

COMPUTATIONAL STUDY ON REDUCTION OF THRUST LOSS IN JET VANE THRUST VECTORING NOZZLE

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ABSTRACT

Present Work in this paper is about reduction of thrust loss in Jet Vane Thrust Vectoring system. By literature survey, one of the main disadvantages found in Jet Vane thrust vectoring system is Thrust Loss. So by present work, these thrust loss can be reduced by increasing the divergent angle of nozzle. This Phenomenon is analyzed computationally using ANSYS 14.5 Fluent software. Velocity is one of the major Flow parameter in Thrust Generation so CFD simulation is carried out for determining the Exit Velocity of Jet Vane TVC nozzle. Most of the missiles use the Jet Vane TVC as their control system.

Keywords

Jet vane, Thrust Loss, Divergent Angle, CFD, Missiles, Exit Velocity.

NOMENCLATURE

θ	Divergent angle of nozzle	Deg ($^{\circ}$)
α	Angle of Attack of vane	Deg ($^{\circ}$)
β	Convergent angle of Nozzle	Deg ($^{\circ}$)
D_i	Inlet Diameter	mm
D_o	Outlet Diameter	mm
D_t	Throat Diameter	mm
V	Velocity	m/s

ABBREVIATIONS

CFD Computational Fluid Dynamics

TVC Thrust Vector Control

TV Thrust Vector

1. INTRODUCTION

Thrust vectoring system is a system which use to control or change the attitude of aerial vehicle such as Aircraft, Rockets, Missiles etc. It changes or controls the attitude of an aerial vehicle by changing the direction of exhaust nozzle to the desired direction at appropriate angle. Many kind of TVC is being used but Jet Vane is one of the efficient TVC configuration used in missiles. Jet Vane TVC system use a vane for thrust vectoring. In Jet Vane thrust vectoring system, thrust vectoring is attained by changing or deflecting the vane which is

located at aft section of the exhaust nozzle to appropriate angle. By literature survey, one of the major disadvantages in Jet Vane TVC is Thrust Loss. So, in this present work reduction of Thrust Loss in Jet Vane TVC is discussed with CFD approach.

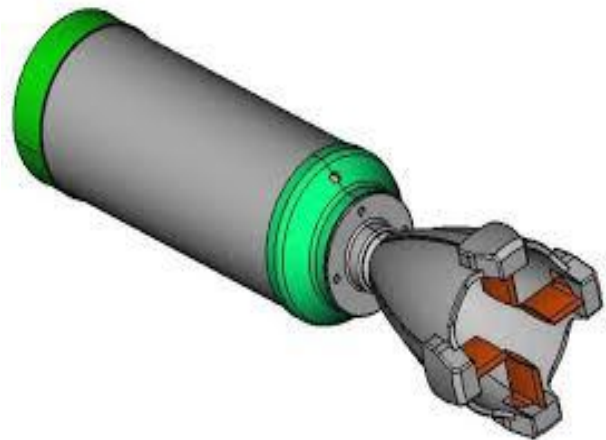
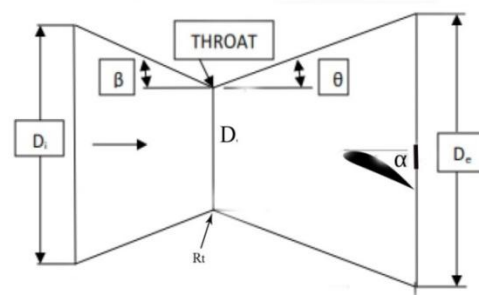


Fig.1 Jet Vane TVC

2. CFD SIMULATION

Computational study is carried out for present work .Because CFD is one of the finest method of solving engineering problems. Experimental study will be costly, but in computational method, solution is being solved using software. In present work ANSYS 14.5 Fluent is used for simulation.



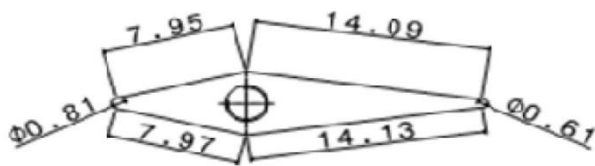


Fig.2 Geometric Parameters

Inlet diameter(mm)	116
Exit diameter(mm)	39
Throat diameter(mm)	14.74
Total Pressure(Bar)	44.1
Total temperature(K)	3400
Convergent Angle(β)	45°

Geometrical Parameters and Flow Parameters have been taken from [1]. Similarly Vane properties have referred with [1].

