

Drag prediction on the conical and ogival shaped noses of aerodynamic bodies

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Abstract. The aerodynamic bodies are designed using different nose sections, as they have different effects on its performance. In this paper two types of nose shapes for aerodynamic bodies are considered and CFD analysis of pressure and velocity is performed at the Mach numbers 0.4, 0.8, 1, 1.2, 1.5, 2, 3. Ogival and conical shaped noses are considered in this paper for analysis. Drag is the main component of force that acts on the aerodynamic shapes. A nose drag contributes to a great extent in total drag nearly 20-30% and thus selecting nose is more important for optimum performance. The total aerodynamic drag acting on a body is the sum of the zero-lift drag, the induced drag due to angle of attack and/or control surface deflection, and the base pressure drag. The magnitude of the nose drag in relation to the total drag is very distinct to a function of body design and Mach number. Here in this project we consider the nose drag of different nose section (conical and ogival) with different areas and compare them with each other which will let us know the most efficient nose section to be used in different Mach numbers at an angle of attack ($\alpha=0$). As per the analysis performed, the conical nose section gives better performance compared to the ogival shape at all the Mach numbers.

1. Introduction

The aerodynamic bodies are having different nose configurations. In these configurations we concentrate on the conical and ogival shaped noses of aerodynamic bodies.

1.1 Aerodynamics

Aerodynamics is a department of fluid dynamics concerned with studying the motion of air, especially when it collaborates with a solid object, for example airplane wing

1.1.1 Flow Classification. As an aircraft travels through the air, the air molecules close the aircraft are disturbed and move around the aircraft. If the aircraft passes at a low speed, usually less than 250 mph, the density of the air stays constant. But for higher speeds, some vitality of the aircraft goes into compressing the air and locally changing the density of the air.

1.2. Types of Drag

In fluid dynamics, drag (now and again called air resistance, a sort of friction, or fluid resistance, another kind of contact or fluid friction) is a force acting inverse to the relative motion of any object moving with regarding an encompassing fluid. This can exist between two fluid layers (or surfaces) or a fluid and a solid surface.

Sorts of drag are for the most part separated into the accompanying classifications:

- parasitic drag, comprising of



- form drag,
- skin friction,
- interference drag,
- lift-actuated drag, and
- Wave drag (aerodynamics) or wave resistance (ship hydrodynamics).

2. Methodology and Modelling

2.1 Methodology

The conical and ogival shaped noses are modeled in the Solid Works and then are imported to the ANSYS for the CFD analysis. The geometry is modeled around the nose then flow with different mach numbers is allowed to flow over the geometry. Through this method the pressure and velocity changes and counters can be known easily. The finite element modeling methods are used to find the contours for each and every point on the nose.

2.2 Modelling:

The conical shaped nose and ogival shaped nose is modeled using SOLID works 2013. Then is exported from the software to ANSYS for

2.2.1 Conical Shape modeled in Solid Works

First the conical shaped aerodynamic body is designed as shown in the figure 1.

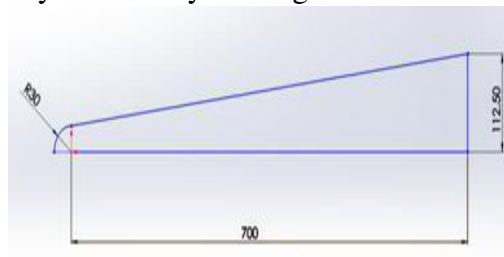


Figure1. Dimensional view of a conical shape nose

The above figures are for conical shape of an aerodynamic body by using solid works software 2013. The domain is given from the basic geometry of the conical body as five times the length is shown in figure 2.



Figure 2: Solid surface of a conical shape in solid works

After creating the domain and its geometry the figure is converted to solid surfaces. Then the figure is saved in the Para solid form to import the figure into the ICEM software.

2.2.2 Modeling of Ogival Shape in Solid Works

First the ogival shaped aerodynamic body is designed the following dimensions in slid works software. It involves different steps as shown below figure 3.



