AUTOMATIC WEAPONS

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ABSTRACT

The article reviews the design approach of automatic weapons working on the blow back principle.

INTRODUCTION

Automatic weapons employ various means to achieve automacity i.e., to extract, eject, reload, cock and fire. The various principles by which automacity is achieved are (*a*) gas action (*b*) short recoil and (*c*) blow back.

In the gas action, the propellant is tapped at a convenient point from the barrel and made to act on a piston. The motion so obtained does the extraction and ejection, and the rest of the energy is absorbed in the recoil spring which is utilized in performing the rest of the functions.

In short recoil weapons, there is a positive lock between the barrel and the breach so that the entire piece moves back till the bullet leaves the barrel, after which the lock opens and the breach block further recoils due to the after effect of the gases as well as its initial inertia against the force of the spring. This does the extraction and ejection, the remaining operations being performed during the forward motion of the breach under the action of the spring. Assuming an exponential decay of pressure after the bullet leaves the muzzle, viz.,

$$\frac{dp}{dt} = -P\frac{a}{L}$$

Where 'a' is a constant and 'L' is the length of the barrel, it can be seen that the maximum impulse that can be given to the breach block is given by the relation:

$$I = P_o \frac{V_o}{a} \qquad \ldots \qquad (1)$$

where 'P_o' is the pressure at the instant bullet leaves the muzzle, and 'V_o' the total volume of the barrel and the chamber. It is estimated that the constant 'a' varies from 1·1 to 1·2 times M.V. for calibres in the region of 20 m.m. tending to slightly higher values for pistols. It may however, be noted that the value of the impulse that can be used in practice is of the order of 50 to 60 per cent due to the finite time over which the integral is done. This principle is therefore effectively used for weapons using small length cartridge cases, where smaller impulses can be utilised.

The blow back principle, however, is the simplest in operation. There is no lock between the chamber and the bolt so that the pressure acting inside the cartridge case forces the breech to recoil against the force of the spring. The bolt pulls the cartridge out and ejects it. The rest of the functions are performed by the energy stored in the spring. The impulse imparted upto the instant of shot ejection is approximately given by;

$$I = (m_p + \tfrac{1}{2}\, m_c)\, V_o$$

where m_p and m_c are the projectile and the charge weights and 'V_o' the M.V. The after effect impulse is of the order of 15 per cent so that the total impulse is given as;

$$I = 1{\cdot}15\,(m_p + \tfrac{1}{2}\, m_c)\, V_o \qquad \ldots \qquad (2)$$

An approximate value of this is indicated below:

Weapon	9 mm	0·303	20 mm	27 mm	50 mm
1 kg. sec.	0·351	1·2	2·7	8·0	40·00

It may therefore be seen that the impulse imparted to the bolt is fairly high and this can be used to perform automacity within a certain calibre range of weapons beyond which the bolt rebound distance and/or its weight become prohibitive. Besides, as the bolt recedes the cartridge is pushed back and is therefore subjected to the internal gas pressure without the adequate support from the chamber walls. This would necessitate either a careful design of the case wall thickness to withstand the internal pressure as it decays or that at any instant the case does not protrude out of the chamber to a magnitude that would endanger its safe operation depending on the internal gas pressure. The motion of the breech is evidently dependent on the spring force and its mass. The best choice of the weight of the breech comes from the considerations of the energy requirements for all the operations. If 'm' is the mass of breech block and 'I' the impulse it receives, then, the energy acquired by it is given as:

(*a*) $E = \frac{1}{2}\,\frac{I^2}{m}$ if the breech block is at rest at the instant of firing.

(*b*) $E = \frac{1}{2}m\left(\frac{I}{m} + V\right)^2$ if the breech block is moving backward with a velocity V at the instant of firing.

and (*c*) $E = \frac{1}{8}\,\frac{I^2}{m}$ if the breech block impacts with a velocity V and rebounds with an equal velocity in the opposite direction due to the firing.

The case (*b*) is dangerous for the energy of the breech block goes on increasing with every cycle. Case (*c*) is the one often desired. A graphic representation of the distance/time and distance/velocity variation in the three cases is shown in figure 1. Besides to keep the overall weight to a minimum the recoil distance of the bolt is almost invariably kept the minimum required from the point of view of suitable ejection and the desired rate of fire.