CFD simulation has been done for various divergent angles as follows, Variation in divergent angle has been considered with the reference of [2].

Cases	Divergent Angle θ (Degree °)
1	4°
2	7°
3	10°
4	13°
5	16°

Same procedure is followed for three different angle of attack of vane (0°, 5°, and 10°). Exit Velocity is increased measured for all cases and also for various angles of attack. Velocity is considered as main component in Net Thrust generation.

$$F = m_e V_e + (P_e - P_o) A_e$$

$$m = \rho V A$$

By above equation, Velocity plays a major role in both Thrust Generation and also in Mass Flow Rate.

3. BOUNDARY CONDITION

Following Boundary condition has been made [3] for the CFD simulation Jet Vane TVC Nozzle,

Procedure	Details
Solution Setup- General	Type-Density based Velocity Formulation-Absolute Time-Steady 2D space-Planar

Models	Energy Equation-On Viscous-Inviscid
Materials	Fluid-Air, Density-ideal gas
Cell zone condition	Operating condition= 101325 Pa(1)
Boundary Condition	Inlet Pressure = 44.1e5 Pa
Solution	Solution initialization-Standard- Compute from Inlet Run calculation-200 iterations
Results	Velocity contours

4. ANALYSIS PROCEDURE

2D model of Jet Vane TVC nozzle is designed with ANSYS 14.5 workbench, Which is then meshed, meshed model is being Analyzed with above boundary conditions[3].Solution has been made with iteration process(upto 200 iterations). Velocity Contour has been made for 2D Jet Vane TVC Nozzle.

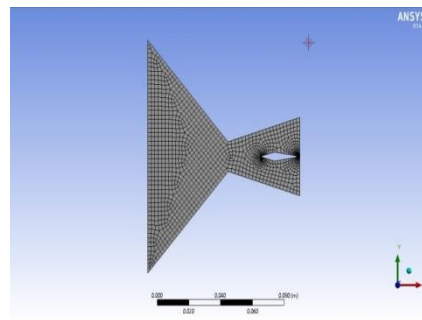
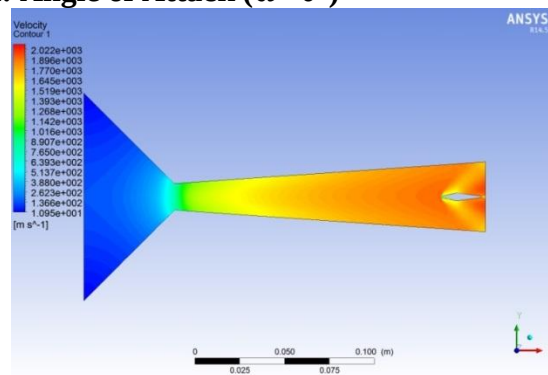


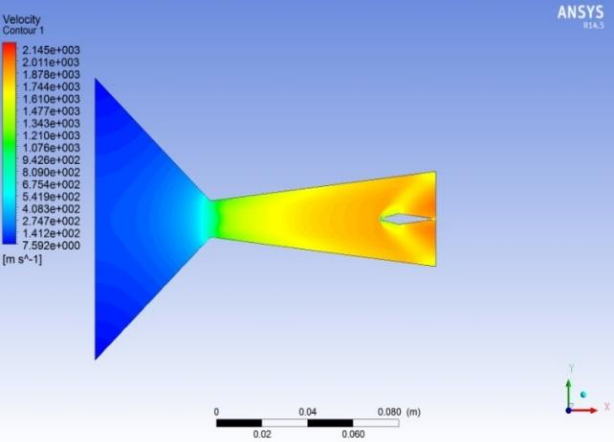
Fig 3 Meshed Model of Jet vane TVC Nozzle