Figure 3. Geometric model of a ogival shape nose with domain

The above figures are for ogival shape of a aerodynamic body by using solid works software 2013. The domain is given from the basic geometry of the ogival body as five times the length as shown in below figure 4.

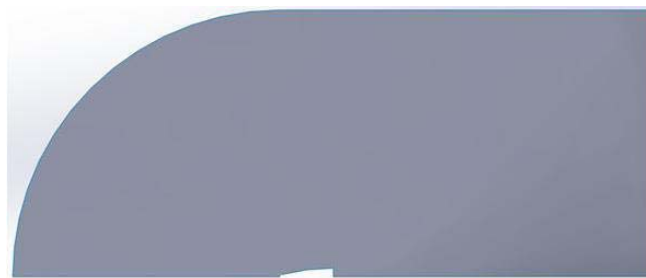


Figure4. Solid surface of an ogival shape in solid works

3. Results and Discussion

3.1 ANSYS Fluent

ANSYS Fluent gives extensive demonstrating capacities to an extensive variety of incompressible and compressible, laminar and turbulent fluid flow stream issues. Relentless state or transient examinations can be performed. In ANSYS Fluent, an expansive scope of numerical models for transport marvels (like warmth exchange and concoction responses) is joined with the capacity to show complex geometries. Cases of ANSYS Fluent applications incorporate laminar non-Newtonian streams in process hardware; conjugate warmth move in turbo apparatus and car motor segments; pummeled coal burning in utility boilers; outer optimal design; course through compressors, pumps, and fans; and multiphase streams in bubble sections and fluidized beds.

3.2 Solver

The fitting utilization of either an in-house or a business CFD code requires a center comprehension of the basic numerical parts of the CFD solver. This area concentrates on the solver component. A CFD solver can for the most part be depicted and imagined by the arrangement method exhibited in the beneath figure. Once the issue physical science has been distinguished, liquid material properties, stream material science model, and limit conditions are set to tackle utilizing a PC. There are famous business programmings accessible for this including: ANSYS FLUENT, ANSYS CFX, Star CCM, CFD++, Open FOAM and so on. These entire products have their one of kind capacities. Utilizing this product; it is conceivable to comprehend the administering conditions identified with stream material science issue.

Density based method:

- Turbulence model $K\omega$ -SST
- Reference length = 0.225 m
- Area = 0.039760875 mm²
- Gauge pressure = 100500 N/m²
- Temperature = 300k

3.3 Post processing

CFD has a notoriety for creating striking illustrations pictures while a portion of the pictures are limited time and are normally shown in staggering and great bright yield the capacity to display the computational outcomes successfully is a significant plan instrument. A portion of the prevalent post-preparing programming include: ANSYS CFD-Post, EnSight, FieldView, ParaView, Tecplot 360 and so on.

3.4 Pressure contour

After the analysis, the pressure contours are formed around the cone and ogival shaped noses. The figures 5, figure 7, figure 9 shows the pressure contours for cone shaped nose and figure 6, Figure 8, figure 10 shows the pressure contours for the ogival shaped nose at different mach numbers.

