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Research Article

MISSILE CONTROL ROTATIONAL TURBULENT FLOW BY PERIODIC INJECTIONS OF FLUID JETS

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ABSTRACT
The fluid jet aerodynamic effects are one of the suitable control devices to promote the accuracy of the rockets in sonic and ultrasonic velocities. The resulted numerical results shows the effect of the fluid jet on the flow field and the aerodynamically coefficient. In this research, by compiling the computer program, firstly, the numerical 3 dimensional solution of the non-permanent and compressible equations for the agitated flow around the rocket with no injection using the organized network has been studied. To solve numerically, the exact time method with the special and temporal accuracy, the 2nd order, has been used. The results have been resulted by Shan Fonlir synthesis method and Bladuimlumax agitated method. In continuation, using the fluid injection, the rocket is method by the guidable rocket. By integration on the sectional stress and strain, the imposed forces on the rocket are obtained and compared to the laboratory results. The main topic of this research in the investigation on the ability of the reciprocal effect simulation of the fluid jet and the cross flow and aerodynamic coefficient estimation in much number 0.4 4.5 and the exist fluid velocities 500, 700, 1000, 1500m/s. the results have been presented for the rocket M910. The calculated aerodynamic coefficients have a good accommodation with the laboratory results. By increasing the much number, the compare hension coefficient reduces slowly with the height. By increasing the rocket velocity, the jet output will increase, in return, by increasing the environmental pressure the jet output will decrease. Factors like: the jet position, the jet velocity, frequency, the injection angle, the rocket shape influence the rocket path correction.

Keywords: *Aerodynamic Coefficient, Fluid Jet, Three Gimensial, Fonlir, Control*

INTRODUCTION

To have a high accurate control rocket, we can inject the fluid the end part of the rocket. So, we can examine an intelligent rocket in the earth's atmosphere. By injecting the fluid, a complicated flow field is created by the provical effect of gas ject and the sonic and ultrasonic cross flow on the materials regarding the injection position. The exist jet serves as an obstacle on the rocket level and creates a strong traumatic wave in the ultrasonic flow in up jet and down jet rotation area. The flow is non-polar at the final area of the rocket due to the reciprocal effect of the non-consistent jet in confronting with the sectional layer of the free flowed causes the vortex generated during this process moves from the exist of the jet towards the flow back.

Therefore, the jet changes effectively the flow field both near the jet and at the back of the rocket and generates the force even in the offence angle 0^0c. Naumann and Srulijes (1985), for their first work, investigated the reciprocal effect of the fluid jet around the material in ISL (institute of saint Louis). The researches were addressed to a wing and for obtaining the appropriate output and they assumed the fluid jet both warm and cold and the flow ultrasonic. The aim of the these experiments is to research the increasing of the output so that the increase was obtained by the reciprocal effect of the fluid jet and the flow around the material. Amitay *et al.,* (1999), conducted the laboratory researches on the separation control of the flow of the cylinder flow by jet. This research showed that the reciprocal effect of the free flow influences correcting the shape and increase the left force. He and Kral (2000), increased the efficiency of the airfil with the fluid jet on it. They used RANS to investigate the effects of the jet position, the imposed frequency of jet, the resistant forces and vertical on the airfoil.

Lee and Goldstein (2000), modeled the two dimensional jet by DNS. Although this simulation had goof results, use of this method was not very interesting for this three dimensional flow, Jenami and Siler (Seiler *et al.*, 2001) used the fluid flow technology in TZN (technologies Zentrun Nord) for the cylindrical rockets with various speed. The fluid jet was generated by burning the combustible materials in the ignition case.

They proceeded to the theoretical work of the sector those years. Sahu and Heavey (2001), the manager, of the ARL (Army research Laboratory) programs conducted the numerical, simulation from the mathematical flows dynamic in the explusive rocket M781BT with and without fluid jet in Mach number 0.1 with the offense angle 0^0c-4^0c. The reason of this choice was the availability of the husk, the stimulus force and the weapon to shoot it. He experimented the different size and places. He put the place of the exist jet both at the peak and along the body in the experiments and calculated the forced imposed. The history of the jet velocity was considered 20m/s. he observed that the jet exerts more force at the end of the rocket, jenami: and Siler (Seiler *et al.,* 2003) associated with ISL and TZN simulated the controllable cylindrical rocket behavior with the caliber 90mm by the fluid jet. They investigated the flow pattern in vitro or numerically. To solve the mass survival and the energy numerically, they used the code CFX TASC flow. Their solution range was restricted by the rocket cylindrical mass but the vortex area was not focused. Similarly, in this study, the hot jet and the synthetic jet were modeled. The mach numbers were 3.5-4.5.

