NUMERICAL SIMULATION OF MECHANICAL THRUST VECTORING IN GAS TURBINES

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Abstract:

Whenever we need an appreciable manoeuvring, the ultimate choice is thrust vectoring control system, because they provide excellent survivability and improved performance in the case of gas turbines. Since, from the time of its inception many researchers worked on to reduce the number of actuators and in improving the thrust vectoring angle. Even through there are different ways to achieve greater jet deflection, mechanical type achieved the better credits. This paper focus on designing a c-d nozzle with various case of vectoring and non- vectoring to attain supersonic flow and optimizing it to achieve maximum drop pressure, velocity, Mach number with various cases. The analysis has been performed according to the c-d nozzle with various cases and keeping the same input condition. Our objective is to investigate the various case of vectoring and non-vectoring c-d nozzle. In this, initially modelling of the c-d nozzles has been done in GAMBIT and later on mesh generation and analysis has been carried out in GAMBIT FLUENT 6.3 and various contour like pressure, velocity have been taken and their variation according to different case C-D nozzle has been studied. Comparing the c-d nozzle with various degrees. Which can varying Mach number, velocity and pressure values which are used to thrust vectoring.

Key words: C-D nozzle, GAMBIT, FLUENT

I. INTRODUCTION

Nozzle is used to convert pressure energy into kinetic energy in order to produce thrust. For design purpose, the nozzle can be assembly of three separate sections operating converging, throat, and diverging section. In an aircraft engine with reheat, the nozzle presents a convergent section, which have task to accelerate the gas jet in order to generate the thrust. Thrust vector control is effective only while the propulsion system is operating an exhaust jet. Since, there are several types of thrust vectoring nozzles, there are different ways to achieve the deflection of the gas jet: the most efficient one is by mechanical deflecting the divergent section only (c-d), hence minimizing the effect on the engine upstream of the throat (sonic) section.

II. MODELING OF C-D OF NOZZLE

Since the nozzle has a circular cross-section, it is reasonable to assume that the flow is axisymmetric and the geometry created to be two-dimensional. The coordinates are provides table 1 for development of 2-d model of supersonic c-d nozzle.

TABLE 1

Coordinates of nozzle profiles

X	Y
-0.5	0.33
-0.4	0.28
-0.3	0.24
-0.2	0.21
-0.1	0.18
0	0.17
0.1	0.18
0.2	0.21
0.3	0.24
0.4	0.28
0.5	0.33

A. Analysis of c-d nozzle

The meshing and analysis is carried out in GAMBIT FLUENT software importing the inlet conditions and the boundary values for the problem statement.

B. Meshing

GAMBIT FLUENT software is opened and import the coordinates and to draw the nozzle in GAMBIT. And the meshing the nozzle is done. With control is set to boundary and inlet, outlet, top wall, bottom wall named selection are defined and the meshing updated.

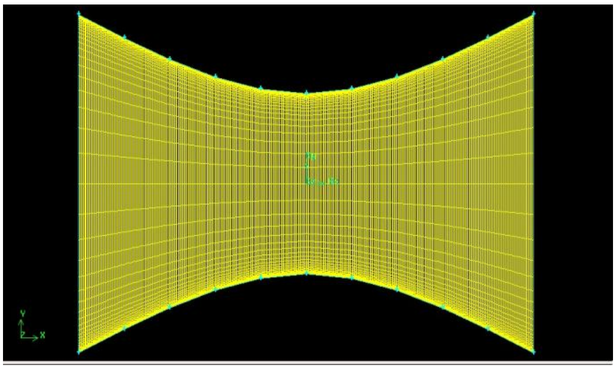

Fig. 1.Geometry of c-d nozzle (θ=0)

