ISSN No:-2456-2165

Analyzing the Aerodynamic Coefficients of a Rectangular Rear Fin Missile

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Abstract:- A Computational Fluid Dynamics Approach to analyse the variations of standard missile geometry with rectangular fin under varying angle of attacks with different ranging Mach number in Supersonic ranges. Here the complete study is focused in static stability derivatives while using a Reynolds Navier stokes method to compute the results. The projectile model used for the study is the basic finned missile with a calibre of 0.03m. The results obtained from the paper allow us to understand the Mach number values ranging from transonic regime to supersonic range.

Keywords:- *Aerodynamic Coefficients, Static stability, Computational Approach.*

I. INTRODUCTION

The Development of different techniques for finding certain numerical values in aerodynamic for various studies using Computational Fluid Dynamics (CFD) has increased its demand in the field aerospace research and development. Computational Fluid Dynamics is a technique for numerical simulation and analysis of fluid mechanics problems.CFD in numerical methods, turbulent models, and mesh generation technology has led to its making strides in simulation accuracy and capacity of complex geometric shapes. Parallel CFD technology has become a accepted tool for solving complex shapes and form different cells through discreteness of the grid, which is then followed by numerical calculations. In CFD for large scale problems basically we go for domain decomposition technologies in order to decompose more sub-blocks and then allocating calculations on them.

The parallel Aerodynamics simulator 3-Dimensional uses a Reynolds Averaged Navier Stokes (RANS) equation based CFD, solver using Cartesian grid and finite volume formulation. It is second order accurate explicit Riemann solver. This code is parallelized and multi threaded to work on cluster of heterogeneous workstations, operated in standard Linux environment. It can solve both RANS and Euler equations.

II. PROBLEM STATEMENT

The objective of the paper is to analyze the variation of the shock generation at each region around the finned finner model and the under the variation of aerodynamic coefficients at various Mach number.

III. CONFIGURATION

The Basic Finner reference model consists of a 20° nose cone on a cylindrical body with four rectangular fins. The L/D of the model was 10.0. The fin dimensions were 1 cal x 1 cal and conical in shape with a thickness of 0.08 cal at the base of the fin. The leading edges of the fins were very sharp with a radius 0.004 cal. The meplat of the nose was also at a radius of a 0.004 cal. The nominal diameter of the tested finner was 30 mm. The finner center of gravity is located on the centerline 6.1 calibers back from the nose.

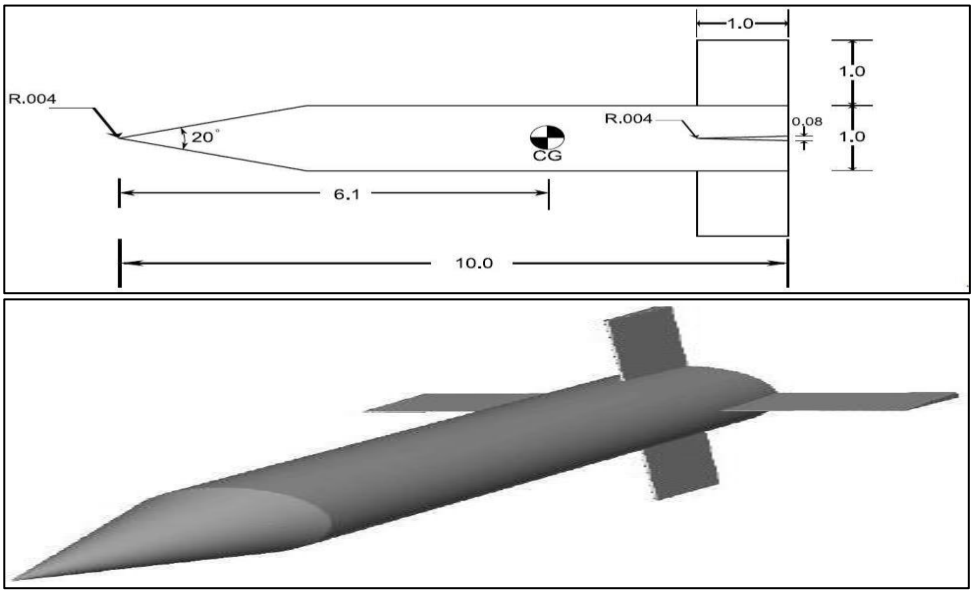

Fig. 1: Basic Finned projectile model, 1cal = 30mm

The boundary conditions taken for the study were:

- **Inlet:** One of the domain's face is taken as the inlet and the conditions taken for inlet is Pressure-far field type were the respective gauge pressures for each mach numbers are taken from the NAL=1.2m free stream condition data which is taken for reference throughout the analysis.
- **Outlet:** The face opposite to the face taken for inlet is kept as outlet. Normally the outlet section is to be set while considering the subsonic flow and for supersonic flow case we usually don't setup the values as it will not have effect felt.
- **Walls:** The walls are usually named separately from the model which we are analyzing for better understanding and identification.