5. RESULTS & DISCUSSION

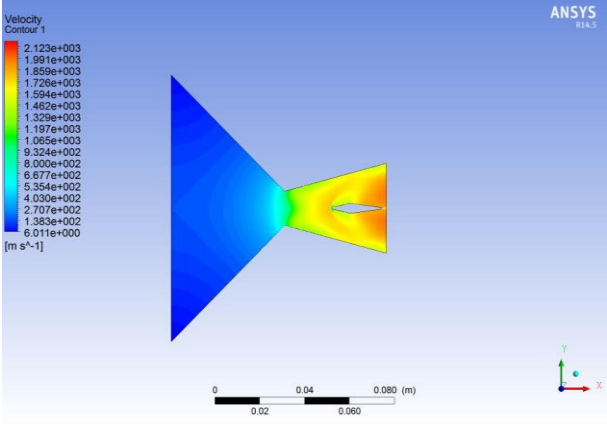
5.1. Angle of Attack ($\alpha = 0^\circ$)



$$\theta = 4^\circ$$

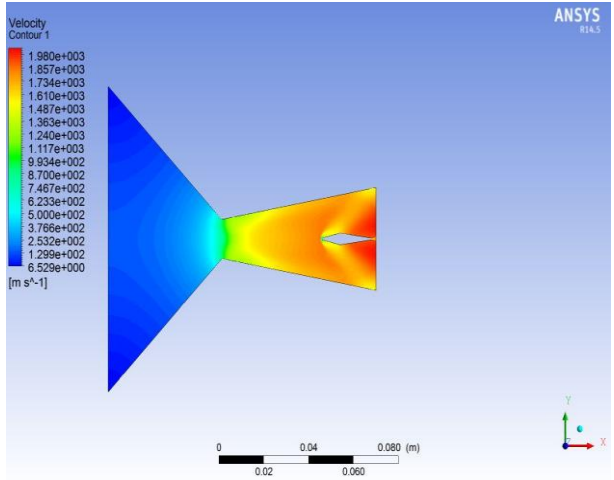


$\theta = 7^\circ$

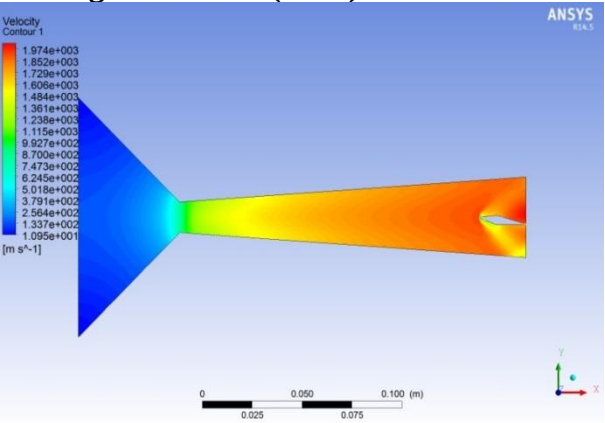


$\theta = 16^\circ$

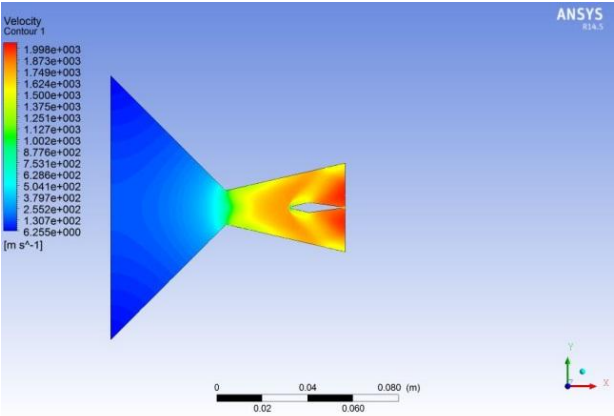
5.2. Angle of Attack ($\alpha=5^\circ$)