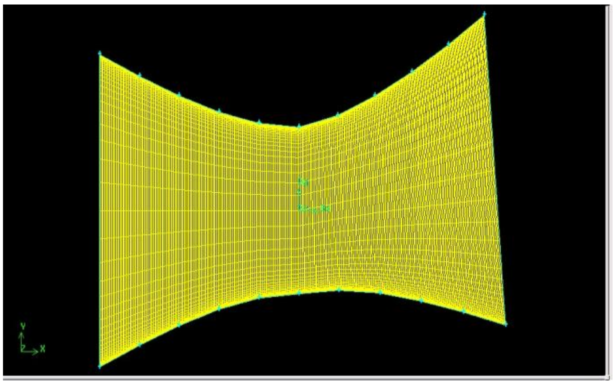

Fig. 2.Geometry of c-d nozzle (θ=10)

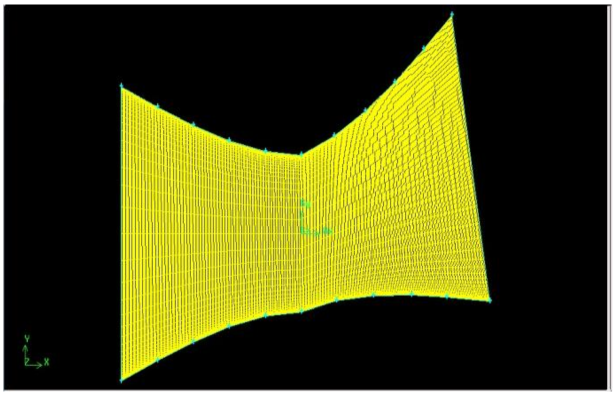

Fig. 3.Geometry of c-d nozzle (θ=20)

III. BOUNDARY CONDITION

A. Material selection

Material selected is gas. The properties of gas taken as follows:

1. density as ideal gas
2. Specific heat capacity = 2034.6 j/ kg. k
3. viscosity = 6.07e-5 kg / m .s

B. Inlet condition

TABLE 2
Inlet condition

Inlet pressure	80bar
Initial gauge pressure	78bar

C.Outlet condition

TABLE 3

Outlet condition

Exit pressure	13e5

D. Control set up

1. turbulence kinetic energy = 0.8
2. turbulence dissipation rate = 0.8

E. Initialization

Solution initialization is done. Compute from inlet. Residual monitoring is done and convergence criteria are setup.

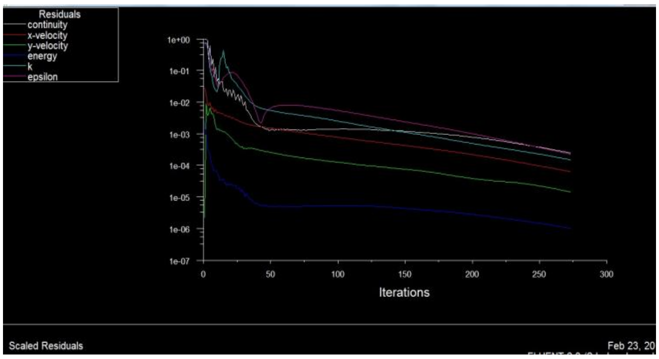

Fig. 4. Convergence history for c-d nozzle (θ=0)

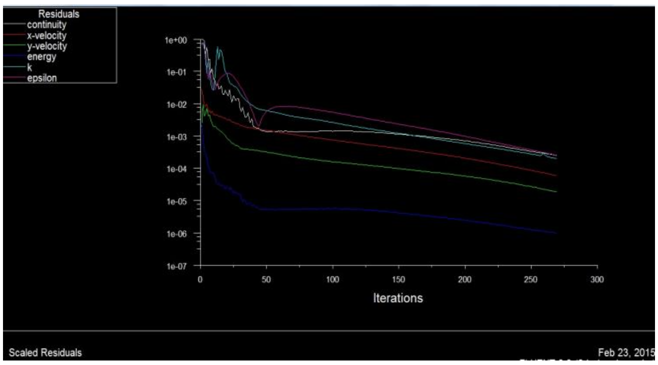

Fig. 5.Convergence history for c-d nozzle (θ=10)

