.

3. CONCLUSIONS

The initial forced vertical velocity of a practical aviation bomb is determined. Based on this speed, it is possible to calculate the technical scattering of aviation bombs and to determine the influence of the forced separation on the technical dissipation.

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