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FLUIDIC THRUST VECTORING OF DUAL THROAT NOZZLE

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ABSTRACT

The study aims the computational method of analysing Fluidic Thrust Vectoring in dual throat nozzle.Fluidic thrust vectoring in the dual throat nozzle is performed by secondary flow injections using the secondary ejector that cause local flow separation, asymmetric pressure distribution and the primary jet thrust vectoring. The vectored thrust has proved to be highly advantageous in pitch and yaw conditions of the supersonic jet aircrafts and this method of deflecting the primary thrust by a secondary flow ejector thereby reduces the weight by neglecting the mechanical parts in the external nozzle region. In this paper we study the supersonic thrust vectored by the secondary flow ejector in three different angles and also two different locations of secondary ejector. The velocity and pressure contours are compared for the wide range of the analysis done. For validation purpose, the ANSYS software is used for the simulation of thrust vectoring based on Fluidic thrust vectoring strategies in the dual-throat nozzle.Nozzle performances and thrust vector are computed for a wide range of angles of the secondary flow ejector and the location of secondary flow ejector.The numerical results obtained are validated for any future applications.

Keywords: fluidic thrust vectoring, secondary ejector, different angles and different locations, ANSYS.

1. INTRODUCTION

1.1 Nozzle

A nozzle is a specially designed device to control the flow charactersitics like velocity,pressure,thrust etc.The nozzle as it is seen as simple device through which the hot gases flow is not something that is seen.Nozzles are designed in varying area and dimensions to regulate the thrust as required. The evolution of nozzle design has reached its zenith when compared to last 10 years. This evolution of nozzle has resulted in a tremendous growth in the field of propulsion. One of the most important evolution in the field of nozzle design is the convergent divergent nozzle. Simple turbojets and turboprops most commonly have fixed convergent geometry nozzle. The rocket engines uses mechanical thrust vectoring convergent divergent nozzle.

1.2 Convergent-divergent nozzle

A convergent-divergent nozzle has varying area in between the entry and exit of the nozzle with a throat region in between. The fusion of the convergent nozzle in the first phase where the area decreases and the divergent nozzle in the next phase where the area increases is a simple defenition of CD nozzle. In the throat region the flow achieves sonic mach number. To be specific about the function of the CD nozzle the high pressure flow after the combustion chamber converges down throught the minimum area until the throat is reached. Across the throat where the shock strength is high the flow achieves high pressure. After the throat when the flow accelerates in the divergent region the pressure drops and the flow achieves high velocity.

1.3 Dual throat nozzle

Modern thrust vectoring concepts in the nozzle has developed with the idea of dual throat nozzle. As the name suggests the dual throat nozzle mean a nozzle with two throats. Based on the requirements, both the throats are either designed with the same throat area or different throat area. The excellent performance of the dual throat nozzle is because of its concaved cavity. A figure that shows the dual throat nozzle is shown below.

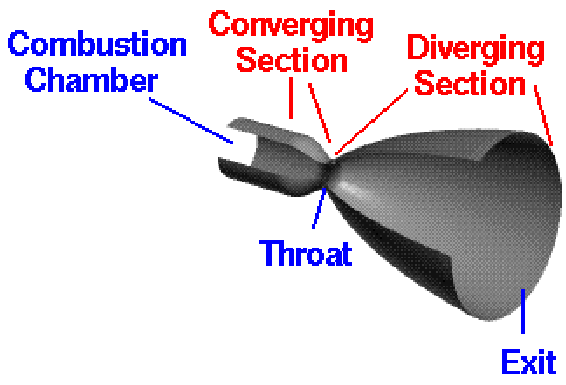

Fig 1.1: Convergent-Divergent Nozzle

1.4 Fluidic thrust vectoring

The fluidic thrust vectoring is the most developing concept in the jet engine aircraft. Unless the mechanical thrust vectoring mechanism the fluidic thrust vectoring neglects the moving parts and thus the weight is reduced to a great extent. The concept of the fluidic thrust vectoring is nothing but vectoring the primary thrust by a secondary airflow through the ejector. This secondary air is achieved from the compressor region as the bleed air.

2. METHODOLOGY

2.1 Geometry design

The 3D model is designed in the CATIA. The nozzle is designed with the inlet dia of 54.568 mm. The inlet is the largest region in the dual throat nozzle. Both the throats are of different diameter in the design. The secondary ejector is placed in the first throat region. In the dual throat nozzle, the design modifications are made in the secondary flow ejector alone. The wide range of angle and location modifications in the secondary flow ejector are:

1 120^0 with a single ejector

2 120^0 with a dual ejector

3 135^0 with a single ejector

4 135^0 with a dual ejector

5 150^0 with a single ejector

6 150^0 with a dual ejector

7 A backward offset location of a 150^0 single ejector

The design parameters of the dual throat nozzle is tabulated below

Table 2.1.1: Design parameters table

Dimensions	Values
Inlet diameter	54.68 mm
First throat diameter	29.21 mm
Second throat diameter	35.14 mm
Exit diameter	28.21 mm
First throat area	670.12 mm^2
Second throat area	970.15 mm^2
Exit area	625.023 mm^2