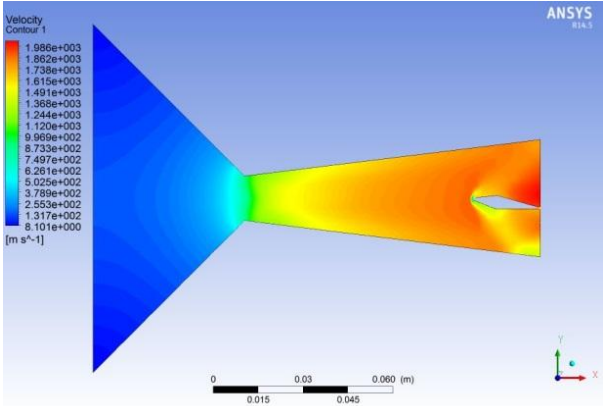
$\theta = 10^\circ$



$\theta = 4^\circ$

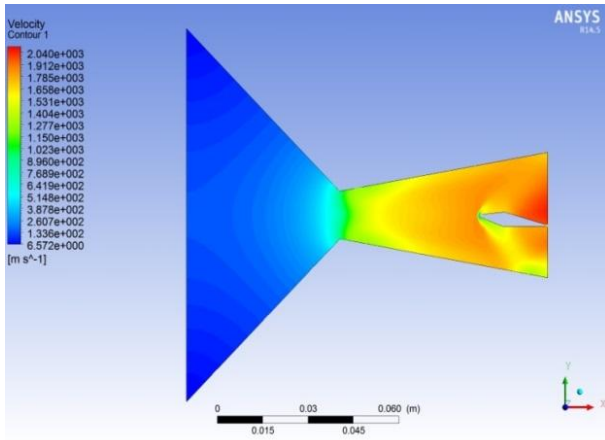


$\theta = 13^\circ$

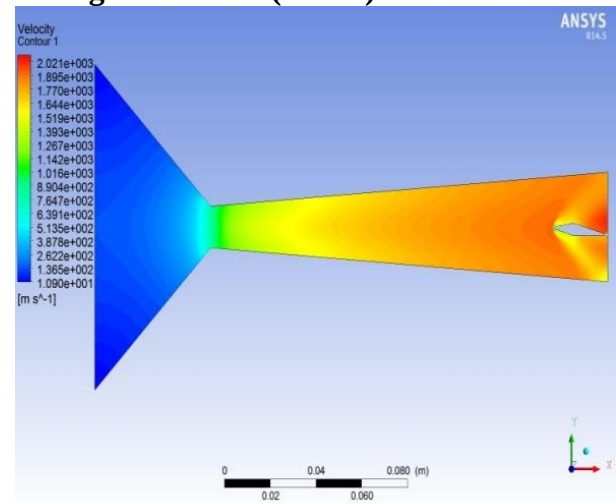


$\theta = 7^\circ$

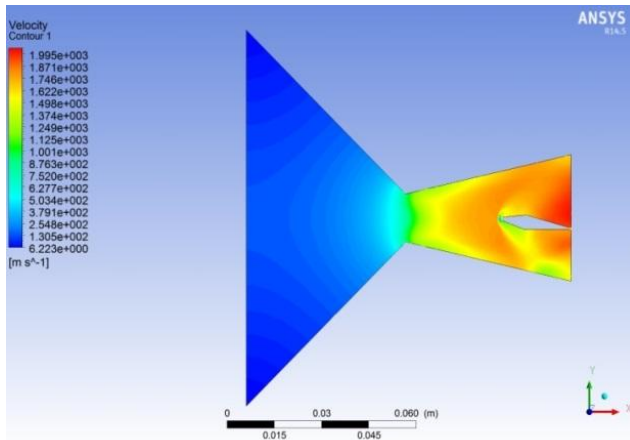
5.3. Angle of Attack ($\alpha=10^\circ$)