Case 1: At Mach number = 0.8

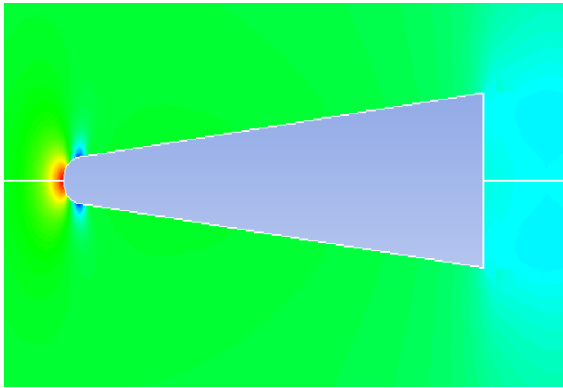


Figure 5. Pressure contours of cone nose

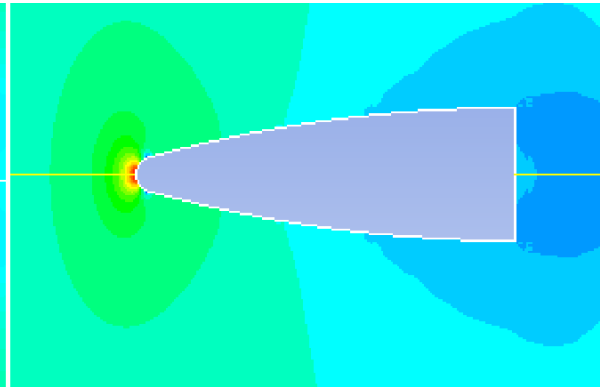


Figure 6. Pressure contours of ogival shaped nose

Case 2: At Mach number = 1.2

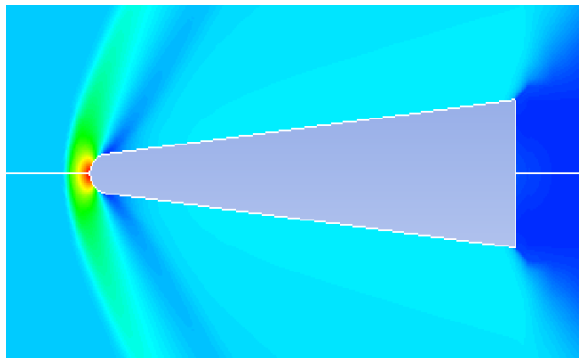


Figure 7. pressure contours of cone shape nose

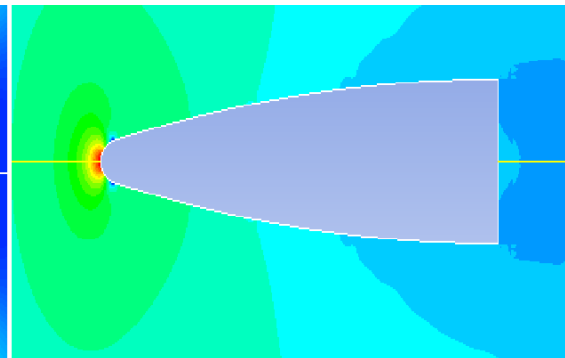


Figure 8. pressure contours of ogival shaped nose

Case 3: At Mach number =2

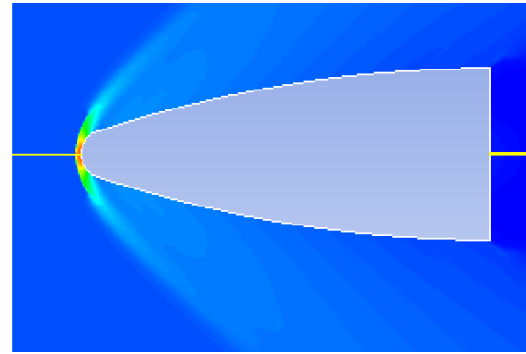
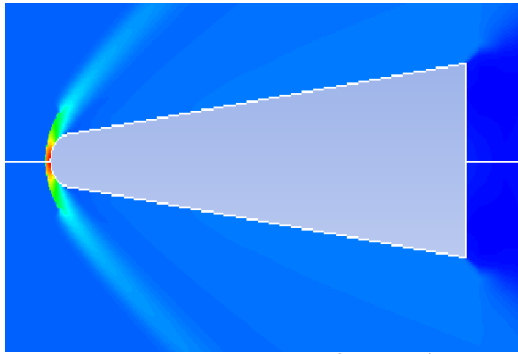


Figure 9.pressure contours of cone shape nose **Figure 10.**pressure contours of ogival shape nose

3.5 Velocity contour

The velocity contours are also taken for the prediction of drag on the cone and ogival shaped noses at different mach numbers. Three cases of mach numbers are shown in the below figures. The figures 11, figure 13, figure 15 shows the velocity contours on the cone shaped nose and figure 12, figure 14, figure 16 shows the velocity contours on the ogival shaped nose.

