

# Flow Field Analysis in The Domain of Work of Turbine Applied to Submunition Fuze

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**Abstract**—According to the requirements of United Nations on cluster munition submunition, this paper provides a kind of MEMS(micro-electromechanical Systems) suitable for the fuze, which uses turbine as the power of submunition fuze, and analyses flow field of turbine in the domain of work with simulation. The velocity of flow field of turbine in the domain of work is founded smaller with the original outline dimension of submunition through analysis, which can't meet the requirement of power generation. An improvement of the outline dimension of submunition is carried on in this paper for the purpose of cutting down the step size near the work field of turbine. The fact discovered through the simulation is that the reduction in measurement of step can improve the speed of flow field of turbine in the domain of work. Moreover, the project of reduction in width of the top size of step is superior to the other projects in the improvement.

**Keywords**-submunition; MEMS; turbine; flow field in the domain of work

## I. INTRODUCTION

The presence of cluster munition dud can bring a huge casualty to common people. America used a lot of submunitions in the Gulf War, Afghanistan and Iraq War, and left numbers of double use Submunitions, cause a large number of casualties. The United states "Convention on Certain Conventional Weapons" in the draft protocol cluster ammunition regulate that the rate of dud is not to exceed 1% in cluster ammunition produced after January 1,1990,which should have the ability of self-destruction, self-neutralization and self-disability, and external transfer must meet the above conditions. The previous research can prove that traditional mechanical fuze can't satisfy that special requirement of rate, therefore, a kind of mechanical-electrical fuze should be developed, which will use the ballistic environment of submunition to generate power, and reduce the rate of dud by electric self-destruction. Power supply is the key in this project.

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More and more new kinds of domestic and overseas conventional ammunition fuze adopt fuze physical power, and present the advantages of the technology in different application fields. The fuze physical power includes a wide range of pneumatic turbine generator, jet generator, ring generator and so on. On the one hand turbine can supply the needed electric energy in the system design, on the other hand it can provide necessary environmental motivation for fuze remove insurance institutions. This is a kind of electromechanical device with mature technology and wide application, which has become the most classical fuze physical power supply. Turbine should be used as the physical power supply of submunition fuze with regard to the characteristics of submunition structure, the volume of power supply is small, and it generates electricity by circumfluence field environment of Submunition to supply power for submunition fuze.

## II. CHARACTERISTIC ANALYSIS OF CIRCUMFLUENCE FIELD OF SUBMUNITION

The diagram of turbine suitable for submunition fuze is described in Fig. 1.

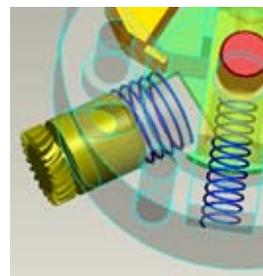


Fig. 1 Diagram of turbine suitable for submunition fuze

In the project, the turbine hides inside fuze without work, pops out in the process of submunition falling down and

generates electricity by circumfluence field environment of submuniton.

The circumfluence field environment of submuniton should be studied since submuniton physical power supply use it to generate electricity.

Firstly, three-dimensional model is created on submuniton. Secondly, FLUENT are used to help to do flow field analysis of submuniton structure(FLUENT is the special CFD software for simulation and analysis of fluid flow in the complex geometric area).Discrete equation should use pressure based couple algorithm and open second order wind model to improve precision in the numerical simulation; pressure far field condition should be applied to boundary, Mach number(falling speed of submuniton) and the rotate speed of Submuniton are set in the import, export is set to natural outflow, the wall use no slip condition and Spalart-Allmarass turbulent model should be enabled in the analysis.

The mean falling speed of Submuniton is 30~50m/s, here 50m/s is selected, rotate speed is 2000rpm,angle of attack is 10°. The obtained velocity distribution of circumfluence field environment of Submuniton is depicted in Fig. 2.

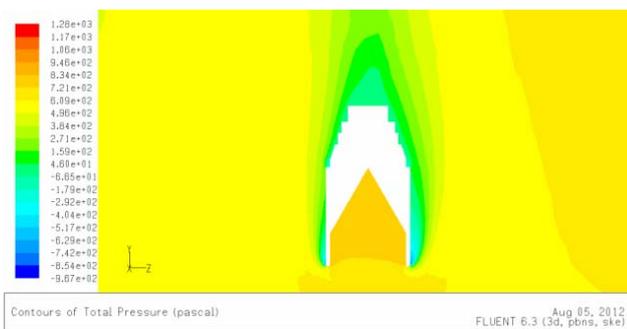


Fig. 2 Velocity distribution of circumfluence field environment of Submuniton

As described in Fig. 2, the velocity of circumfluence field environment of Submuniton is smaller than velocity of the area slightly far from Submuniton wall, and moreover the velocity increases as the distance from the wall increases.