Sahu (2003) studied arithmetically the aerodynamic effects in jet as the control device of the rocket in the non-ultrasonic velocities by the trademark CFD. He considered the mach numbers 0.11, 0.2 and the offence angle between 0^0c-4^0c and two dimensial jet and the agitated model combinatively (large Edies and k-ε). The results obtained showed the effects of jet on the field flow, surface pressure and the aerodynamic coefficients.

Increase of the accuracy in small and medium caliber needs the modern technologies to increase the capability of the infantry in the land operations. To achieve this accuracy, controllable aerodynamic force must be imposed on the rockets. The deviation along with the ject creates plenty of effects on the force coefficient and torque causing the rocket direction to change and control it. Supported by DARPA (Sahu and Heavey, 2004), GTRL (Georgia Institute of technology) and ARL, a team was constituted namely "Scorpion" to perform the program. Their aim was to use the ability of fluid injection technology in the aerodynamical direction of the rocket. This program was the joint investment between DARPA and GTRI in the area of airspace, transmission, the laboratory of the progressive systems, mechanical engineering, electronics, computer, materials and weapons. The scorption program was divided in to two successful phases: the 1st phase was to show the capability of using the fluid injection in the 40 mm rockets and the ability of deviative and directive control.

The 2nd phase was to use the injectors of the gaseous generators and use the faster and smaller control rocket that was underway in the recent years. The first phase was completed in February 2004. The second phase of scorpion was performed for 30 months following it aiming to use the fluid injection in the 25 mm rockets with the non-ultrasonic velocities, Controlling flight systems and special weapons (Mcmichael *et al.*, 2005). The next report of Sahu (2006) to ARL was the comparison of the numerical data obtained by the trademark CFD^+ and the results of the real flight test in mach 0.3 and the offence angle 2^0c.

In this report the effect of micro jet on the coefficients and the aerodynamic forces were observed. The results showed the capability of the micro- jet as a tool for controlling the rocket in the non-ultrasonic velocities. To attain the aims of the second phase, Saho simulated the field flow around the 25 mm rocket with or without jet. He presented the results for the number mach 0.7 and the offense angle 0^0c and the exit jet pressure 3, 6, 12 atmosphere and they showed the effect of the jet on the forces and the flexible torque (Heavey and Sahu, 2007).

Most of the mentioned-above investigations have been performed for the trademarks and the low speeds. In this paper, the computer program with very high capability for studying the effect of much number, the offence angle on the aerodynamic coefficient changes has been compiled.

MATERIALS AND METHODS

Method and the Equations Dominated on the Flow

The complete stocks Navier equations include the mass survival equations, energy, momentum and experimental relation for the thermodynamic properties, are the equations dominated on the flow. These equations in the survival from have been displayed vectorically.

Shaping is so that includes both Decartians and cylindrical coordinates:

$$\frac{\partial \vec{Q}}{\partial t}+\frac{\partial \vec{E}}{\partial x}+\frac{\partial \vec{F_\iota}}{\partial y}+\frac{\partial \vec{G_\iota}}{\partial z}=\frac{\partial \vec{E_v}}{\partial x}+\frac{\partial \vec{F_v}}{\partial y}+\frac{\partial \vec{G_v}}{\partial z}+\vec{H} \quad (1)$$

$$\vec{Q}=[\rho,\rho u,\rho v,\rho w,e_t]^T$$

The non-viscous fluxes $\vec{E_\iota},\vec{F_\iota},\vec{G_\iota}$ and viscous fluxes $\overrightarrow{E_v},\overrightarrow{F_v},\overrightarrow{G_v}$ and the well clause, $\vec{H}$, in these relations u, v, w are the components of speed, x, y, z the physical coordinated, e_t the total fluid energy by mass unit, g is the gravity acceleration,T, temperature, P, static pressure, ρ is the density of the fluid. To calculate the antiquated viscosity Edy, μ_t, the BaldvinLumax model on the rocket surface and the combination length model for back of the material has been used.