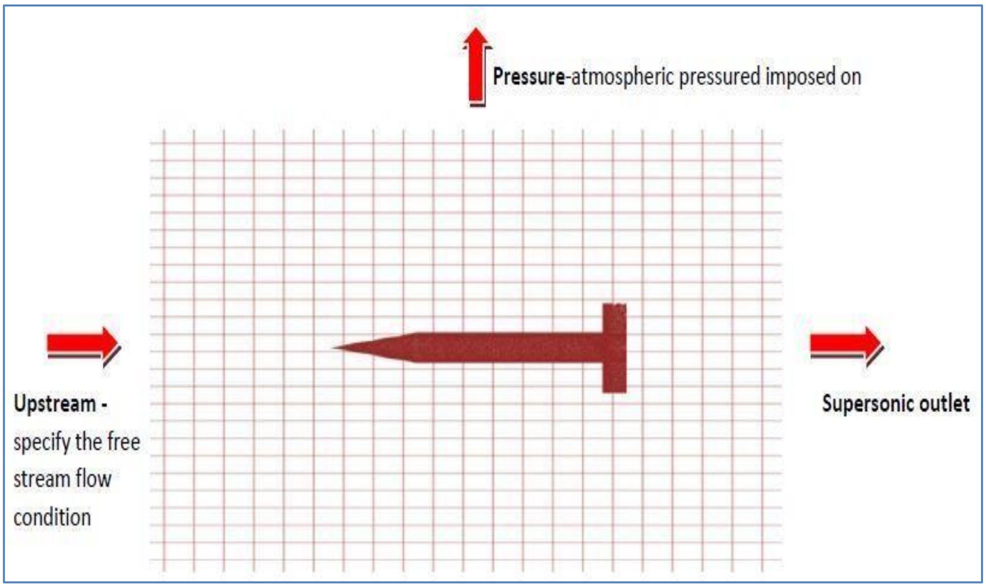

Fig. 2: shows the domain sectional view with generic boundary condition

IV. METHODOLOGY

The parallel 3D computational fluid dynamics software that uses Reynolds Navier Stokes equation (RANS) Cartesian mesh using finite volume approach.

The configuration (config.) is to be setup and then we will start off with the grid generation procedure. Maximum refining level for grid generation was set to 12.

In the Pre-Processor were we define the boundary condition, computational domain, free stream conditions and importing geometry through STP format and checking convergence.

Then followed by the solver and Post-Processor that brings out flow parameter obtained like flow field solution, extracting field values of parameters and also getting overall forces and moments on acting on the body.