Case 1: At Mach number =0.8

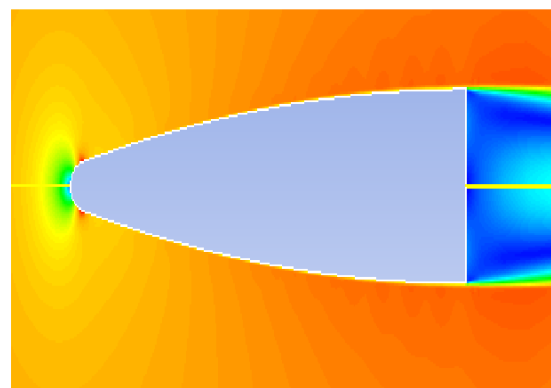
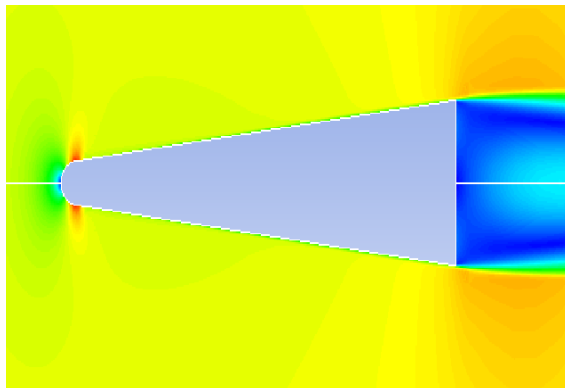


Figure 11.Velocity contours of cone shaped nose **Figure 12.**Velocity contours of ogival shaped nose

Case 2: Mach number =1.2

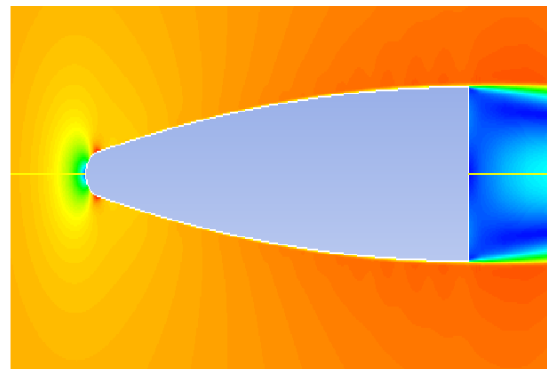
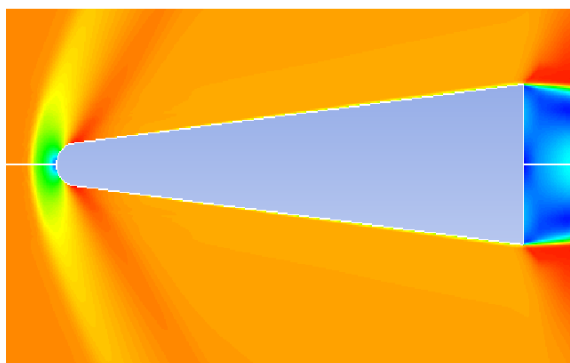
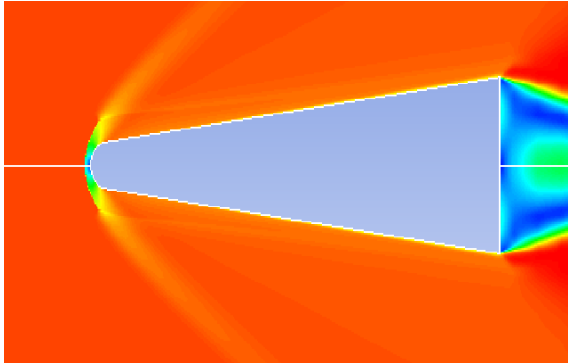
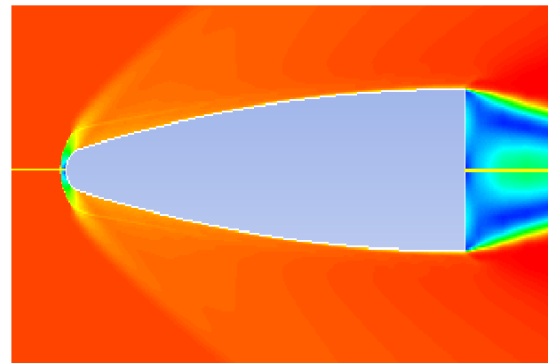


