CFD ANALYSIS OF INTERACTION OF THE FLUID STRUCTURE OF THE CONVERGENT-DIVERGENT NOZZLE

Anubhav Vishwakarma, Devesh Kumar,
Department of Mechanical Engineering
Madan Mohan Malaviya University of Technology
Gorakhpur Uttar Pradesh 273010

Abstract: In the present work, a convergent-divergent nozzle is aerodynamically designed. The structural loads of the fluid flow nozzle and the temperature of the fluid in it. Initially, the CFD simulation is performed with thermal considerations in the NPR range of the nozzle. Furthermore, the CFD result is used as a load in the nozzle structural analysis. Nozzle is working in the NPR range in its NPR design service. The maximum load on the nozzle structure can occur at any NPR flow value. The problem associated with the design of the nozzle structure is the prediction of the load at various nozzle pressure ratio intervals. It is difficult to find and solve this problem analytically. Experimentation will lead to a more expensive investigation. Therefore, a calculation method is needed to find the load in different NPRs. The maximum load of the CFD simulation is used for structural simulation to complete the nozzle thickness. The interaction of the fluid structure (FSI) is the interaction of some mobile or deformable structures with an internal or surrounding fluid flow. The interaction fluid structure can be stable or oscillatory. The problems of interaction of the fluid structure and the problems of multi physics in general are often too complex to be solved analytically; therefore they must be analyzed by means of experiments or numerical simulations.

IndexTerms - FSI, Computational Fluid Dynamics, Structural Simulation

I. INTRODUCTION

Food-Structural Interaction (FSI) is the interaction of a structure that can be changed and has a fluid flow inside or around. Food aluminum reactions can be stable or shaken. In the transition of the cradle, caused by strong structures, it moves, so that the source of the pressure is reduced and the structure returns to its former state to repeat. The structural interaction of food is important in the design of many engineering systems. Aircraft and bridges. The inability to think about the effects of interaction can be particularly disastrous, especially in structural structures related to fatigue-related materials. The Tacoma Narrows Bridge (1940), the first Tacoma bridge, is perhaps one of the major failures. The plane and the wagons can be split due to variations in FSI. Relation with the structure of the fluid should be considered in the arterial analysis of arterioles and artificial neurons. Reed actually produces sound because the system of its dynamic management equation has cradle solutions. The potential of the pipe holes used in two engines and chainsaws is controlled by the FSI. The act of "green flax" is another example. Will suffer from suffocation, which will be part of the expansion to atmospheric pressure that arises after the throat flow (for example, the smallest flux) into the flow of the aircraft. Although the flow does not stay strong, the balance between throat pressure and atmospheric pressure still creates some pressure.

Newton's approach or Raphson-another fixed point can be used to solve PLP problems. The Newton-Raphson-based approach used in this approach is solid and divide both. These approaches are solutions of straight equations and flow throughout the structure of solids and rigid equations using the Newton-Raphson method. The system of the linear equation in the Newton-Raphson replay can be resolved without the knowledge of this method with Jacobins nonmetric times using the probable product of the Holy Vector Jacob. While the Newtonian approach - to address the Raphson flow and structural problems for the whole state of this robust liquidity, it is also possible to prepare this issue as a system of FSIs with only the degrees of freedom in the interface, an unknown location. The domain's decomposition, the frozen gas in the subspace FSI error associated with this interface. The problem of PLP can thus be written as any problem or root problem finding fixed points at the location of the unknown interface. The Supersonic flight capability is a joint exhaust feature - to create a supersonic flow. The heavy-duty rocket engines owe their form, especially of their very high proportion of the area of the head. If the ratio of pressure exits the head through the excess of the main pressure of the engine exhaust gas, the excess pressure exits the air. This reduces the effectiveness of the nozzle injection, causing a large part of the bottom section from the expansion of the nozzle. Therefore, rocket engines and engines for faster flying speeds include the C-D nozzle, which allows for more expansion against the inside of the nozzle. However, unlike the common nozzle - constant opposites are used on a conventional rocket engine, those in the turbojet engine will go into heavy and expensive, variable geometry to handle with a large proportion of head pressure exits occurring at a rate from subsonic to over Mn3s. For sub-subsonic applications, nozzle C -D constant fixed geometry, see section "Low proportion nozzle."