Numerical Solution Method

To make disjointed the equations, the finite volume method was used. In this method, the equation (1) is integrated on the considered cell and with turning the integration on the volume on the integration on the surface it is obtained:

$$\frac{\partial \vec{Q}}{\partial t}+\frac{\partial \vec{E}}{\partial x}+\frac{\partial \vec{F_\iota}}{\partial y}+\frac{\partial \vec{G_\iota}}{\partial z}=\vec{H} \quad (2)$$

Where $\vec{G}=\vec{G_\iota}-\overrightarrow{G_v}$and $\vec{F}=\vec{F_\iota}-\overrightarrow{F_v},\vec{E}=\vec{E_\iota}-\overrightarrow{E_v}$ new from the equation (2) on the considered cell with turning the integration on the volume on the integration on the surface (Divergence case) is obtained:

$$\frac{\forall_c}{\Delta t}(Q^{n+1}-Q^n)+\left[\left(n_xE+n_yF+n_zG\right)A\right]_L^R+$$
$$\left[\left(n_xE+n_yF+n_zG\right)A\right]_B^T+\left[\left(n_xE+n_yF+n_zG\right)A\right]_{BA}^F=H\forall_c \quad (3)$$

Where $n_x And n_y, n_z$ are the vector components vertical on the cell surface, A is the menstruation of the cell volume, $\forall$ is the cell mass and Δt is the temporal step. Equation (3) can be rewritten as follow:

$$\frac{\forall_c}{\Delta t}\Delta Q+\left(\widehat{E_R}-\widehat{E_L}\right)+\left(\widehat{F_T}-\widehat{F_B}\right)+\left(\widehat{G_F}-\widehat{G_{BA}}\right)=H \quad (4)$$

To calculate the faces fluxes, they have been divided into two groups. The negative part is influenced by the down hand and the positive one is influenced by the up hand. Equation (4) creates a 7 diameter matrices. Since the equation is solved more easily, it is inserted into the 3 matrixes 3 diameters. For this purpose, the solution field in 3 directions $\zeta,\eta\ and\ \xi$ is solved independently. It means for each constant lineξ, we write equation 4 once and all ΔQ on this line is considered unknown. When for all linesξ, this work was done; this work is performed on the line ηandξ. When for the line ξ the constant equation is solved. Use the newest quantity; it makes more the velocity of convergence higher. So for each lineξ, the multi equation and multiple equations should be solved

$$a_1\Delta Q^{\xi}_{i-1,j,k}+b_1\Delta Q^{\xi}_{i,j,k}+c_1\Delta Q^{\xi}_{i+1,j,k}=d_1 \quad (5)$$

The purpose of $\Delta Q^{\xi},\Delta Q$ that has been obtained by solving the lines data has been provided. Equation (5) has been returned to the 3 dimensional set.

RESULTS AND DISCUSSION

The Numerical Solution Results

To assess the accuracy the accuracy of the numerical simulation, firstly, the non-rotative rocket for the numbers of mach between 0.4-4.5 is investigate. The aim of this study is to investigate the 3 dimensional flows for prediction the intra response the wave to each there. The navier stocks equations using the clear way of fun lire with the special and temporal accuracy of the second order have been simulated. To study the network for the rocket m910 (figure 1) has been performed and the network 100×60×25 cells from right to left in accordance with x,y,z have been chosen. The rocket m910 board is 8000m and the useful one is 2000 meters and is shouted by the throwing system M2/M3. M910 in December 1988 in class A

has been classified and reached the multiple productions. The organized network is from the condition border of type O.
Table 1 shows the studying data for the offence angle 0^0c, in these surveys, the coefficients and the aerodynamic forces for both flows are calculated.

Table 1: The data studied for the offense angle 0^0c.

Much number	U_∞ m/s	Rinold number m^{-1}	Total pressure kpa	Total temperature k
0.70	238.1	1.62×10^7	140.5	316.2
0.90	306.2	2.1×10^7	171.4	334.7
1.02	3047.0	2.28×10^7	196.4	347.9
1.20	408.2	2.80×10^7	245.7	370.9
1.40	476.3	3.26×10^7	322.4	400.9
2.0	680.4	4.46×10^7	792.8	518.4
2.50	850.5	5.83×10^7	1731.2	648.0
3.50	1190.7	8.16×10^7	7728.3	993.6
4.50	1530.91.05	1.05×10^7	29324.9	1454.4

Figure 3 show the convergency of solution for the much numbers 0.7, 2.5, 3.5, 4.5 after 2000 repetitions. It is observed that after 14000 repetitions, the solutions reach the constant manner and the force coefficient is constant in this time.