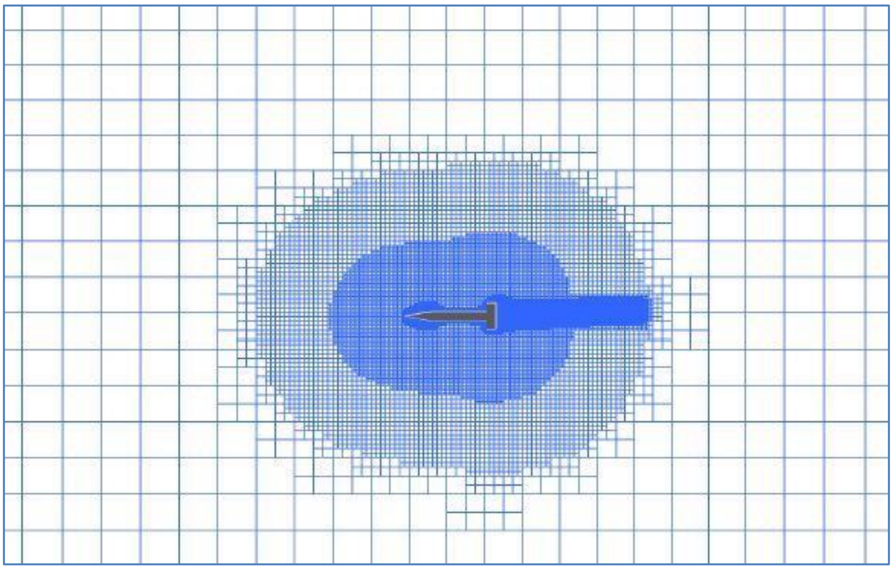

Fig. 3: mesh around the basic finner model

V. SIMULATION PARAMETERS

- The reference length is taken as diameter of the finner
- Pressure and temperature values taken from the standard NAL wind tunnel for various Mach number ranges.
- Area = 0.0007065 m^2
- Diameter of Finner = 0.03m
- Mach number = 0.8, 0.95, 1.1, 2.0, 2.5, 3.0
- Flow medium = Air
- Angle of attack = 2^o

VI. RESULTS AND DISCUSSION

For the Mach values which we have taken here that is 0.8, 0.95, 1.1, 2.0, 2.5 and 3 which refers to the transonic and supersonic ranges.

The detachment in the flow is felt as going from nose to the rear portion of the model and then in the fin section. Shocks generated by the fins are very evident from the mach palette and the pressure palette.

The cumulative axial, normal and pitching coefficients distribution is plotted. In a cumulative way if we see the flow then there is an increase in the drag coefficient from the nose tip along the ogive length and then at the fin attachment section at the body which can be observed from the results.

Table 1: Aerodynamic coefficients For Angle of Attack 2^o

Mach	C_A	C_N	C_M
0.8	**0.40097**	**0.579213**	**4.728908**
0.95	**0.602584**	**0.652409**	**5.435782**
1.10	**0.744935**	**0.68194**	**5.729309**
2.0	**0.431969**	**0.379346**	**2.913033**
2.50	**0.348399**	**0.324149**	**2.36335**
3.0	**0.292869**	**0.293485**	**2.055805**