The design is calculated by using following formulas

$T^* / T1 = (2 /\gamma + 1)$ ……………………… (1)

$P^*P1 = (2/\gamma + 1)^{\gamma/(\gamma-1)}$…………………. (2)

$V^* = (\gamma RT^*)^{½}$ ………………………… (3)

$V_{exit} = 44.72 * (C_p [T_1 - T_{exit}])0.5$……...(5)

$L_{div\ nozzle}$ (length of divergent nozzle)

$= (d_{exit} – d^*) / 2 * \tan \alpha_d$ …………… (6)

$L_{cov\ nozzle}$ (Length of convergent nozzle)

$= (d1- d^*)/ 2 * \tan \alpha_c$…………………. (7)

2. Design of proposed convergent-divergent nozzle

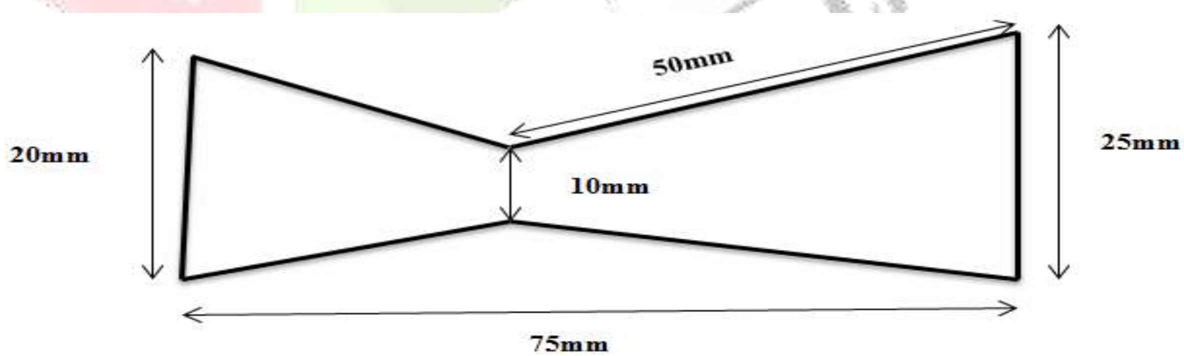


Fig 1 C-D Nozzle layout

Inlet length	20mm
Outlet length	25mm
Throat length	10mm
Breath length	10mm
Total length	75mm
Pressure	3bar
Ideal gas viscosity	Sutherland

Table 1: Layout dimension in mm

3. Meshing convergent-divergent nozzle

The mesh obtained initially will be unstructured mesh and this cannot be used to obtain accurate results. Since the edges are prismatic can be converted into structured meshing by using Mapped Face Meshing.

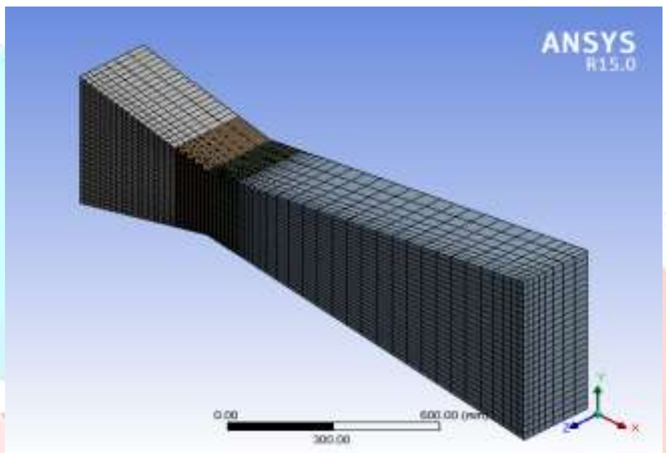


Fig 2 Meshing of C-D Nozzle

4. Boundary condition convergent-divergent nozzle

1 Mass flow inlet

2 Outlets

3 Walls

Specification of the boundary zone has to be done in Workbench only, as there is no possibility to specify the boundary zones in FLUENT.

Material	Fluid –air Energy Equation-On
Pressure inlet	3e5
Pressure outlet	0
Ideal gas Viscosity	Sutherland

Table 2: Boundary Condition

5. Results and Discussion

The following graphs present the convergence history of the nozzle.

