EFFECT OF SPIN STABILIZATION ON FINAL STAGE ROCKET FOR DIFFERENT CROSS WIND CONDITIONS IN MARS ATMOSPHERE

MANIKANDAN. S^{1*}, SARATHKUMAR SEBASTIN. J² & DHANAJAYAN. M³

School of Mechanical Engineering, Lovely Professional University, Phagwara, Punjab, India

School of Mechanical Engineering, Kalasalingam Academy of Research and Education, Virudhunagar, Tamilnadu, India

ABSTRACT

Space Shuttle which planned for Mars mission usually designed with multi-stages. The shape of the final stage is almost "Cone". In order to stabilize the final stage inside the Mars atmosphere, we have to employ certain stabilization technique. In these paper, we discuss spin stabilization to stabilize the final stage rocket and finding the RPM for which "No side force" acts on the final stage. Finally, we compare results of same final stage stabilization in Earth and Mars atmosphere

KEYWORDS: Mars atmosphere, Side force, Spin Stabilization, Upper stage rocket

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INTRODUCTION

To make scientific research on Mars planet, we send multi-stage rocket with payload which can examine minerals, atmospheric properties and Human living possibilities. Mars atmosphere contains 95.32 % Carbon dioxide, 2.6 % nitrogen and 1.9 % argon. To avoid atmosphere disturbance and keep the final stage on correct flight path, the final stage can be stabilized Spin about its longitudinal axis. Cross-wind direction considered in this paper is normal to the Longitudinal axis. Flight velocity considered in this paper is 50 m/s and crosswind velocity as 5 m/s and 15 m/s. we found RPM of stabilized path for above two conditions

Figure 1: Normal Crosswind and Free Stream Direction with respect to final stage rocket in XYZ Coordinate System

METHODS

We have used 2 linear velocities and 1 angular velocity in this paper. Linear velocities are flight velocity and crosswind velocity. Angular velocity is RPM of the missile. By keeping the both linear velocity constant and changing the RPM, we will get different side forces for different RPM. Plotting the side forces for different RPM, we will get Zero side force for the particular RPM. That RPM is stabilized one for respective flight velocity and crosswind velocity.

DESIGN

Figure 2: Final Stage Rocket with Dimension

Figure 3: Domain Dimension

Figure 4: Final stage rocket with Domain

INTRODUCTION TO CFD

Meshing is done in ICEM CFD. ANSYS CFX will be appropriate for rotating component since Final stage rocket is spinning.

1. Type: Flow Analysis
2. Software Package: ANSYS 16.1
 - a. Meshing: ICEM-CFD 16.1
 - b. Pre-processing: CFX-Pre 16.1
 - c. Solver: CFX-Solver 16.1
 - d. Post-Processing: CFD-Post 16.1

Figure 5: Meshing of Fluid 1 Domain and Final Stage Rocket

Figure 6: Final Stage Rocket with complete domain and Boundary Condition

Note: Black Arrows represents inlet and outlet Boundary condition and blue arrow represents opening boundary condition

SOLVER: Steady state analysis with 1000 iteration

RESULTS

Graph 1: Side Force vs RPM of Final stage rocket in Earth Atmosphere for Flight speed:50m/s & Cross wind:5m/s

Note: Positive RPM denotes clockwise rotation and Negative RPM denotes Anti-clockwise about positive X-axis. Value of side force becomes “zero” at RPM 88 (Clockwise)

Graph 2: Side Force vs RPM of Final stage rocket in Mars Atmosphere for Flight speed:50m/s & Cross wind:5m/s

Note: Positive RPM denotes clockwise rotation and Negative RPM denotes Anti-clockwise about positive X-axis. Value of side force becomes “zero” at RPM 256 (Clockwise)

Graph 3: Side Force vs RPM of Final stage rocket in Earth Atmosphere for Flight speed:50m/s & Cross wind:15m/s

Note: Positive RPM denotes clockwise rotation and Negative RPM denotes Anti-clockwise about positive X-axis. Value of side force becomes “zero” at RPM 70 (Clockwise)

Graph 4: Side Force vs RPM of Final stage rocket in Mars Atmosphere for Flight speed:50m/s & Cross wind:15m/s

Note: Positive RPM denotes clockwise rotation and Negative RPM denotes Anti-clockwise about positive X-axis. Value of side force becomes “zero” at RPM 224 (Anti-clockwise)

Graph 5: Comparison of RPM required for Final Stage Rocket to stabilize in Earth atmosphere and Mars Atmosphere

DISCUSSIONS

- Final stage rocket need 88 (Clockwise) RPM to stabilize its flight path in Earth atmosphere. But in Mars, its need 256 (Clockwise) RPM to stabilize its flight path at flight velocity 50m/s and cross wind velocity 5m/s
- Final stage rocket need 70 (Clockwise) Rotations per minute to stabilize its flight path in Earth atmosphere. But in Mars, its need 224 (Anti-clockwise) Rotations per minute to stabilize its flight path at flight velocity 50m/s and

cross wind velocity 15m/s.

- The detailed comparison of RPM of Final Stage Rocket in Earth and Mars atmosphere is given in Graph 5

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