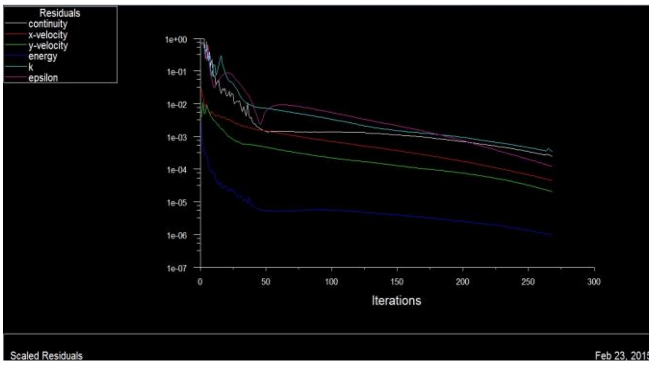

Fig. 6.Convergence history for c-d nozzle (θ=20)

IV. RESULTS FOR NOZZLE

By deflecting the divergent section of nozzle with various angle which can change the exit mass flow rate of the air. Can change the pressure, velocity and Mach number values at exit of the nozzle. This variation in Mach number and pressure velocity which leads to thrust vectoring. Nozzle profile which is examined is considered in 2D. Flow through the nozzle for given input condition with velocity 186.3 m/s and maximum output was observed 604 m/s such that Mach number increased for 0.2 to 1.82 in which nozzle is acting as supersonic nozzle. The pressure and velocity contour are plotted as shown in fig 7 to 12.

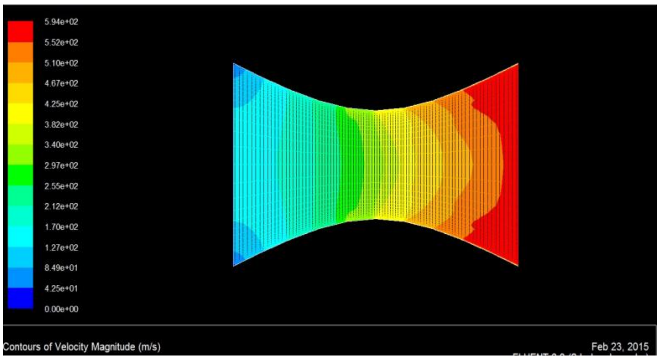

Fig. 7.Velocity contour of c-d nozzle (θ=0)

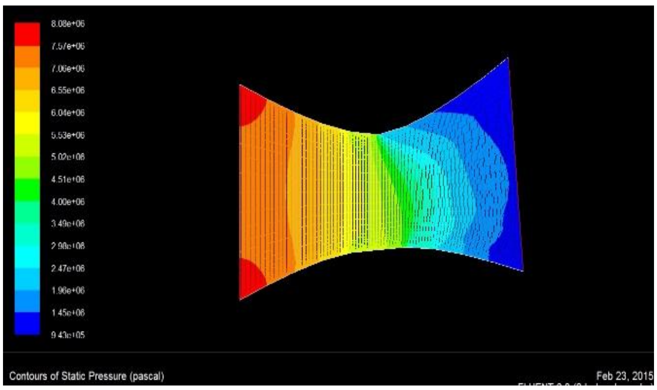

Fig. 8.Pressure contour of c-d nozzle (θ=10)

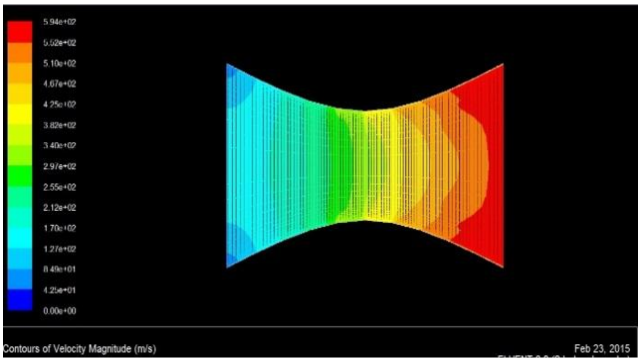

Fig. 9.Pressurecontour of c-d nozzle (θ=0)

