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CALCULATION OF THE VERTICAL INITIAL VELOCITY OF AN AIRCRAFT BOMB

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Abstract

The vertical initial velocity of an aviation bomb pushed from a beam holder is calculated. Accounting for this speed reduces the technical distraction of aerial bombs.

Introduction

The effectiveness of the combat use of unguided aviation bombs is determined not only by the effectiveness of their striking action (high-explosive, fragmentation, penetrating, etc.), but also to a significant extent by the accuracy of solving the targeting task and the error of technical distraction. Increasing the accuracy of hits is possible by increasing the accuracy of solving the aiming task and reducing the error of technical distraction. The causes of target distraction operate until the beginning of the bomb's separation from the aircraft, and the causes of technical distraction - during and after the bomb's separation. Technical dispersal depends on: the method of release (forced or free) of the bombs; the ballistic characteristics of bombs; the distance between the bombs mounted on the beam holders; the distance from the center of mass of each bomb to the center of mass of the aircraft; the area of the turbulent flow around the aircraft, etc. Aircraft mainly use single-piston pyrotechnic mechanisms to eject the bombs, and by calculating the gas dynamic parameters in the chamber of the mechanism, the ejection force of the aviation bomb can be determined, which is introduced into the equations of motion of the bomb at the initial stage of separation from the plane. As a result of the solution of the equations, the magnitude of the pusher stroke, the initial vertical and linear speed of the bomb, the acceleration of the center of gravity, the angular acceleration, and the speed of rotation of the bomb are obtained. The magnitude of the stroke of the pusher of the pyrotechnic mechanism depends on the working volumes of the gas in the pyrotechnic mechanism and on the pushing force. These values of gas dynamic parameters are calculated by solving the equations of internal ballistics from the moment of ignition of the powder charge in the pyrocartridge with calculation of the pressure increase in the combustion chamber and in the pusher cylinder for the time of burning of the powder and the pressure drop at the end of combustion.

Results

For a given pyrotechnic system (fig. 1) and (fig. 2), the initial and final volumes are determined, as well as the pressures created in it during the combustion of the gunpowder of the pyro cartridge. With known dimensions of the pyrotechnic system, its initial $V_н$ and final V_k volumes are determined by the formulas:

(1) $V_н = V_1 + V_2 + V_3 - V_{пат.}$;

(2) $V_к = V_н + V_4 + V_5 - V_т$,

where

V_1, …….. V_5 are the volumes of the constituent parts of the system; $V_{пат.}$ – the volume of the chuck;

$V_т$ – the volume of the part in which the pusher moves.

Individual volumes are calculated depending on their shape and size.

From form. 1 and 2 for the initial and final volume of the pyrotechnic system of a lock (Fig. 1) with a given type of pyrotechnic cartridge with pyroxylin powder with the corresponding characteristics of the power, mass and volume of the gunpowder, the volume of the pyrotechnic cartridge and the maximum pressure of the powder gases are obtained:

$V_H = 6.10^{-5}\ m^3$;

$V_K = 8.10^{-5}\ m^3$.

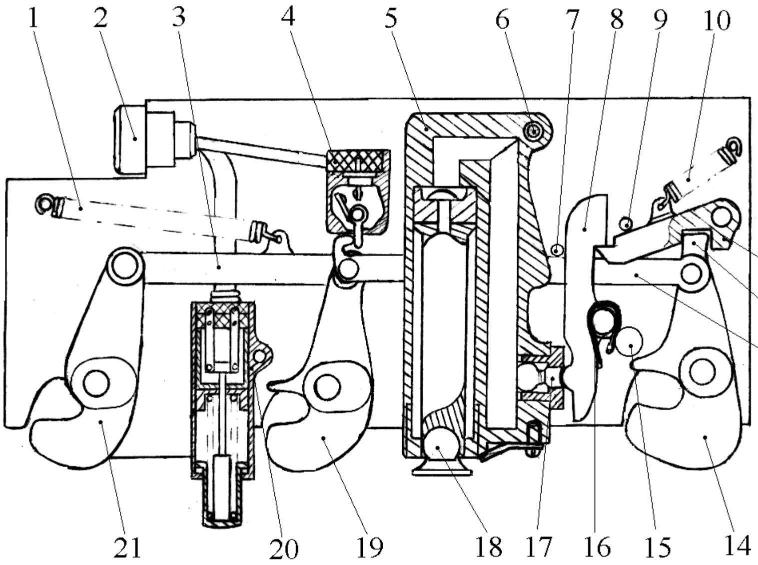

Fig. 1. Lock

1, 10, 16-spring; 2-plug socket; 3-thrust; 4-locking mechanism; 5-pyro chamber; 6-pin; 7- hole for "kinematics control"; 8-lever: 9-hole "locked kinematics"; 11-intermediate lever; 12-protrusion; 13-plank; 14-rear support arm; 15-thrust; 17-piston of the pyromechanism; 18-thruster; 19-middle bearing lever; 20-locking and alarm mechanism; 21-front support arm.