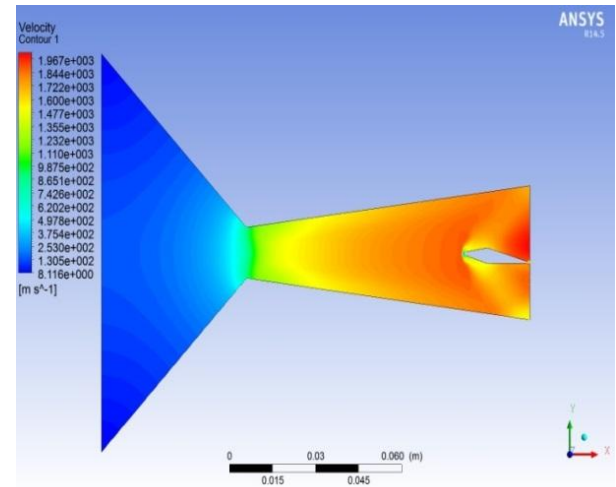
$\theta = 10^\circ$



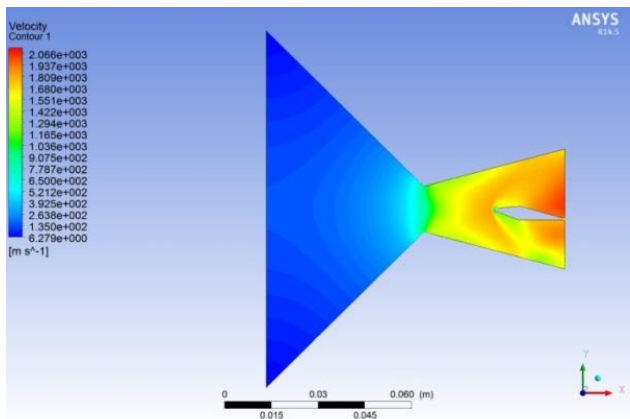
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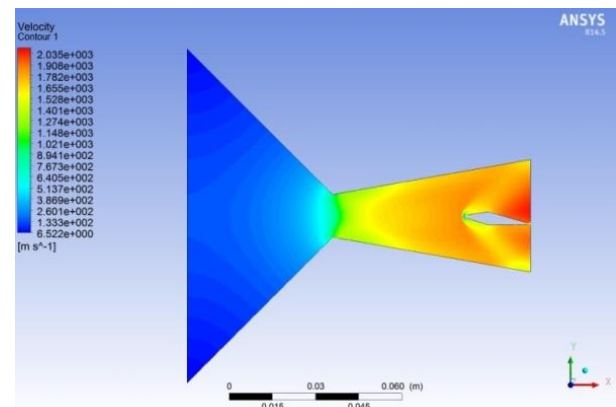
$\theta = 13^\circ$



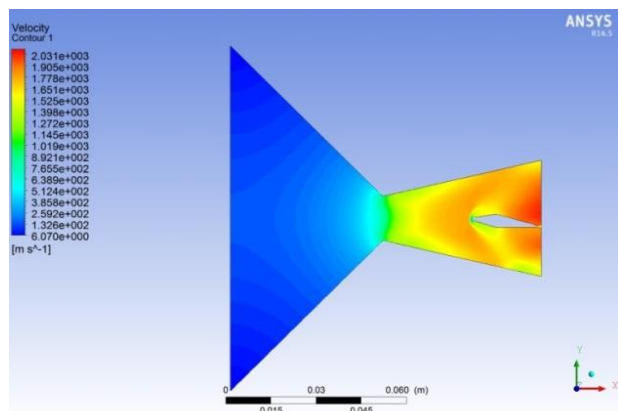
$\theta = 7^\circ$



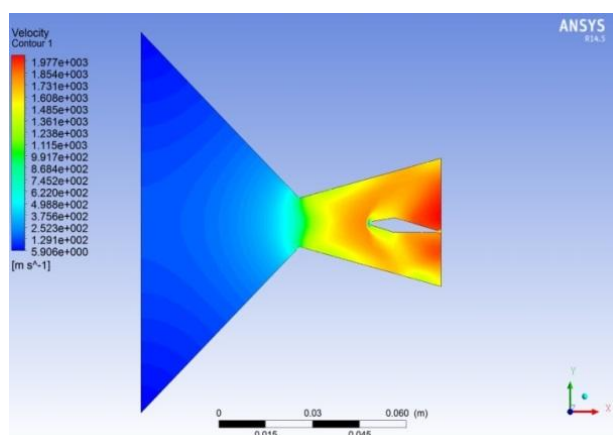
$\theta = 16^\circ$



$\theta = 10^\circ$



$\theta = 13^\circ$



$\theta = 16^\circ$

Table.1 Exit Velocity at Various AOA

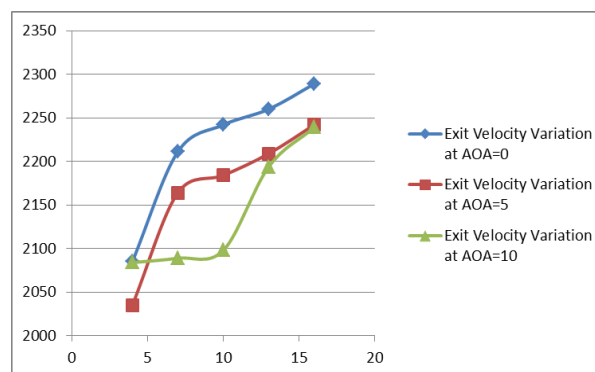
θ	V_e at $\alpha = 0^\circ$ (m/s)	V_e at $\alpha = 5^\circ$ (m/s)	V_e at $\alpha = 10^\circ$ (m/s)
4°	2085	2035	2084
7°	2211	2164	2089
10°	2242	2184	2098
13°	2260	2209	2194
16°	2289	2242	2239

