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New Empirical Approach to Enhance The Accuracy of Cannon Tube Erosion Rate

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Various methods that utilize erosion rate measurement of standard cannon, 155mm Howitzer M185, as reference, are being used to ca'.ulate erosion rate of an interested unknown cannon tubes. We know ten measured erosion values of the standard cannon from 391 rounds to 4,000. An approximate function fitting these values is derived. The new erosion equation is also suggested and computer simulations are presented.

Keywords : Erosion Rate, Empirical Approach, Approximate function, New Erosion Equation

1. INTRODUCTION

The erosion prediction of cannon tube is an important issue associated with cannon development and maintenance. The actual firing test is the most accurate method to measure the erosion rate of cannon tube. But it costs a great deal and requires a long measurement time. Hence many empirical methods have been proposed to estimate the erosion rate and lifespan of cannon tubes.

Various methods that utilize erosion rate measurement of standard cannon, 155mm Howitzer M185, as reference, are being used to calculate erosion rate of an interested unknown cannon tubes. We predict the erosion rate of unknown cannon tubes by substituting measured values of the standard cannon and their allistic data for the erosion equation. Ballistic parameters are loading density, maximum pressure, muzzle velocity, and barrel length. The ratios of the parameters involved are weighed according to their importance.

We know ten measured erosion values of the standard cannon from 391 rounds to 4,000. An approximate function fitting these values is derived. The new erosion equation is also suggested and computer simulations are presented.

2. IMAM'S EMPIRICAL METHOD

Rauf Imam considered that higher rates of erosion were generally associated with higher muzzle velocity, higher pressure and higher quantities of charge. He concluded that one of the most significant factors was the muzzle velocity. Thus he suggested the following erosion equation

$$w_2 = w_1 \frac{D_2}{D_1} \left(\frac{P_2}{P_1}\right)^{1/2} \frac{L_2}{L_1} \left(\frac{V_2}{V_1}\right)^2 \times (PF)(CF) \quad (1)$$

where w is he erosion rate, D is the loading density, P is the maximum pressure, V is the muzzle velocity, L is the barrel length, PF is the propellant factor, and CF is the coolant factor. The subscript 1 refers to the standard cannon and the subscript 2 refers to the unknown cannon.

He also suggested another erosion equation to enhance the effect of muzzle velocity as follows:

$$w_2 = w_1 \frac{D_2}{D_1} \left(\frac{P_2}{P_1}\right)^{1/2} \frac{L_2/V_2}{L_1/V_1} \frac{e^{2V_2}}{e^{2V_1}} \times (PF)(CF) \quad (2)$$

3. APPROXIMATE FUNCTION

The data for erosion rate of standard 155mm cannon are actually quite limited. In fact, only ten measurements of erosion rate ranging from after 400 rounds to 4,000 exist in 400 rounds interval. Therefore erosion rate calculation model is very important in predicting erosion rate of cannon tubes.

In this research, it was assumed that lifespan of cannons end when the erosion reaches 0.254cm. According to the existing data, erosion rate reach 0.2794cm at 2,000 rounds. Therefore a new model was designed to calculate erosion rate only between 0 round and 2,000 rounds. The new model is designed as a function of number of rounds fired.

We derived the following approximate function fitting from the values

$$y = 0.00079532\, e^{0.001052 R} \times R^{-0.000149 R + 0.6652} \quad (3)$$

where y is the erosion value of standard cannon and R is rounds

Table 1 Erosion Values of Standard Cannon

Rounds	Measured Value (cm)	Calculated Value (cm)
391	0.1143	0.1141
812	0.1778	0.1819
1,217	0.2235	0.2261
1,600	0.2540	0.2535
2,000	0.2794	0.2699

Table 1 shows that the calculated values for w_1 are close to the measured values.

Data in Table 2 were calculated using the ballistic data, the value of w_1 from formula (3), and equation (1).

Table 2 Erosion Values: Imam Eqn. (1)

Cannon		A(155mm)	B(8inch)
Measured Value (cm/Rounds)		0.2794/700	0.254/2000
Calculated Value	Imam's Results [1]	0.2794/827	0.254/2300
	Approximate Formula	0.2794/667	0.254/1745

Table 2 shows the effectiveness of the formula (3). Since the calculated value of w_1 from approximate formula (3) is accurate, its corresponding results are more accurate than those by Imam in reference [1].

4. NEW EROSION EQUATION

As it can be seen in the approximate formula (3), empirical approach was conducted under assumption that the part of the formula that incorporates muzzle velocity parameter will be in exponential form.

Thus the new erosion equation is suggested as follows:

$$w_2 = w_1 \frac{D_2}{D_1} \sqrt{\frac{P_2}{P_1}} \frac{L_2 / V_2}{L_1 / V_1} \frac{V_2^{cV_2}}{V_1^{cV_1}} \times PF\,CF \quad (4)$$

In this equation, c is an empirical constant that are specific to the diameter of cannon tube.

Table 3 Values of w_2

Cannon		A(155mm)
Measured Value (cm/Rounds)		0.2794/700
Calculated Value	Eqn. (4) C = 0.6	0.2827/700
	Eqn. (1)	0.2890/700
	Eqn. (2)	0.4521/700

Table 3 demonstrates that the new erosion equation is more accurate, compared to Rauf Imam's equation, in calculating erosion rate for the cannon A(155mm).

5. CONCLUSION

We predict the erosion rate of unknown cannon tubes by substituting measured values of the standard cannon and those ballistic data for the erosion equation.

We know ten measured erosion values of the standard cannon at every 400 rounds. An approximate function fitting these values is derived. Numerical example applying this formula to the Rauf Imam's erosion equations is presented.

The new erosion equation is also suggested. This equation produces more accurate cannon tube erosion rate than the Rauf Imam's empirical approaches. Computer simulations are presented.

REFERENCES

[1] Imam, R., "An Empirical Approach to Predicting Cannon Tube Erosion Rate: AD-786 531", Benet Weapons Lab., 1974.
[2] Kruczynski, D. L., Stobie, I. C., Krummerich, M. B., "Gun Tube/ Charge/ Projectile Interactions and Gun Tube Wear: BRL-TR-3004", U.S. Army Lab. Command, 1989.
[3] Montgomery, R. S., Sautter, F. K., "Erosion and Its Control: Arlcb-Tr-82040", U.S. Army Armament Research and Development Command, 1982.
[4] Chapra, S. C., Canale, R. P., "Numerical Methods for Engineers", McGraw Hill, 1988.
[5] Chung, D., Kong, H., Nam, S. "A Study on the precision wear measurement for a high friction and high pressurized gun barrel by using a diamond indenter", WEAR 225-229 Elsevier, pp. 1258-1263, 1999.