A. *PRESSURE PALETTE*

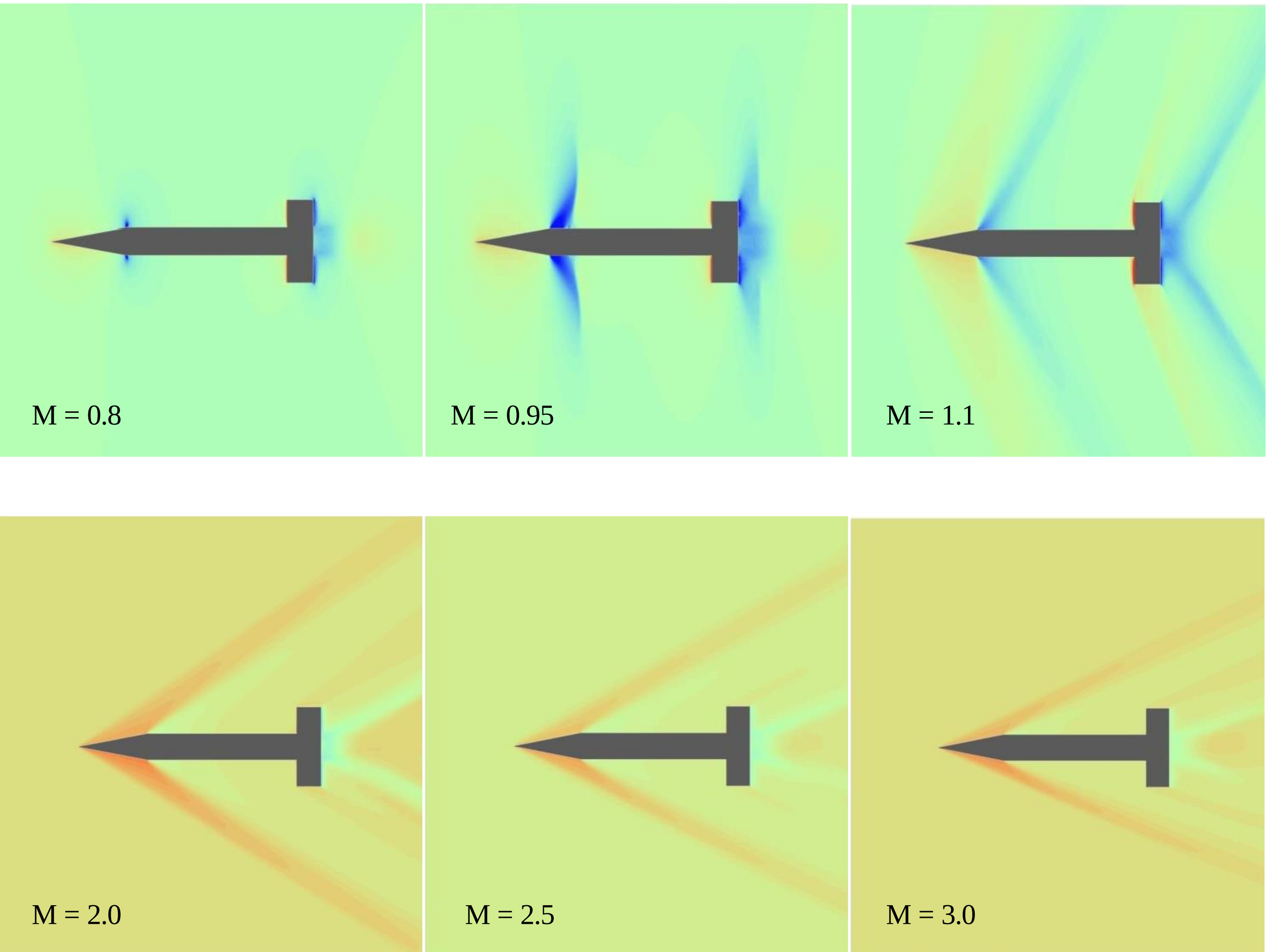

Fig. 4: Pressure distribution on the basic finner at various Mach number

B. MACH PALETTE

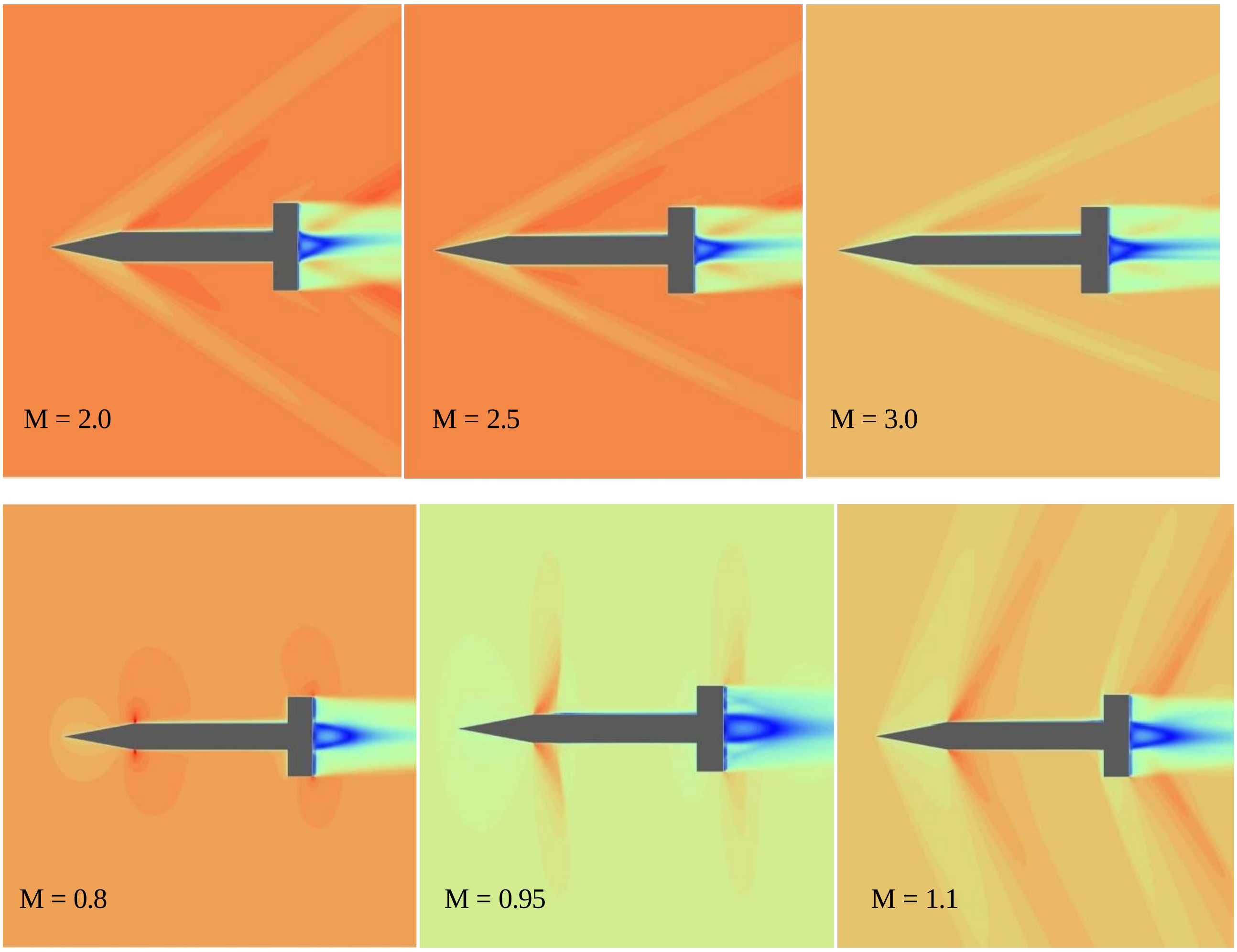

Fig. 5: Mach palette on the basic finner at various Mach number

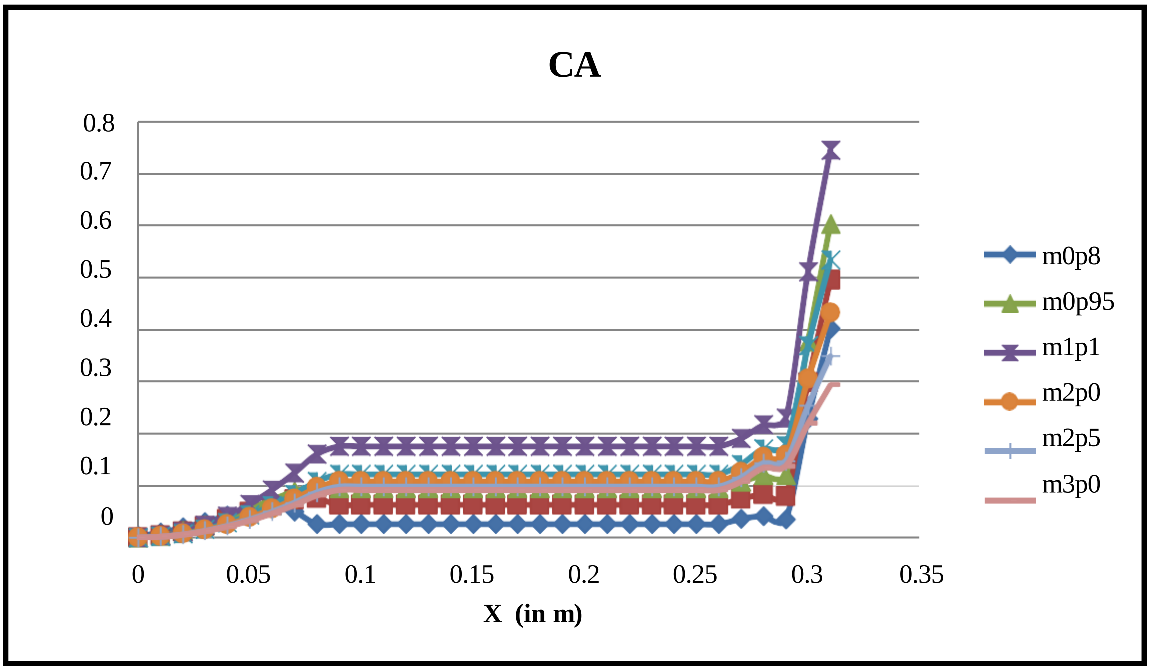

Fig. 6: Cumulative axial force coefficients at all Mach number taken

