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Research on the Optimized Algorithm about Brake's Initiative time for Course Correction Fuze

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***Abstract*—The algorithm about Brake's Initiative Time for Course Correction Fuze(CCF) has a large mount of calculation in the total trajectory calculation, so this part cost a majority of time when using DSP as processor. We should optimize the algorithm related to this part in order that the processor can accomplish the calculation for CCF quickly. This paper puts forward a kind of algorithm as approaching gradually to the real solution by a line of two points. Simulation has proved that this algorithm can reduce times of trajectory calculation and get the brake's initiative time more quickly.**

***Index Terms*— CCF, Brake's Initiative Time, trajectory, algorithm**

I. INTRODUCTION

The algorithm of FFC consists of two major modules: one is Trajectory Identification module, which identifies the initial velocity and equivalent angle of fire by detecting the trajectory parameters of flying; the other is Brake's Initiative Time calculation module, when the trajectory parameters are got, a appropriate Brake's Initiative Time will be calculated according to the target course set before and both the trajectory parameters before and after braking, and then course will be corrected. Generally, Brake's Initiative Time can be tentative calculation and interpolated with a step length of certain time. However, accomplishing one tentative calculation needs calculating one trajectory, and the finally Brake's Initiative Time will be got with several trajectory calculations. In this paper we will analyze the relationship of course correction and Brake's Initiative time, and raise an algorithm as approaching gradually to the real solution by a line of two points in order to get Brake's Initiative Time.

II. THE RELATIONSHIP OF BRAKE'S INITIATIVE TIME AND COURSE CORRECTION

Fig 1 and Fig 2 show the relationship of Brake's Initiative Time and course correction by simulation, assuming that the trajectory parameter after braking is 10.

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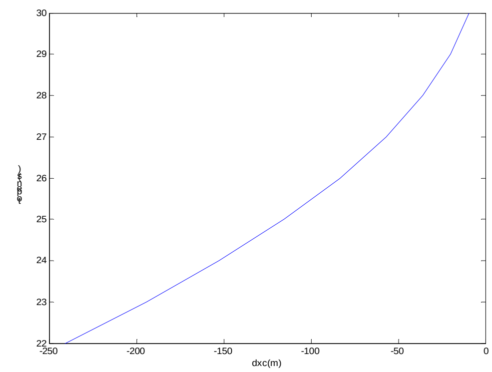

Fig 1 Relationship of distance corrected and Brake's Initiative Time (Initial velocity 265 m/s, Angle of fire 45^{o})

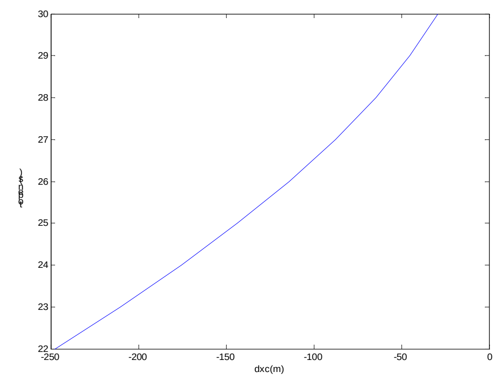

Fig 2 Relationship of distance corrected and Brake's Initiative Time (Initial velocity 242 m/s, Angle of fire 55^{o})

From the Figs, the relationship of Brake's Initiative Time and course correction is nearly a curve of conic, but the relationship will be changed with different initial velocities and angles of fire. So, it is necessary to fix a range of the relationships of Brake's Initiative Time and course correction appropriate for Course Correction Fuze in different conditions.

