COMPARATIVE EVALUATION OF UNDER WATER SHOCK PARAMETERS OF ALUMINISED AND NON-ALUMINISED EXPLOSIVE CHARGE

V.P.Singh, Perminder Singh and D.S.Murty
Terminal Ballistics Research Laboratory, Chandigarh

ABSTRACT

Propagation and attenuation of spherical shock waves produced by the detonation of aluminised explosives (Torpex) and Non-aluminised explosives (RDX:TNT) in water is studied using Energy Hypothesis. Theoretical results are compared with those obtained by the experimental data in this laboratory.

INTRODUCTION

Shock attenuation in water, produced by the detonation of an explosive, which releases energy instantaneously, was studied by Singh et.al (1980). Energy Hypothesis proposed by Thomas (c.f. Bhutani et.al.1966) and modified for under water explosion by Singh (1976) was used in the above paper. But there are certain explosives which do not release energy instantaneously. Aluminised explosives come in this category.

Aim of the present paper is to see whether it is possible to predict the shock wave attenuation produced by such explosives. Following Singh et.al.(1980), we have found theoretically the pressure variations due to an typical aluminised explosive and the compared the results with the data obtained by actual trials, using underwater gauges developed by Sethi et.al(1980) in this Laboratory. It is found that the theoretically predicted curves agree well with the experimental data.

THEORETICAL FORMULATIONS

Let us assume that a shock wave of spherical shape propagates in water, which is produced by the detonation of a spherical charge of an aluminised explosive. At time t, if the radius of the shock front is R and p_2, ρ_2, U, u_2 are the pressure, density, shock velocity and the particle velocity behind the shock front, we have (Singh et.al.1980),

$$p_2 = \frac{\rho_1 C_o^2 \delta(\delta - 1)}{[C_1 - \delta(C_1 - 1)]^2} \tag{1}$$

$$U = C_o \delta / [C_1 - \delta (C_1 - 1)] \tag{2}$$

$$E_2^{*} = E_1^{*} + \left[\frac{(\delta - 1)\, Co}{C_1 - \delta(C_1 - 1)} \right]^2 \qquad (3)$$

where $\delta = \rho_2/\rho_1$, $E^{*} = E + 1/2\, u_2^2$

Equation of state of water used in above relations is

$$U = Co + C_1 u_2^2 \qquad (4)$$

where c_o and c_1 are experimentally determined parameters. Relations (1)-(4) relate p2, U, u_2, E_2 with the shock strength δ which is unknown at present.

To determine the variations of shock strength δ with the shock radius R, we use Energy Hypothesis, postulated first by TY Thomas (1957) and later used for MHD shocks by Bhutani et.al (1966). Singh (1976) modified this method for underwater explosion produced due to an explosive of finite radius. It was shown by Singh (1976), that total energy of the shock in water, is given by the relation,

$$E_2^{*} - E_1^{*} = \frac{3\alpha Q}{U\pi R^3 \rho_1} \qquad (5)$$

where α is a constant of proportionality and Q is the total energy released by the explosion.

From relation (5) and (3), we have

$$\delta \left[\frac{Co\, (\delta - 1)}{C_1 - \delta(C_1 - 1)} \right]^2 = \frac{3\alpha Q}{4\pi\rho_1 R^3} \qquad (6)$$

which give variation of δ versus shock radius R. If at $R = a_o$, where a_o is the charge radius, $\delta = \delta^{*}$ we have

$$\delta \left[\frac{Co\, (\delta - 1)}{C_1 - \delta(C_1 - 1)} \right]^2 = \delta^{*}\left[\frac{Co\, (\delta^{*} - 1)}{C_1 - \delta^{*}(C_1 - 1)} \right]^2 \left(\frac{a_o}{R}\right)^3 \qquad (7)$$

Value of δ^{*} can be calculated by the mismatch method at the explosive-water boundary (Pack, 1957). Relation (7) gives an expression for δ in terms of R, other parameters can be evaluated from the jump conditions (1)-(4).

EXPERIMENTAL SET UP

An under water pressure gauge was used to record the shock pressure in water. A spherical charge of aluminised explosive is hanged freely below the gauge at a known distance. Charge is centrally initiated by inserting a detonator, reaching the center of the charge. A trip wire, to initiate the oscilloscope is inserted in the charge through a whole in it. This trip wire and the gauge are connected with the oscilloscope(Fig.1). When the charge is detonated, a shock wave is produced in water. When this shock wave interacts with the crystal of the gauge, a pressure pulse is recorded in the oscilloscope. A typical record of the shock pressure is given in the Figure , where as experimental setup is shown in the Figure 1.