### III. FLOW FILED VELOCITY DISTRIBUTION ANALYSIS IN THE DOMAIN OF WORK OF TURBINE

Flow field environment of turbine work area should be analyzed in order to obtain the velocity distribution, flow field in the six lines of submuniton circumfluence are selected according to fuze pop-up physical power supply (see Fig. 3).

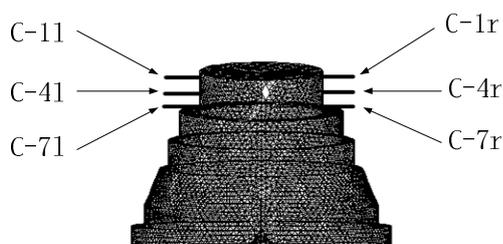


Fig. 3 Locations of selected six lines of submuniton circumfluence

As shown in Fig. 3, C-11,C-41, C-71, C-1r, C-4r, C-7r are six lines. C-41, C-11, C-71 are the locations of center axis, impeller upper edge and lower edge of turbine installed on the left side, respectively. C-4r, C-1r, C-7r are the locations of center axis, impeller upper edge and lower edge of turbine installed on the right side, respectively.

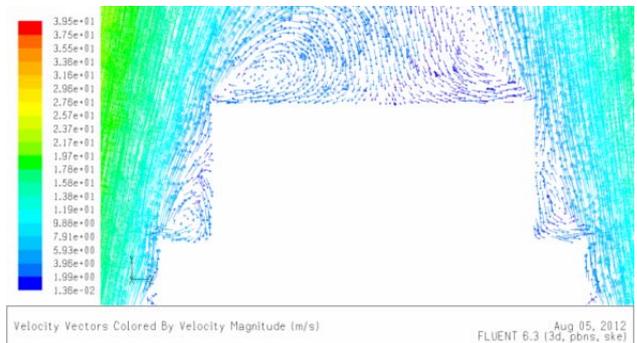


Fig. 4 The illustration of velocity vector of turbine in the domain of work

The fact founded in the Fig. 4 is that within the range of closer distance from the wall, the velocity of flow field is small and in the step whirlpool appears, and the velocity becomes negative.

Velocity distributions are drawn in Fig. 5 and Fig. 6 with analysis at a distance of 0~5mm from wall in the six lines.

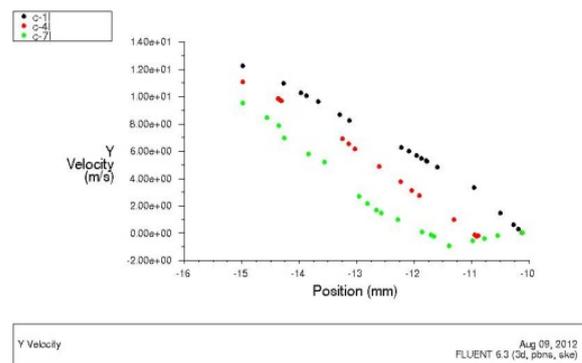


Fig. 5 Velocity distribution in the three lines on the left side

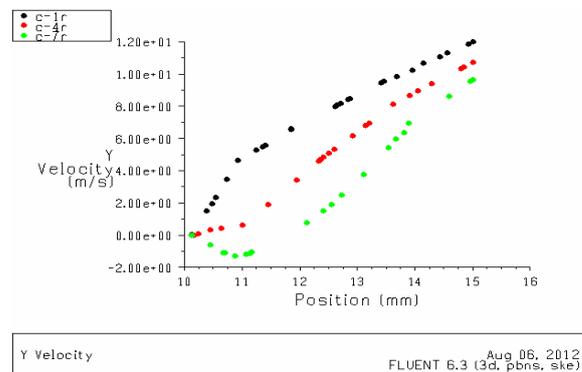


Fig. 6 Velocity distribution in the three lines on the right side

The velocity of turbine in the domain of work distributes basic symmetrically in the symmetric positions of submuniton's left and right as described in Fig. 5 and Fig. 6.

Since the angle of attack of  $10^\circ$  exists, velocity of left is a little larger than the right in the symmetric position; the direction of velocity will reverse in the position line of lower of turbine at a distance of 1mm from the wall. The closer to the upper position of submuniton, the larger velocity of circumfluence field will become; velocity of flow field has a relationship to the distance from the wall within a range of 0~5mm, it increases basically along with the increasement of the distance from the wall.

