Estimation of Impact Points for An Artillery Rocket Fitted with a Non-standard Fuze

Pawat Chusilp and Weerawut Charubhun
Defence Technology Institute
Nonthaburi, Thailand
pawat.c@dti.or.th, weerawut.c@dti.or.th

***Abstract*—This paper describes a quick method to predict the impact point of an artillery rocket when it is equipped with a non-standard fuze and the firing tables and a fire control program supplied by the rocket manufacturer become no longer accurate. The method has been applied to a 122 mm artillery rocket that was originally designed to be used with MRV-U fuze but it was replaced by M423 fuze. Live fire tests of six rockets were conducted at a half range and a full range. The impact points were measured by a radar. From the test results, the average relative error of predicted range by the proposed method was –1.4% at half range and –3.3% at full range.**

Keywords—Fuze, Firing tables, Artillery rockets, Trajectory simulation, Aerodynamics, External ballistics

I. Introduction

Artillery rocket systems produced by any weapon manufacturer are normally supplied with either a fire control program or printed tabular firing tables. These firing tables and program provide necessary data required to compute firing angles, which consists of quadrant elevation and azimuth, to deliver an effective fire on a given target under any set of conditions. Data for making such firing tables are obtained from live fire tests conducted at various quadrant elevations [1,2]. The projectile trajectory model is adjusted so that the simulated results match the test results. Then data in other quadrant elevations are computed and tabulated in a standard format such as [3]. The adjusted trajectory model can also be utilized by a fire control program to compute firing angles for any set of conditions.

Equations of motion to formulate a rocket trajectory model and firing solution algorithms may be shareable [4,5] but rocket characteristics, e.g. aerodynamics, thrust profile, moment of inertia, are generally different from one to another. So the data in tabular firing tables and the fire control program are valid for a particular rocket with specified configurations only. On some occasions, users of the artillery rockets need to make a few changes to the rockets due to many reasons. Such changes include replacing an original fuze with another one that is not specified by the rocket manufacturer.

Using a non-standard fuze can affect both the rocket aerodynamics and mass properties and consequently alter the original rocket trajectory. As a result, the tabular firing tables and fire control program provided by the weapon manufacturer become no longer be accurate and hence inability to deliver an effective fire on a target. Requesting new firing tables or a new fire control program from the weapon manufacturer may incur time and cost. Moreover, the source codes of the fire control program and rocket parameters, such as aerodynamic coefficients and thrust profiles, are often not provided by the manufacturer. As a result, it is hardly possible for users to adjust the rocket trajectory model employed in a fire control program and regenerate new firing tables. So there is a need for a method to counter this problem.

This paper describes a simple method to predict impact points of an artillery rocket that is fitted with a fuze not specified by the manufacturer. The proposed method has been applied to a 122 mm artillery rocket, whose fuze was replaced by a non-standard fuze. Section 2 explains the problem background and describes the artillery rocket investigated in this paper. Section 3 proposes a method and describes details of each step. The adjusted trajectory model was employed to predict impact points during live fire tests described in Section 4. The test results were discussed and compared to the prediction in Section 5. Finally, Section 6 draws a conclusion.

II. Problem Description

The rocket investigated in this paper is a 122 mm unguided artillery rocket used by Defence Technology Institute (DTI), Thailand, for its research and development works. The rocket length is less than 3 m and the total mass is about 70 kg. The rocket employs 4 wrapped around tail fins for aerodynamic stabilization. The maximum range is above 40 km in standard conditions i.e. standard atmosphere, no wind, no earth's rotation, sea level, etc. The rocket can be fitted with a drag ring to reduce range. The rocket was designed by the manufacturer to be used with a point detonating MRV-U fuze. The MRV-U fuze weighs 0.74 kg and has the exposed length of 142 mm after assembled to the rocket. Fig. 1 shows the picture of MRV-U fuze from an available reference [6].

Several rounds of the rocket were planned for live firing within a test range for research purposes. Initially, the fire control program provided by the rocket manufacturer was to be used for calculating firing angles—quadrant elevation and azimuth. Tabular firing tables were also available but were kept as a backup. Prior to the fire tests, a few static tests of the rocket motors were carried out to measure the thrust profile. These data are a critical input for trajectory simulation later.