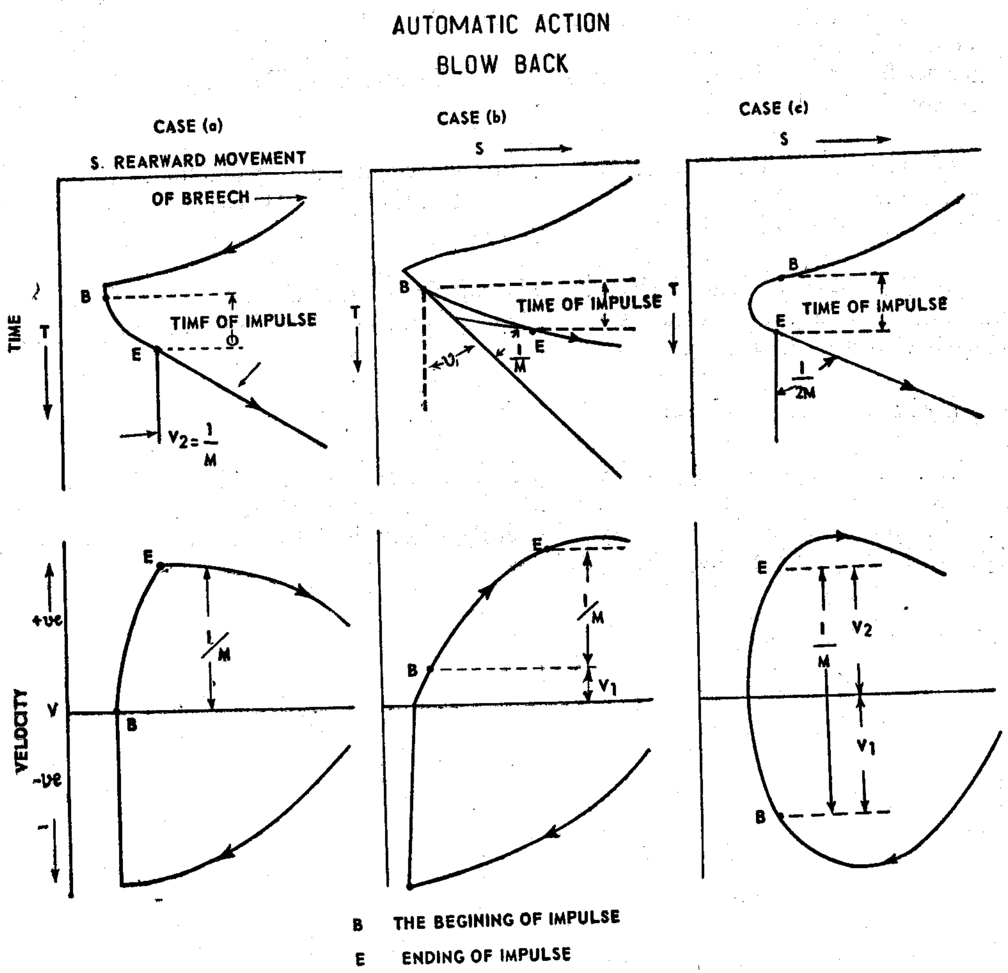

Fig I

Design Approach

To assess the basic design parameters for a blow back operation, the following approach may be suggested.

(*a*) Knowing the internal ballistics of the weapon, p-t and v-t curves can be plotted. The total impulse under the p-t curve can be evaluated.

(*b*) Energy of free recoil of the bolt is known in terms of mass of the bolt.

(*c*) From a layout sketch the distance of recoil of the bolt is estimated.

(*d*) From the desired rate of fire, the time for a cycle is calculated. The time for forward motion may not necessarily by the same as that for backward motion but if case (*c*) is attempted then the time for the two motions will be nearly equal.

(*e*) The energy of extraction can now be estimated by a graphical integration of the p-s curve. It may be pointed out that the value of coefficient of friction would be almost three to four times its normal value due to vibrations, oscillations, and temperature/pressure effects.

(*f*) The energy consumed in reloading and fire are often fairly small and therefore the balance energy may be assumed to be absorbed in the spring over the distance of recoil. This decides about the stiffness of the spring.

(*g*) The velocity of the block can now be calculated and this has to be checked against the value as obtained from the calculations of (*c*) and (*d*). Quite often successive approximations will be necessary.

(*h*) Mass of the block can now be estimated.

It need hardly be emphasised that the above leads to theoretical estimates of the various parameters which more often than not would need experimentation trial to establish them in a practical case. Besides, a theoretical design might have to be amended in the light of the proposed engineering layout.