Figure 13.Velocity contours of cone nose**Figure 14.**Velocity contours of ogival nose

Case 3: Mach number =2

**Figure 15.**Velocity contours of cone nose**Figure 16.**Velocity contours of ogival nose

3.6 Comparison of Coefficient of Drag for both conical and ogival shaped noses:

Both the conical and ogival shaped noses are analyzed for finding the coefficient of drag in both the nose shapes. From the analysis, the values of coefficient drag are tabulated in the table 1, table 2 and table 3. From the tabular values graphs are plotted to show how the drag changes with mach number for different shapes of nose shown in figure 13, figure 14, figure 15, figure 16, figure 17 and figure 18.

Table 1.Drag Comparison for ogival and cone shapes

M	CD(Ogive)	CD (cone)
0.4	0.207789	0.267021
0.8	0.223567	0.302273
0.9	0.237768	0.336733
1	0.39384	0.508609
1.1	0.416134	0.458583
1.2	0.406104	0.42766
1.5	0.371936	0.373774
2	0.31167	0.303144
3	0.225458	0.208512

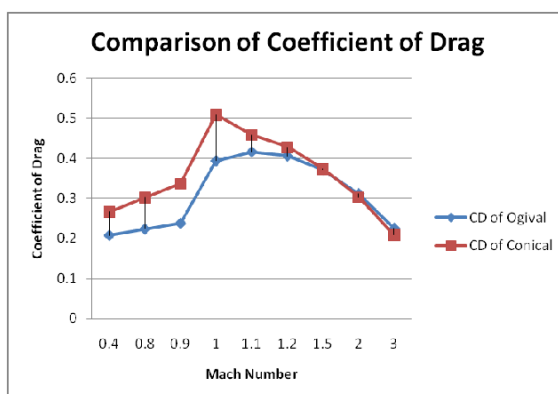
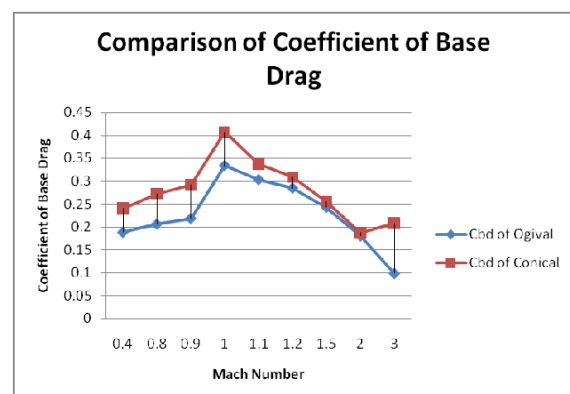
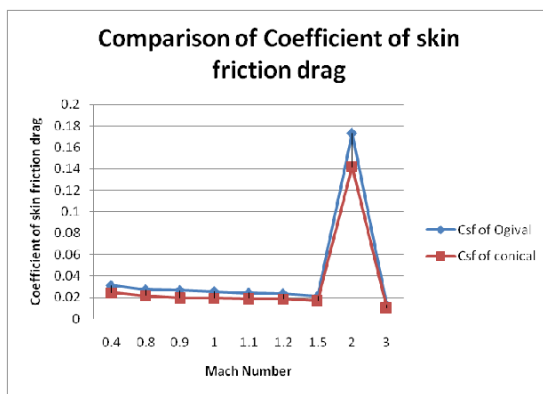
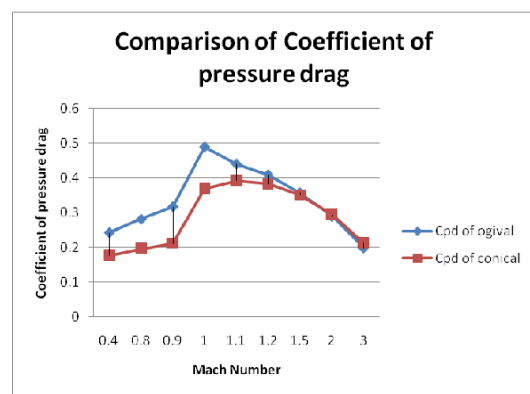
**Figure 17:** Comparison of Coefficient of Drag**Figure18:** Comparison of Coefficient of base Drag