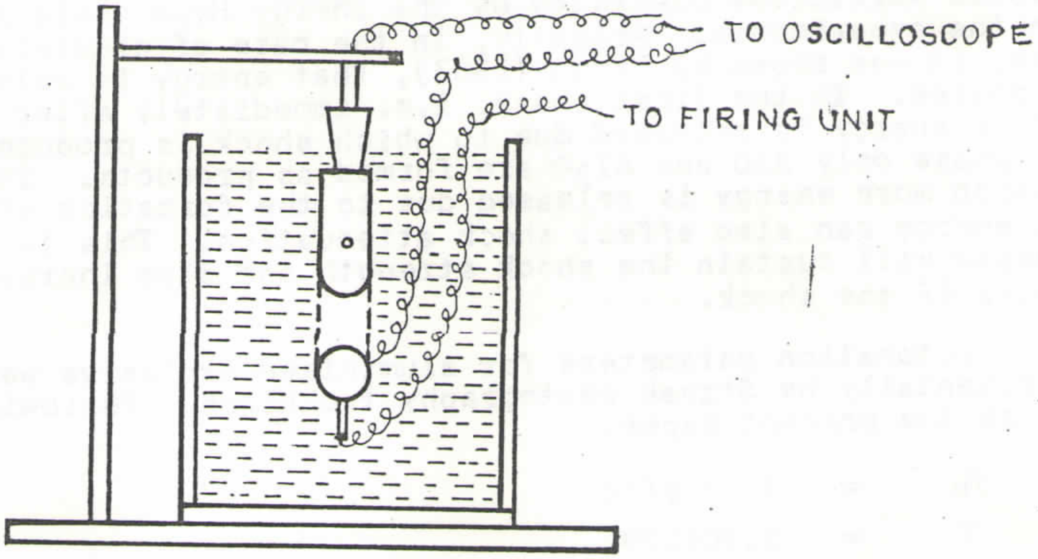

FIG. 1 EXPERIMENTAL SET-UP

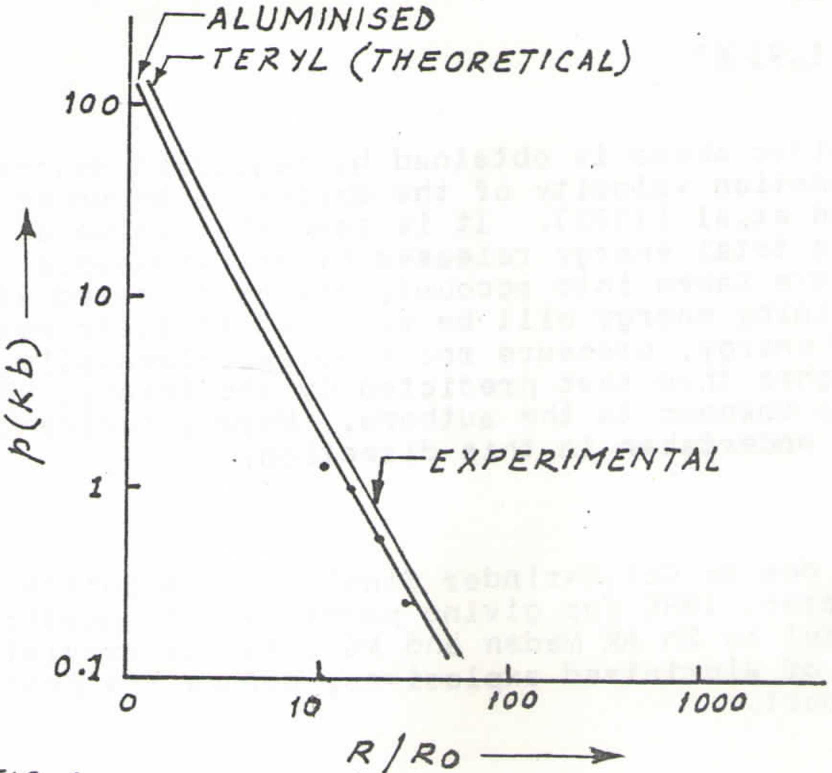

FIG. 2

RESULTS AND CONCLUSION

In figure 2, we have shown the comparison of theoretical curve with the experiments, for a typical aluminised explosive. It was shown by Singh et.al. (1980), that Energy hypothesis gives shock attenuation produced by CHON explosives, which also agrees with the experimental data. In the case of aluminised explosives, pressure variations predicted by the Energy Hypothesis also agree with the experiments. Actually, in the case of aluminised explosives, it was shown by Singh (1983), that energy is released in two phases. In the first phase, i.e. immediately after explosion, part of energy is released due to which shock is produced. In this phase only AlO and Al_2O are formed as products. In later reaction more energy is released due to the formation of Al_2O_3. This energy can also effect shock attenuation. This later energy released will sustain the shock strength and also increase the impulse of the shock.

Detonation parameters for aluminised explosive were obtained experimentally by Streak photography technique. Following data is used in the present paper,

$$\rho_D = 1.71 \text{ g/cc}$$
$$\gamma = 2.806129$$
$$U_D = 6.9 \times 10^3 \text{ cm/s}$$
$$Q = 827.09175 \text{ Kcal/Kg}$$
$$c_o = 1.55649$$
$$c_1 = 1.91067$$

Energy Q given above is obtained by measuring detonation pressure and detonation velocity of the explosive by under water technique by Madan et.al (1983). It is seen that value of Q is almost half of the total energy released by the explosive. Here, in figure 3, we have taken into account, energy released at C-J plane only. Remaining energy will be released in later reaction. Due to this later energy, pressure recorded experimentally is expected to be higher than that predicted by the theory. But it is not so, reasons unknown to the authors. More experimental work is required to be undertaken in this direction.

ACKNOWLEDGEMENT

Thanks are due to Col.Harinder Singh for the interest in the work and Director, TBRL for giving permission to publish it. We are also thankful to Sh AK Madan and MS Bola for providing experimental data of aluminised explosives, before its publication in the form of report.

REFERENCES

1. Thomas, TY (1957). J.Math. Mech., 6, p.607.

2. Bhutana OP (1966): J.Math., Anal., Appl., 13, p.565.

3. Singh, VP (1976): Ind. J.Pure Appl. Math., 7, p.147.

4. Singh, VP et.al. (1980): Proc.Ind.Acad.Sci., (Engng Sci), 3, p.167.

5. Singh, VP (1983): Theoretical evaluation of Heat of Explosion of aluminised and Non-aluminised explosives, To be published.

6. Pack, DC (1957): Phil. Mag., 2, 14.

7. Sethi, VS (1980); TBRL Tech. Rep. No.TBR-810.