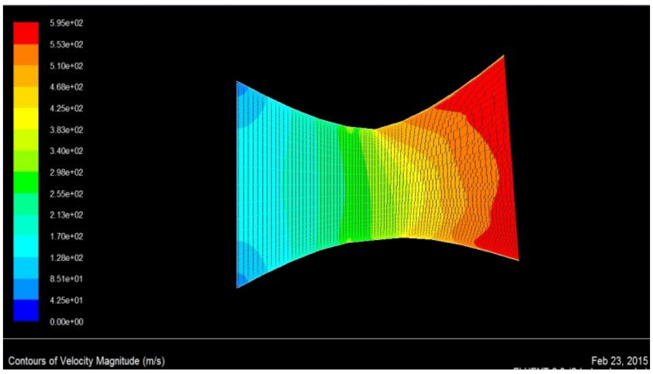

Fig. 10.Velocity contour of c-d nozzle (θ=10)

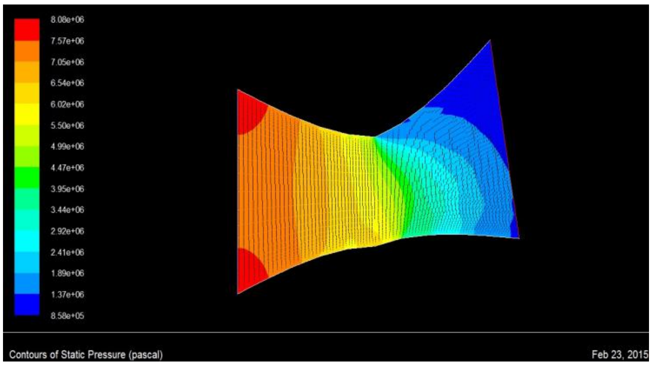

Fig. 11.Pressure contour of c-d nozzle (θ=20)

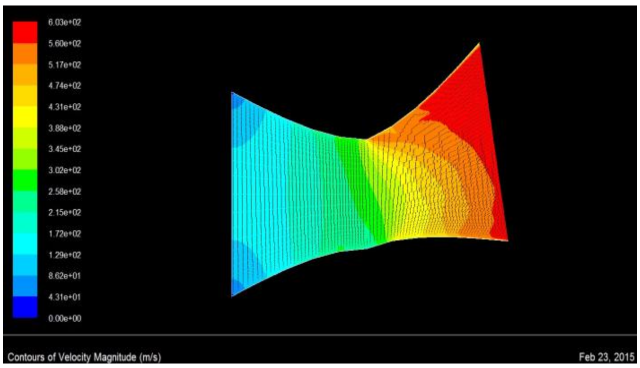

Fig. 12.velocity contour of c-d nozzle (θ=20)

TABLE 4
Results with different angle

c-d nozzle	Pressure drop(pa)	Velocity (m/s)	Mach number (exit)
0	1017139	594.45	1.79
10	943110.9	595.47	1.80
20	857751.6	603.125	1.82

Compared to the three different angles of c-d nozzle gives an increased velocity of about 5% and 10% respectively and an increase the pressure drop of 10% and 20% respectively and increase the exit Mach number 1% and 3% respectively and also variation of thrust vectoring to be increased .

V. RESULTS

CFD analysis has been done on c-d nozzle different angles. It has been found that c-d nozzle gives to increase velocity and Mach number and drop pressure. Maximum deflect angle at 20 degree the Mach number, velocity increase so, thrust vectoring applicable in c-d nozzle. Further deflecting with various angle thrust vectoring will be varying and increased. Then the solution is converged around 280 iteration residual is ignored after 10^{-6} value.

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