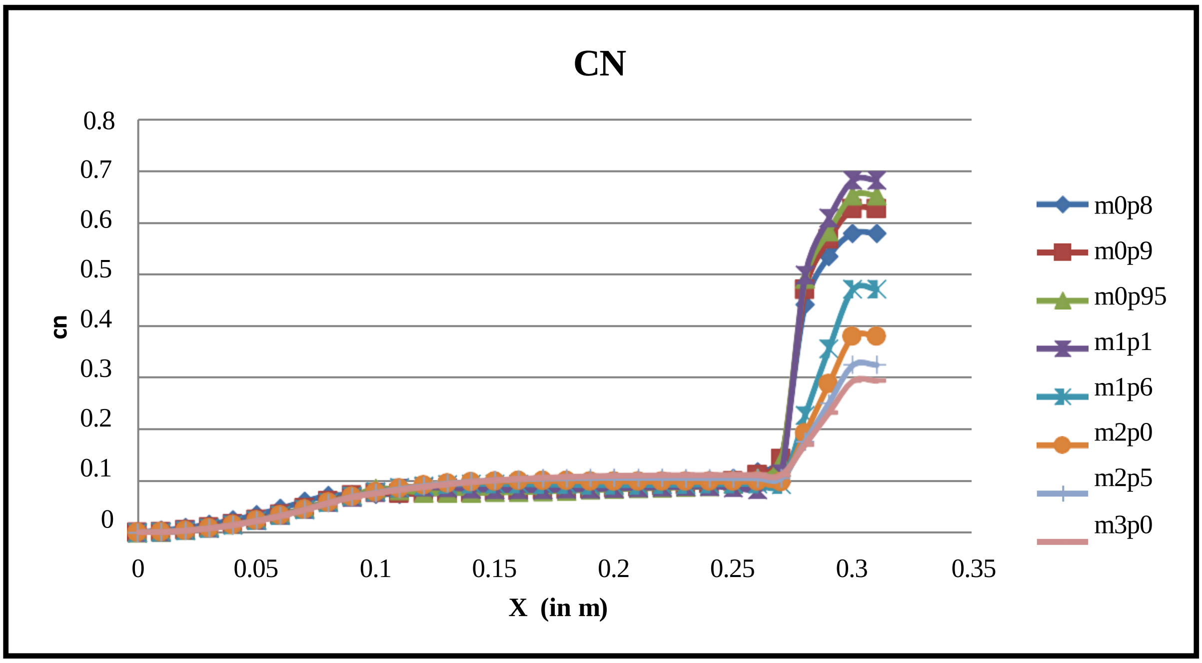

Fig. 7: Cumulative normal force coefficients at all Mach number taken

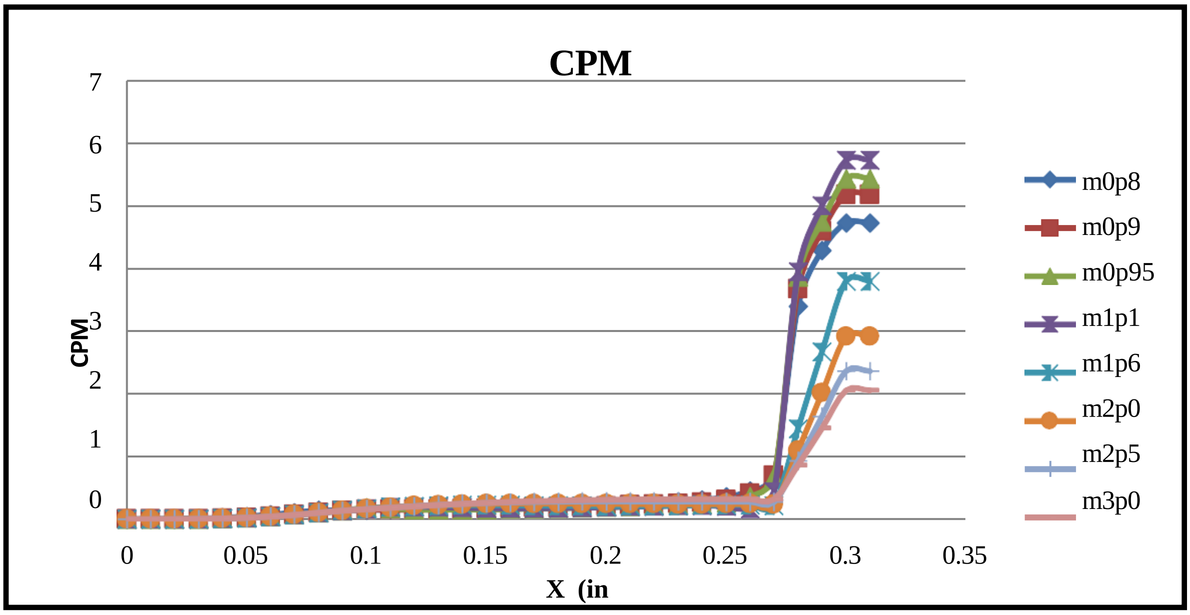

Fig. 8: Cumulative pitching moment coefficients at all Mach number taken

VII. CONCLUSION

The conclusions that we come out at the end of the project work are:

- The flow over the different sections of the finner.
- Various Aerodynamic static stability derivatives of the structure.
- Trend of shock generation at different Mach number ranges and angle of attack.
- The effect of Mach number range resulting in different shock fans at convex surface.

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