Velocity of flow field is small within the work area of turbine. At a distance of 5mm from wall, the velocity in the center axis of turbine is 11m/s, it is small. Such velocity can't meet the power requirement of the whole power system through calculation. Therefore, the velocity should be raised and the distribution of the flow field velocity should be improved to meet the power requirement of submuniton.

#### IV. MEASURES TO IMPROVE THE FLOW FIELD VELOCITY IN THE DOMAIN OF WORK OF TURBINE

This paper increases the velocity by the shape improvement of submuniton. The step near whirlpool of velocity vector is one of key factors to influence the distribution of velocity of circumfluence field. This paper improves shape of step and analyses which measure to increase the velocity is most effective.

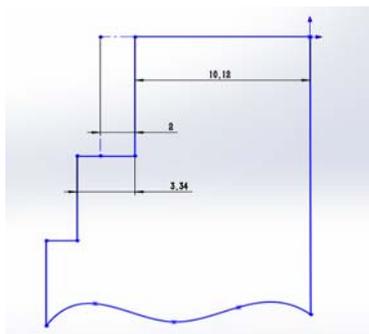


Fig. 7 The step's size in original outline of submuniton

The step's size is 3.34mm in original outline of submuniton(see Fig. 7).There are some projects of improvement in the size.

(1) The size reduces to 2.34mm, namely reduce 1mm (see Fig. 8).

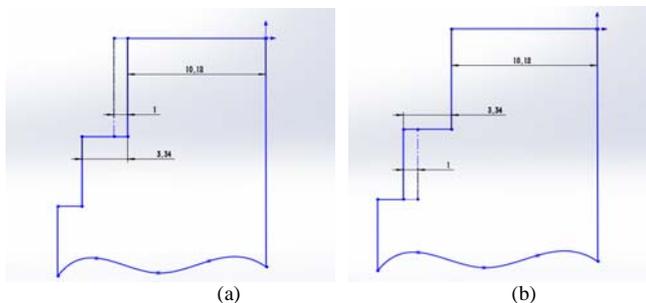


Fig. 8 The size reduces to 2.34mm

(2) The size reduces to 1.34mm, namely reduce 2mm (see Fig. 9).

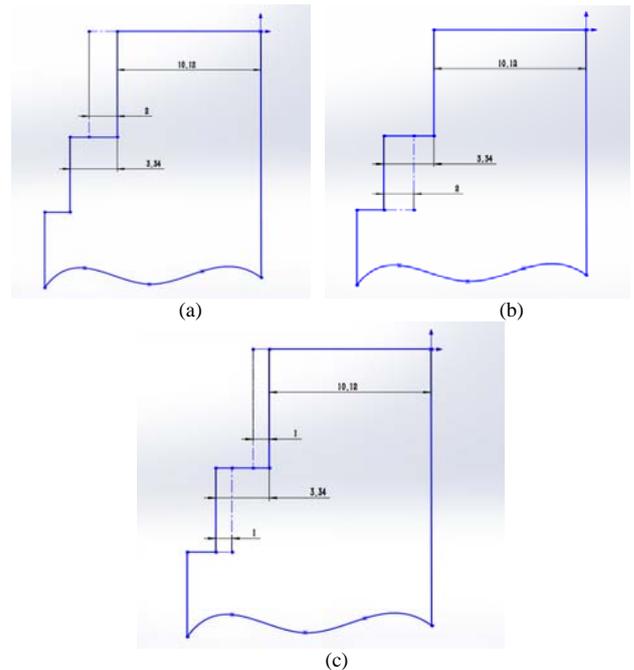


Fig. 9 The size reduces to 1.34mm

(3) Round off the step, the radius is 2mm (see Fig. 10).

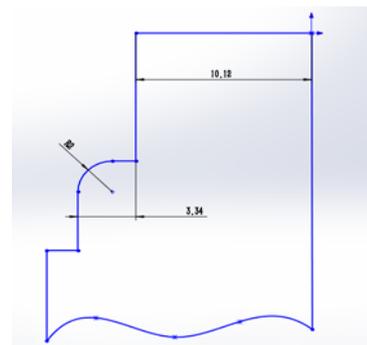
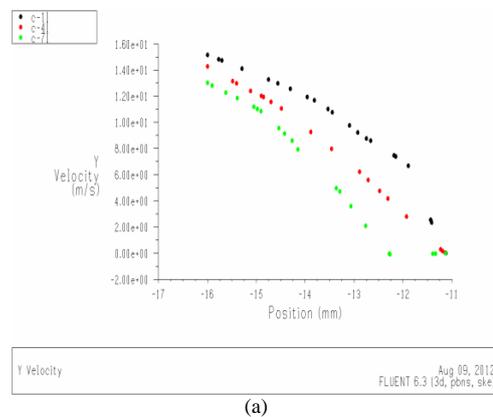


Fig. 10 Round off the step

Considering only the left side in the projects shown in Fig. 8~Fig. 10, the distribution curve of velocity are drawn in Fig. 11.