III. FIXING THE RANGE OF RELATIONSHIP OF BRAKE'S INITIATIVE TIME AND COURSE CORRECTION

A. Project of course expansion

When the correction coefficient is given, the earlier it brakes, the bigger correction and course expansion there will be. But the precision of correction will be reduced if it brakes

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too earlier. On the other hand, the smaller correction and extension are, the higher level of precision there will be. To the algorithm of Course Correction, it is necessary to get the Brake's Initiative time rapidly and easily. Moreover, the range of correction will have an effect on selecting of resistance coefficients, and also, the little to be corrected, the smaller resistance coefficient is needed. From above, selecting the appropriate rang of correction will have an influence on the design of brake, the precision of correction and the speed of course correction. The range of correction is determined by the project of course expansion, and Fig 3 and Fig 4 show the two projects of course expansion. In these Figs, A is the target point and B is the arming point. In Fig 3, the points of pills which fall into the corrected scattering ellipse need no correction, and the course expansion and range of correction are small; in Fig 4, all of the pills need correction, the course expansion and correction are big. Thinking of it in terms of trajectory calculation, the project given in Fig 3 is favorable for fixing the Brake's Initiative time accurately and rapidly. Thinking of it in terms of bombarding the target accurately, the project given in Fig 4 can put the efficiency of course correction into full play. Focus on the Optimized Algorithm about Brake's Initiative time for Course Correction Fuze, this paper will choose the project given in Fig 3 as the project of course expansion.

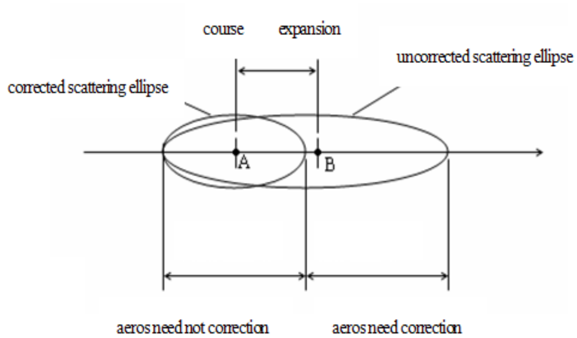

Fig 3 Project 1 of course expansion

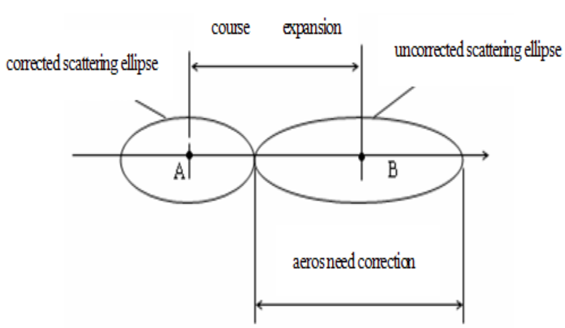

Fig 4 Project 2 of course expansion

B. *Fixing the range of correction*

According to Fig 3, the relationship of target course point and aiming course point is

$$X_A - X_A \cdot \xi_1 = X_B - X_B \cdot \xi_2 \quad (1)$$

in Which

X_A -------target course point

X_B -------aiming course point

ξ_1 -------the ultimate value of relative error of course scattering corrected

ξ_2 ------the ultimate value of relative error of course scattering uncorrected

The relationship of the ultimate value of relative error of course scattering ξ and the density norm of course scattering P is

$$\xi = \frac{3 \times P}{0.6745} \quad (2)$$

Assuming that the density norm uncorrected is 1/150, corrected 1/300, we can get the result

$$\xi_1 = 1.48\%, \xi_2 = 2.97\%$$

According to Equation (1), the course expansion is

$$X_B - X_A = ((1-\xi_1)/(1-\xi_2) - 1) \cdot X_A = 0.015 X_A$$

The range of correction is

$$0.0148 X_A \sim 0.045 X_A$$

Assuming that the target course is 3500~4500m, the range of correction will be 51.8m~202.5m. When the initiative velocities and angles of fire are considered, the Brake's Initiative time is probable 22s~30s.