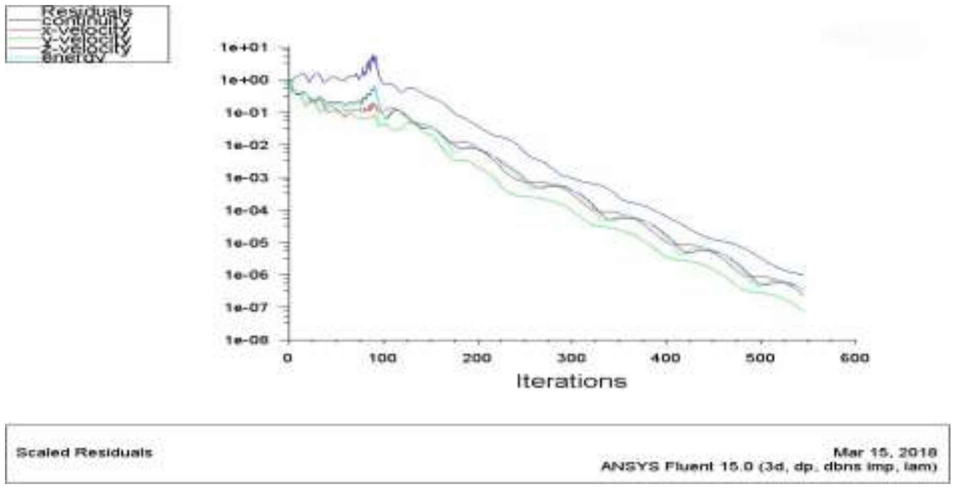
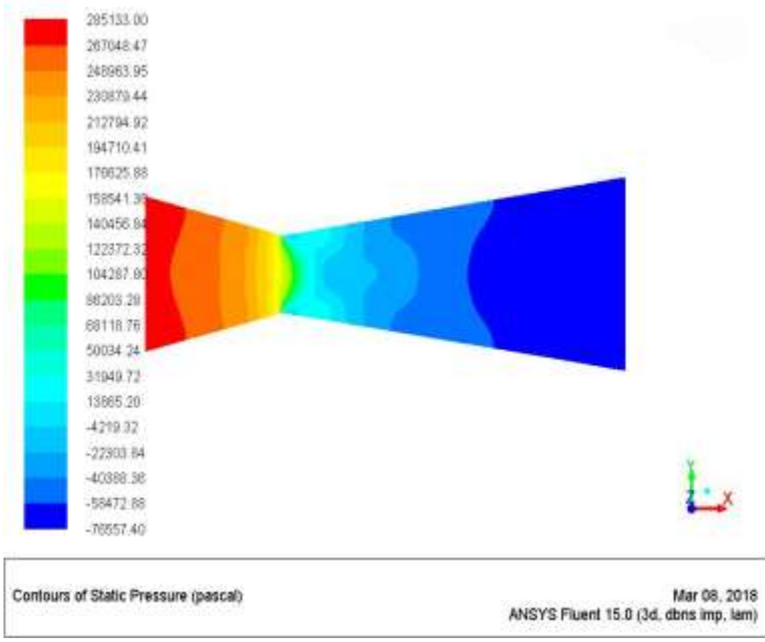


Fig 3 the nozzle convergence at 545 iterations.