Table 2. Co-efficient of base drag comparison for ogival and cone shapes

M	Cbd(Ogive)	Cbd (cone)
0.4	0.18862	0.240246
0.8	0.206304	0.272571
0.9	0.218577	0.292031
1	0.333904	0.407282
1.1	0.303175	0.337642
1.2	0.284726	0.308784
1.5	0.242836	0.2555286
2	0.180498	0.187428
3	0.098883	0.208512

**Figure19.** Comparison of C_{sf} Skin friction drag**Figure 20.** Comparison of C_{pD} pressure drag**Table 3.** Co-efficient of skin friction comparison for ogival and cone shapes

M	Csf(Ogive)	Csf (cone)
0.4	0.030992	0.024535
0.8	0.027157	0.021457
0.9	0.0264	0.019739
1	0.025423	0.019422
1.1	0.02409	0.018887
1.2	0.023371	0.018573
1.5	0.020881	0.016959
2	0.17322	0.14213
3	0.012584	0.010304

Table 4. Co-efficient of pressure drag comparison for ogival and cone shapes

M	Cpd(Ogive)	Cpd (cone)
0.4	0.242486	0.176797
0.8	0.280816	0.19641
0.9	0.316994	0.211367
1	0.489187	0.368417
1.1	0.439696	0.392044
1.2	0.409087	0.382734
1.5	0.356815	0.351055
2	0.288931	0.294348
3	0.198207	0.212874

Comparison of conical and ogival shape of the skin friction co efficient for all the Mach numbers (0.4, 0.8, 0.9, 1, 1.1, 1.2, 1.5, 1.5, 2, 3) at zero angle of attack. Different graphs been plotted at different Mach numbers.