IV. Optimizing of the algorithm about Brake's Initiative time

A. *The general algorithm about Brake's Initiative time*

The general method of fixing Brake's Initiative time is as follows: Firstly, assuming that the pill brakes at the earliest point in the declining stage of trajectory, the course correction will be calculated. It is too earlier for the pill to brake, if the course correction is less than the fall course, a time step length is necessary to enable the course correction more than the fall course, and then an appropriate Brake's Initiative Time can be calculated based on the target course interpolation. The weak point of this method is that the step length is fixed and hard to choose, and the precision of calculation will be reduced if the step length is too long, but the amount of calculation will increase when the step length is too short. For instance, with the small correction, the Brake's Initiative Time will lag, and accumulating several step lengths is needed. Because of the correspondence of one trajectory calculation and one course detection calculation, many trajectory calculations are needed, and the time of calculation is so long that the it can not be finished in the set time.

B. *The optimized algorithm of Brake's Initiative time*

1) *Basic theory*

Fig 5 shows the basic theory of the optimized algorithm about Brake's Initiative Time. In Fig 5, A is the actual point needs correction. Firstly, with the trajectory equations, the distance corrections of 22s and 30s will be calculated, getting C and D, which can be connected with a line. Inputting the distance correction into the linear equation, a reference Brake's Initiative time will be got. Then, the actual distance correction B can be calculated with the trajectory equations. According to the rule of correction curve, B must locate behind A. Connecting C and B' with a line again. By parity of reasoning, the actual Brake's Initiative Time will be approached gradually, so the amount of calculation will be reduced significantly, and the time is saved.

2) The simulation result of optimized algorithm

When the difference of course correction and target course is less than 2m, the conditions can be simulated with the optimized algorithm about Brake's Initiative time mentioned above. Table 1 shows the results. If the correction falls in the range of 50m~200m, there are only 5~6 trajectory calculations are needed to get Brake's Initiative time, and the amount of calculation of this method is smaller than the general method. The conditions less than 50m are also simulated, more than 10 trajectory calculations are needed to get Brake's Initiative time. As a result, the correction should be less than 50m in the design of the project of course expansion.

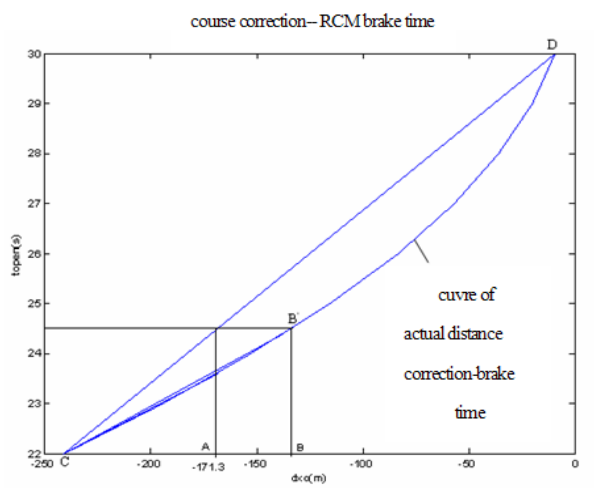

Fig 5 Optimized Algorithm about Brake's Initiative time

TABLE 1 the simulation results of the optimized algorithm about Brake's Initiative Time

Initial velocity /$m \cdot s^{-1}$	angle of Fire /°	Course uncorrected /m	Scheduled Course correction /m	Actual Course correction /m	Brake's Initiative time /s	the time of trajectory calculation	
						Optimized Algorithm	general algorithm
265	45	4571	4500	4502	26.5	6	12
265	45	4571	4450	4448	24.8	6	10
265	45	4571	4400	4398	23.5	5	8
265	50	4455	4300	4298	25.8	6	11

V. CONCLUSION

With the analysis mentioned above, in order to reduce the mount of calculation of Brake's Initiative time, the problems should be considered from two sides: the one is designing an appropriate project of course expansion, ensuring the appropriate range of correction; the other is designing an optimized algorithm for the relationship of correction and correction time, for example, the algorithm as approaching gradually to Brake's Initiative Time by a line of two points mentioned in this paper, reducing the amount of calculation and saving time.

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