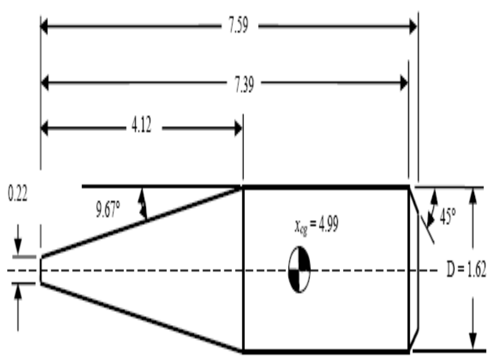

Figure 1: the accounting model of the rocket M910

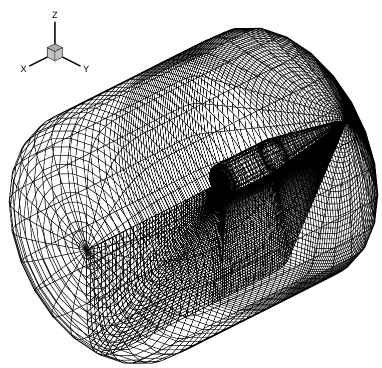

Figure 2: the organized accounting network

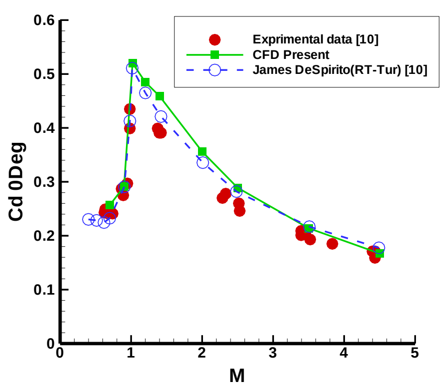

Figure 4: The strength force coefficient for the data in table 1 and with no offense angle

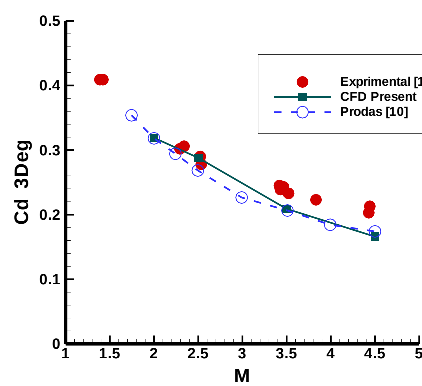

Figure 5: the strength force coefficient for the data in table 1 and the offense angle 3^0c

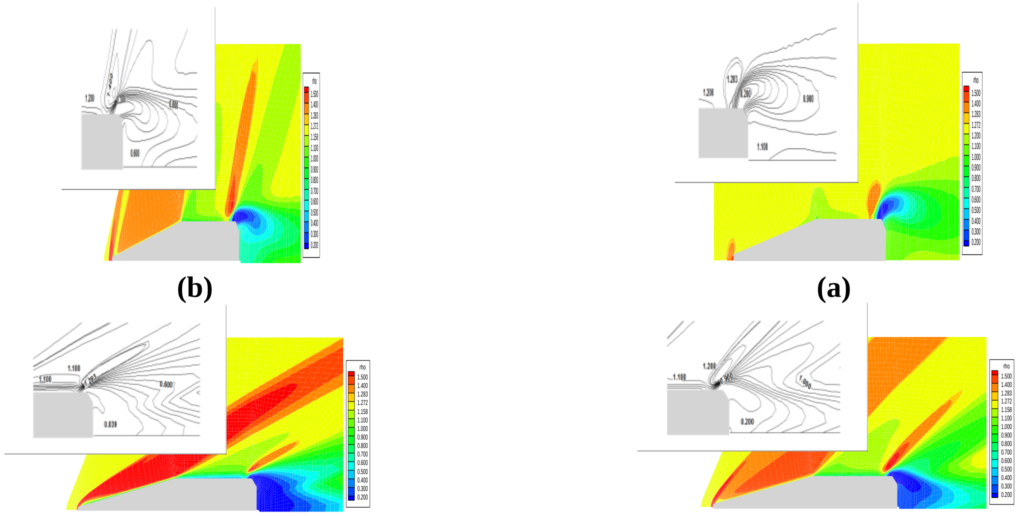

Figure 6: Contour and the density plane lines for the exit speed of the jet 1000m/s and 0.7 (a), ½(b),2(c),3.5(d)