The initial $p_н$ and final $p_к$ pressure of the powder gases are determined by the formulas [1]:

$$p_н = \frac{m_б.f_б}{V_н}$$

$$p_к = p_н \left(\frac{V_н}{V_н + l_{14} S_б} \right)^k,$$

where $m_б$ is the mass of gunpowder in the pyro cartridge;

$f_б$ – the power of gunpowder;

$S_б = \pi d^2/4 = 1{,}2.10^{-4}\ m^2$ – the area of the piston;

$k = 1.22$ – the adiabatic index;

l_{14} – the stroke of the pyrotechnic piston.

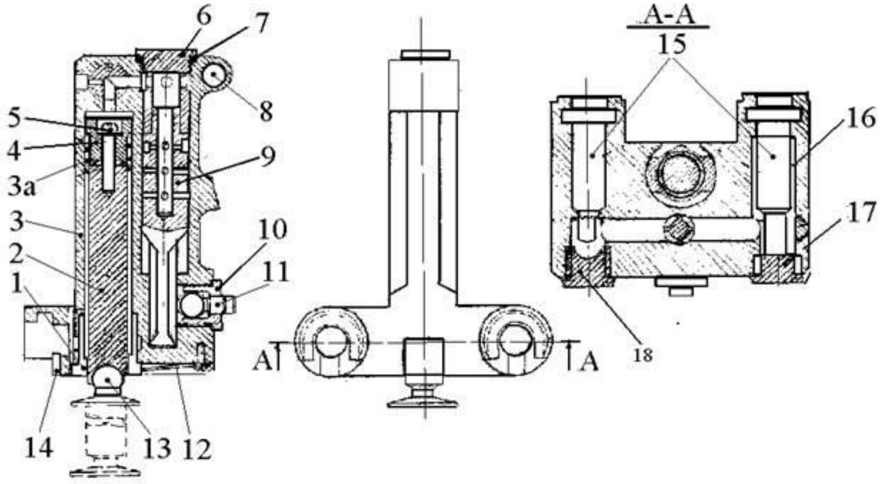

Fig.2. Pyrotechnic lock mechanism

1, 6, 10, 18-nuts; 2-push rod; 3-body; 3a-ring; 4-glass; 5-screw; 7-washer; 8 pin hole; 9-filter; 11-piston; 12-spring; 13-rest of the pusher; 14, 16-pad; 15-cartridge-2 pcs.; 17-plug.

For the initial and final pressure, for the given power and mass of gunpowder, of the set pyrotechnic system, we get:
$P_н = 5.\ 10^7$ [N/m^2]; $P_к = 3.\ 10^7$ [N/m^2].

The work $A_П$ done by the pyrotechnic system is determined by the formula [2]:

$$A_п = \eta p_н V_г^k \left[V_к^{1-k} - V_н^{1-k} \right] \frac{1}{1-k}$$

where n=0.6 is the coefficient of useful action, taking into account the leakage and friction of the powder gas.

The work done by the system is obtained as $A_п$ = 25[Nm].

The vertical velocity of the forced separation is calculated by the formula [1]:

$$V_{уп} = \sqrt{\frac{2}{m_б}\left(A_п - m_б n_y g l_{14}\right)}$$

where n_y is the normal overload of the aircraft;

g – the acceleration of the Earth;

$m_б$ – the mass of the bomb.

The value of the forced vertical velocity for a 100kg aviation bomb under overload $n_y=3$ is $V_{уп}= - 2,5$ m/s.

Conclusion

The vertical initial ejection velocity of an aviation bomb from a beam holder is calculated. From the research carried out, it is found that as the strength increases $f_б$ of gunpowder and normal reloading n_y, the forced vertical velocity $V_{уп}$ increases, like normal overload n_y of the aircraft has a greater influence on the vertical speed $V_{уп}$ of the aerial bomb than the power of gunpowder $f_б$. The technical dispersion of a forced release of an aerial bomb is less compared to the technical dispersion of a freely released bomb [3].

References

1. Нестеров В. А., Полянский В. В., Проектирование универсального замка балочного держателя, Проблемы создания перспективной авиационной техники, Сборник статей научно–исследовательских, проектно-конструкторских и технологических работ студентов, молодых ученых и инженеров, под ред. Проф. Ю. Ю. Комарова, В. А. Мхитаряна, Р. Д. Лисина М.,МАИ,2004г. p. 21-25. https://vk.com/doc247409661_448151632?hash=tig9m2Omq57tXZQLiP1UIgrbu5TvZ49j0OXRNE3opz0
2. Нестеров В. А., Конструкция и проектирование балочных, кассетных и ящичных держателей, М, МАИ, 2007 г., ISBN 5-7035-1832-6.
3. Стойков С. О., Влияние на принудителното отделяне на авиационните бомби върху техническото разсейване, ВВВУ „Г. Бенковски“, 2022, p. 111, ISBN 978-954-713-112-5.

ИЗЧИСЛЯВАНЕ НА ВЕРТИКАЛНАТА НАЧАЛНА СКОРОСТ НА ИЗТЛАСКВАНЕ НА АВИАЦИОННА БОМБА

С. Стойков

Резюме

Изчислена е вертикалната начална скорост на авиационна бомба, изтласквана от гредови държател. Отчитането на тази скорост намалява техническото разсейване на авиационните бомби.