Static pressure



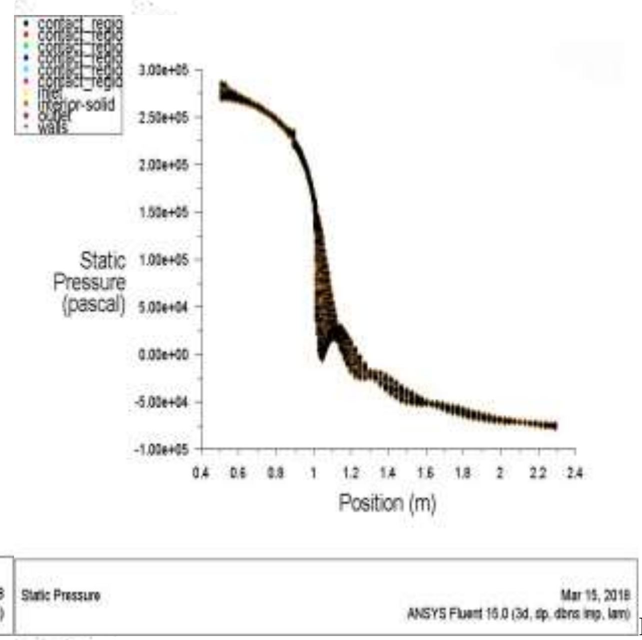
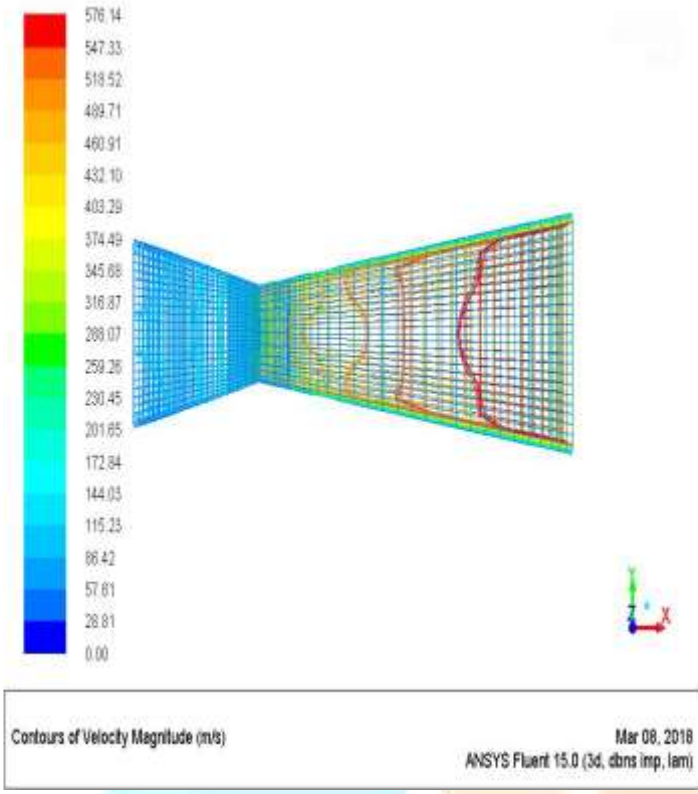


Fig 4 the maximum value of the static pressure (285133 Pa) & the minimum static pressure value (-76557 Pa).

Fig 5 Static pressure X-Y Plot

Velocity magnitude



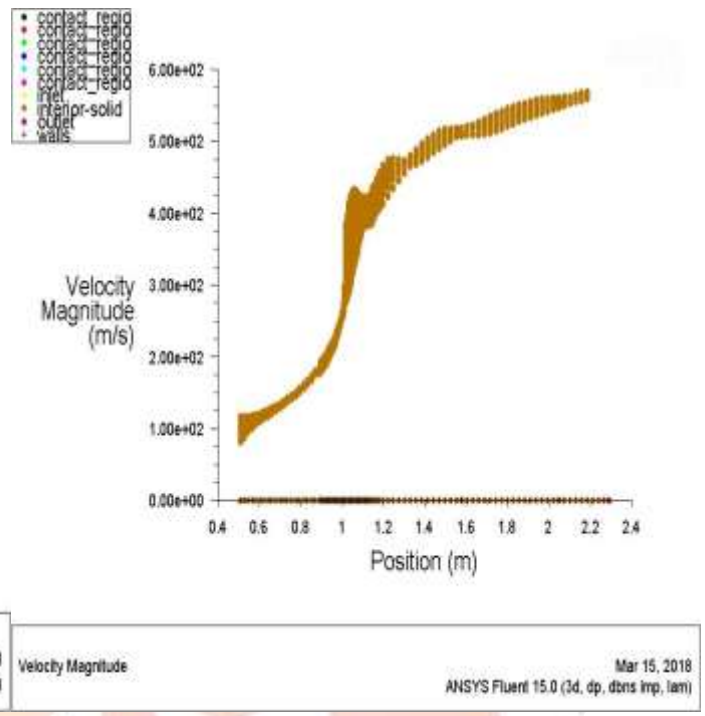
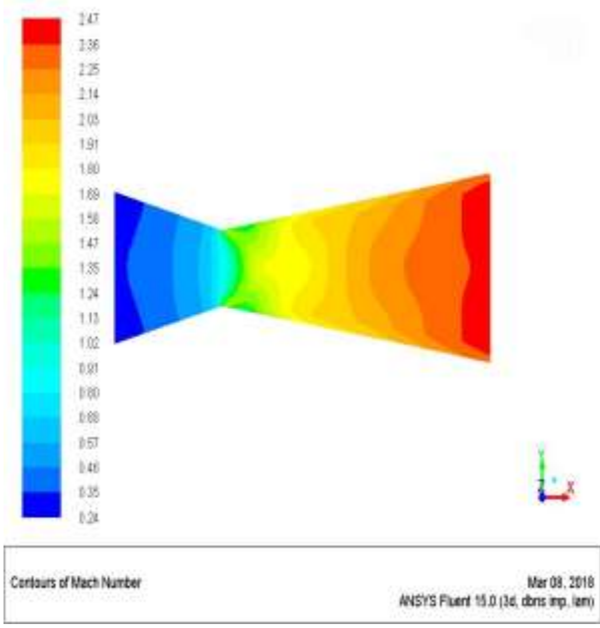