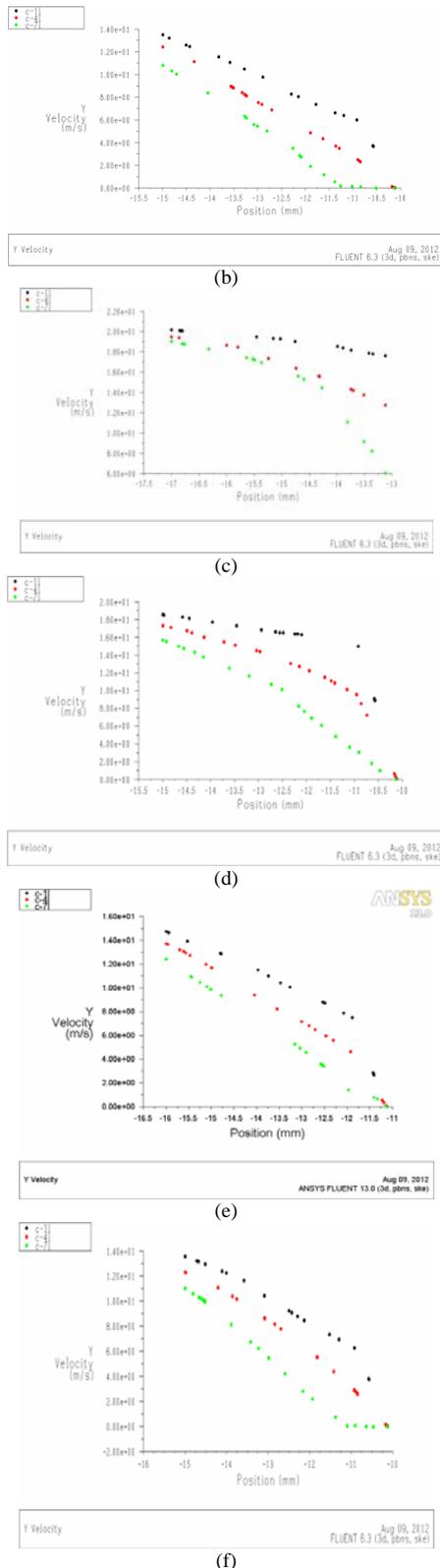


Fig. 11 Distribution curve of velocity after improvement

Some conclusions can be obtained from Fig. 11 as follows:

1) The velocity of flow field after improvement is greater than the velocity in the original project;

2) With regard to the project of reducing size to 2.34mm shown in Fig. 8, the velocity of the improvement method depicted in (a) is a little larger than the velocity of the improvement method depicted in (b) in the corresponding position. The method depicted in (a) is more superior;

3) About the project of reducing size to 1.34mm shown in Fig. 9, the velocity of the improvement method depicted in (a) is a little larger than the velocity of the improvement method depicted in (b) and (c) in the corresponding position. The method depicted in (a) is more superior;

4) The velocity of the improvement method depicted in Fig. 9(a) is a little larger than the velocity of the improvement method depicted in Fig. 8 and Fig. 10. The method depicted in Fig. 9(a) is more superior.

Therefore, in order to improve the flow field velocity in the domain of work of turbine, the method to improve the shape of the submunion is effective. The method depicted in Fig. 9(a) is more superior than the other methods. The reduction in width of the top size of step can improve the flow field velocity in the domain of work of turbine effectively.

## V. CONCLUSION

This paper provides a kind of MEMS suitable for submunion fuze and analyses the flow field in the domain of work of turbine with simulation. The simulation result demonstrates that the flow field velocity in the domain of work of turbine is small under the current outline dimension of submunion, which can't meet the power requirement. This paper improves the outline dimension to increase the velocity, especially in the step near the turbine work area. The simulation result proves that the reduction in width of the top size of step can improve the flow field velocity in the domain of work of turbine effectively. This method is an effective measure to improve the flow field in the domain of work of turbine, which has a value of further research.

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