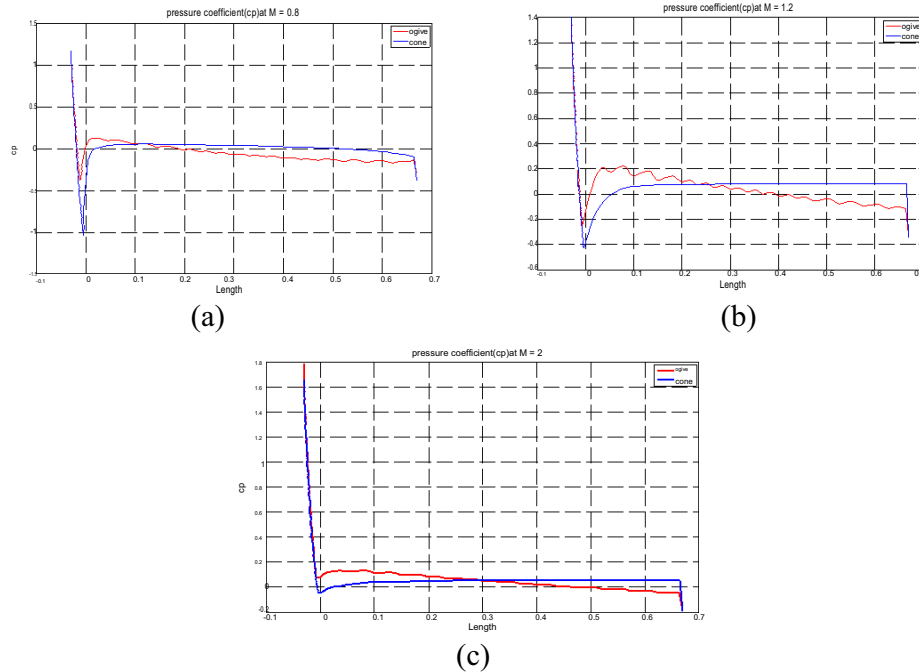


Figure 21. Pressure co efficient at (a) $M=0.8$, (b) $M=1.2$, (c) $M=2.0$

Different graphs for the different Mach numbers for skin friction co efficient

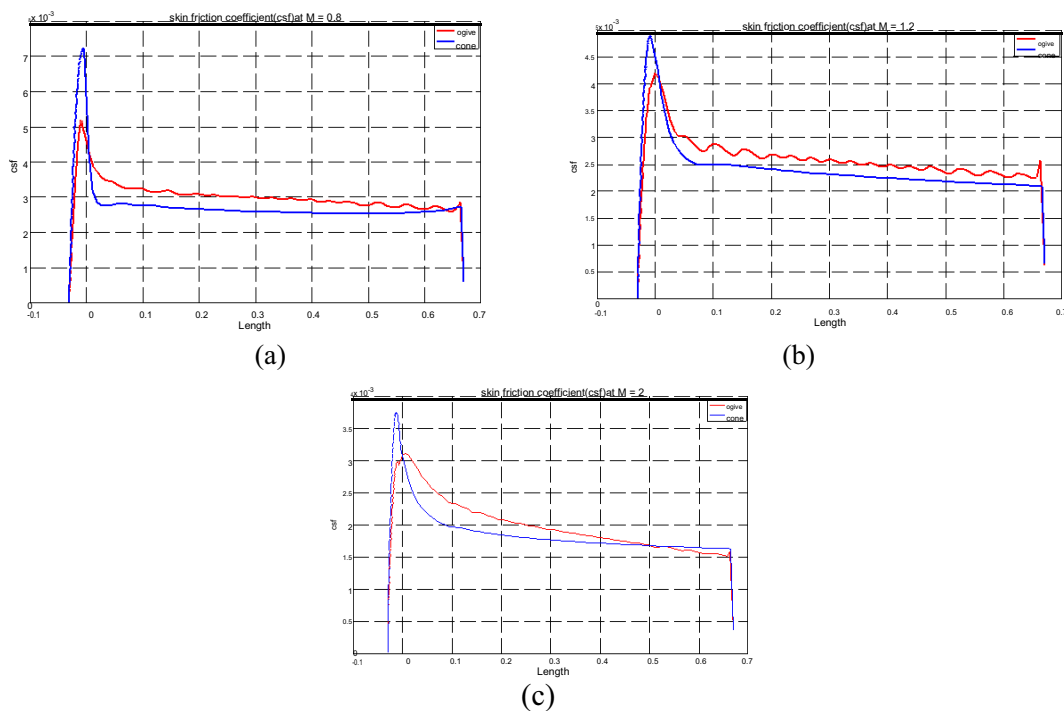


Figure 22. Skin friction co efficient at (a) $M=0.8$, (b) $M=1.2$, (c) $M=2.0$

4. Conclusion

As discussed in the results and discussions, the performance of the conical and ogival shaped nose are analyzed in the CFD for the coefficient of drag. The values obtained from the analysis are been plotted with respect to their Mach numbers (0.8, 1.2, 2) at $\alpha=0$ for both the conical and Ogival shaped noses of aerodynamic bodies which resulted in the highest co-efficient drag with the conical shaped aerodynamic bodies compared to the Ogival shaped bodies.

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