Fig 6 the maximum value of velocity magnitude (576 m/s) & The minimum velocity magnitude (26.61m/s).

Fig 7 Velocity Magnitude X-Y Plot

Mach number



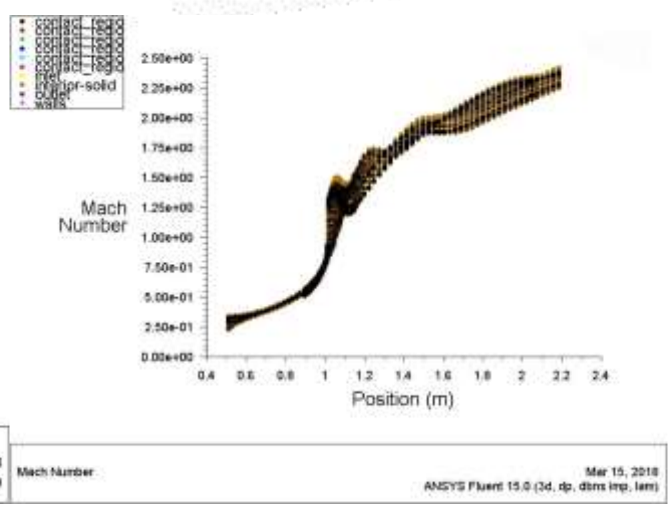


Fig 8 The maximum Mach no (2.47) and minimum Mach no (0.24).

Fig 9 Match Number X-Y Plot

6. Conclusion

For CFDs to get distinctive NPR esteems, information and yield conditions are unique. These are recorded beneath. From these outcomes, the auxiliary investigation with the built up the decide the weight Mach number Velocity magnitude. The shapes of the above kept up parameter are found subsequent to dissecting the model effectively in solver. Additionally the base and most extreme esteems.

7. References

[1]. Aginsky Z. et. al (2011) 'Numerical analysis of nonlinear acoustic fluid-structure interaction of a two dimensional plate in an in-viscid compressible fluid', ENOC, pg: 24-29.

[2]. Ali S. et. al (2013) 'Numerical analysis and simulation of the interaction between a Von Karman vortex street and elastic flaps', Congress François de Technique.

[3]. Birken P. et. al (2014) 'Thermo mechanical Coupling In Fluids, Structures and Fluid-Structure-Interaction', 6th. European Conference on Computational Fluid Dynamics.

[4]. Driss Z. et. al (2007) 'Computer Simulations of Fluid-Structure Interaction Generated by a Flat-Blade Paddle in a Vessel Tank', International Review of Mechanical Engineering, Vol. 1, no. 6, pg: 608-617.

[5]. Goud S.K. et. al (2014) ' Analysis of Fluid-Structure Interaction on an Aircraft Wing', International Journal of Engineering and Innovative Technology, Volume 3, Issue 9, pg: 146-152.

[6]. Guruswamy G.P. et. al (1988) 'Integrated Approach for Active Coupling of Structures and Fluids', AIAA Journal Vol. 27, No. 6, pg: 788-794.

[7]. Hai E.M.S.B. et. al (2013) 'Numerical Simulation of Fluid Structure Interaction (FSI) on a double wedge Airfoil based on Arbitrary Lagrangian-Eulerian Frameworks', The workshop on Numerical Modeling of Grains/Fluid Flows, pg:1-6.

[8] Siva V, PROF .V. Sanker(2015) `Fluid Structure Interaction Based Investigation of Convergent- Divergent Nozzle 'International journal of engineering research and application ISSN 2248-9622 VOL 5