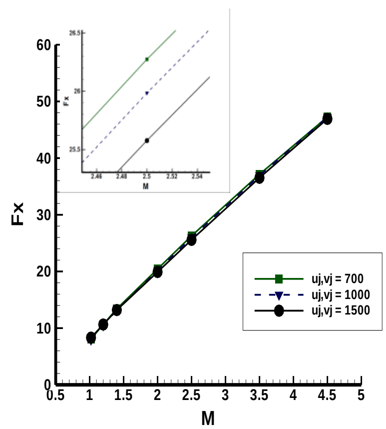

Figure 7: the resistant force to much number for the different jet speeds

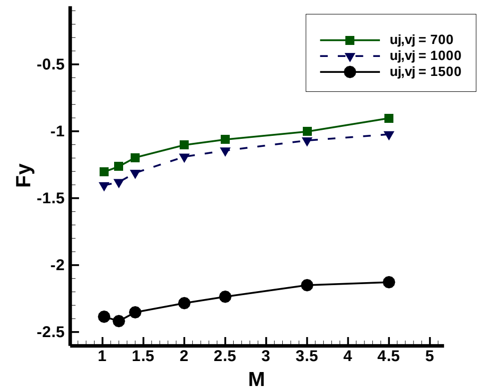

Figure 8: the upright force to much number for the different jet speed

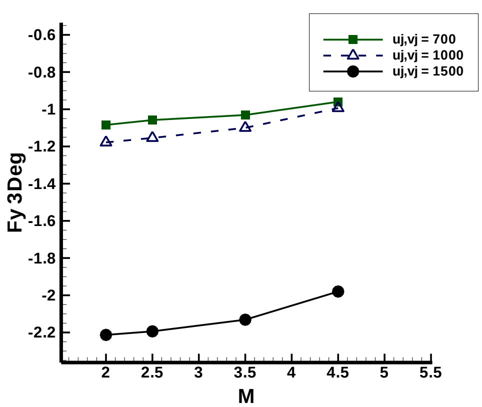

Figure 9: the lateral force to much number for the different jet speed

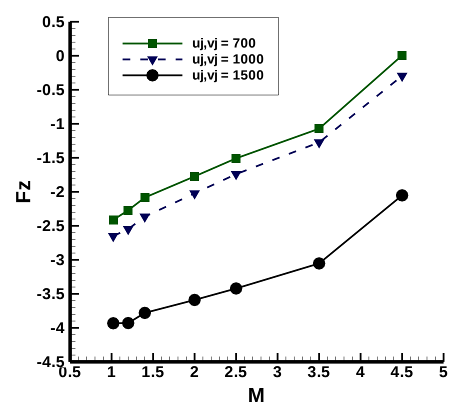

Figure 10: the upright force to much number for the different jet speeds and the offense angle 3^0c

Table 2: The data studied for jet

U	V	W	T	M
0	500	500	1244	1
0	700	700	2438/7	1
0	1000	1000	4976	1
0	1500	1500	5000	1/4

Figure 4 shows the resistant force coefficient for much numbers 0.7-4.5 and the offense angle 0^0c. Compared with the invar Results and the trademark CFD^+ in reference 13.
Figure 5 shows the comparison of the resistant force coefficient for the offence angle 3 degree with the invar results and the empirical results prods. The results obtained have a good accommodation with the in vivo data.
Figure 6 shows the contour and the lines in accordant with the density changes for the numbers much 0.7, 1,2, 3.5 and the jet speed 1000m/s.
In this figure, the compressible area near the peak and the non-compressible is shown on the back of the rocket.

Conclusion

In the current paper the numerical 3 dimension so lotion of the compressible non-constant stocks navier equations for the agitated flow around the rocket with or without injection using the.
organized network has been studied. For the numerical solution, it has used the exact temporal method with the special and fluid jet effect on the flow field and the aerodynamic coefficients. The main topic of this investigation is the capability of simulation of the reciprocal effect of the fluid jet and the sectional flow and the evaluation of the aerodynamic coefficient in much numbers, the Derg coefficient reduces slowly on the basis of the height. By increasing the rocket speed, the output of the jet has increased, in return, by increasing the environmental pressure of the output reduces. Some factors such as the jet location, the jet speed, frequency, the injection angle, and the rocket shape influence the rocket pathway correction.

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