Table.2 Thrust Loss at Various AOA

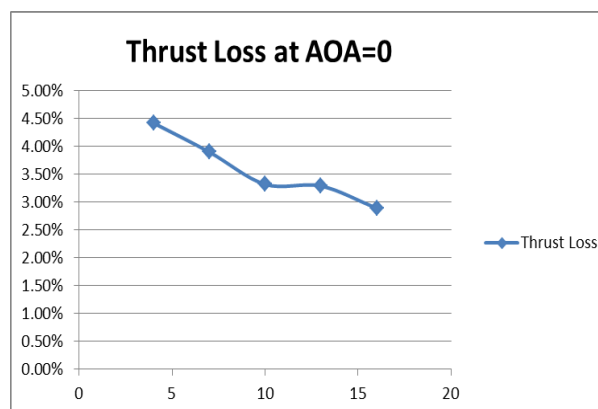
θ	Thrust Loss at $\alpha = 0^\circ$ (%)	Thrust Loss at $\alpha = 5^\circ$ (%)	Thrust Loss at $\alpha = 10^\circ$ (%)
4°	4.42%	6.52%	4.32%

7°	3.90%	6.01%	4.06%
10°	3.32%	5.87%	3.85%
13°	3.29%	5.56%	3.53%
16°	2.89%	4.94%	3.12%

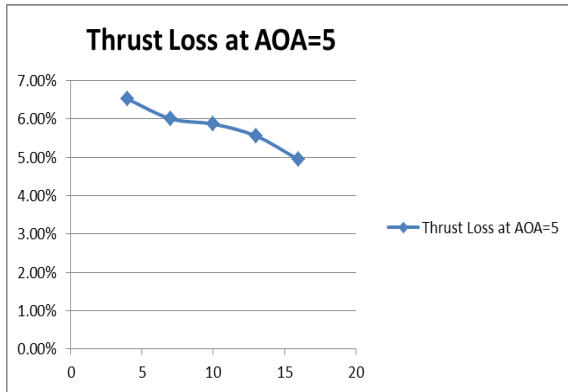
With the help of Velocity Contours, Table.1 and Table.2 has been made which shows the reduction of Thrust Loss in Jet vane TVC nozzle by Increase in Divergent angle (θ) of Nozzle. Graphical representation has been made with reference of Table.1 and Table.2



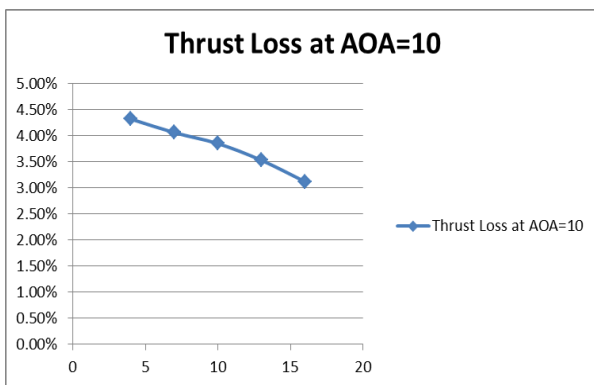
Graph.1 Exit Velocity Vs θ



Graph.2 Thrust Loss Vs θ at $\alpha = 0^\circ$



Graph.3 Thrust Loss Vs θ at $\alpha = 5^\circ$



Graph.4 Thrust Loss Vs θ at $\alpha = 10^\circ$

Graphs and Table.1 &2 show the reduction of thrust loss with increase in Divergent Angle of Nozzle in Jet vane TVC.

6. CONCLUSION

Hence Jet vane TVC nozzle has been analyzed using ANSYS 14.5 Fluent Software. By which Thrust Loss in Jet Vane TVC nozzle has been reduced. CFD simulation has been done to get Velocity Contour and Graphs has been plotted for clear Explanation.

7. REFERENCES

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