3. ANALYSIS

3.1 Pressure contour

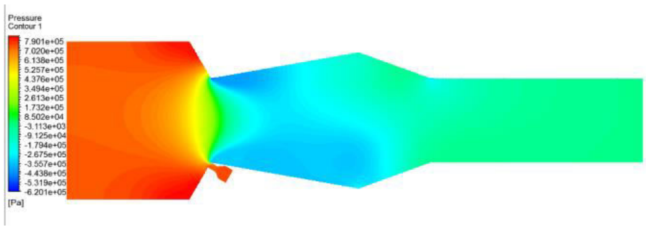

Fig 3.1.1: pressure contour of DTN of single 150^0 ejector

The total pressure produced in the dual throat nozzle of single 150^0 ejector at 1.5 mach number at the ejector throat region is 437600 pa and the exit region is -51130 pa.

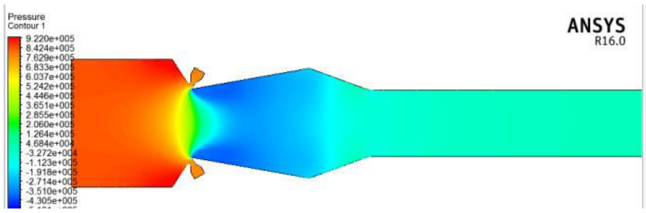

Fig 3.1.2 : pressure contour of DTN of dual 150^0 ejector

The total pressure produced in the dual throat nozzle of single 150^0 ejector at 1.5 mach number at the ejector throat region is 555600 pa and the exit region is -32720 pa.

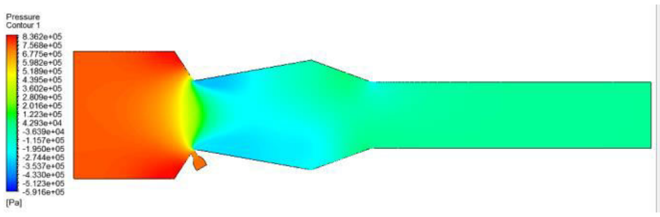

Fig 3.1.3: pressure contour of DTN of 120^0 single ejector

The total pressure produced in the dual throat nozzle of single 120^0 ejector at 1.5 mach number at the ejector throat region is 439500 pa and the exit region is -36390 pa.

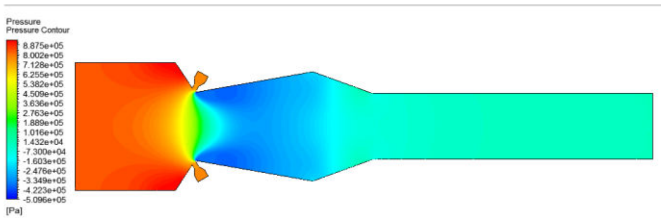

Fig 3.1.4 : pressure contour of DTN of dual 120^0 ejector

The total pressure produced in the dual throat nozzle of single 120^0 ejector at 1.5 mach number at the ejector throat region is 538500 pa and the exit region is -43000 pa.

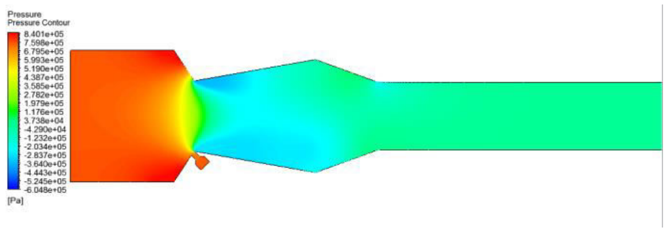

Fig 3.1.5: pressure contour of DTN of single 135^0 ejector

The total pressure produced in the dual throat nozzle of single 135^0 ejector at 1.5 mach number at the ejector throat region is 438700 pa and the exit region is -22900 pa.

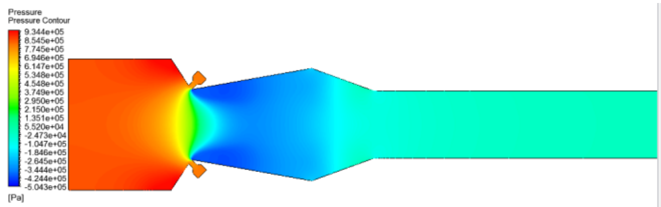

Fig 3.1.6 : pressure contour of DTN of dual 135^0 ejector

The total pressure produced in the dual throat nozzle of dual 135^0 ejector at 1.5 mach number at the ejector throat region is 534800 pa and the exit region is -24730 pa.

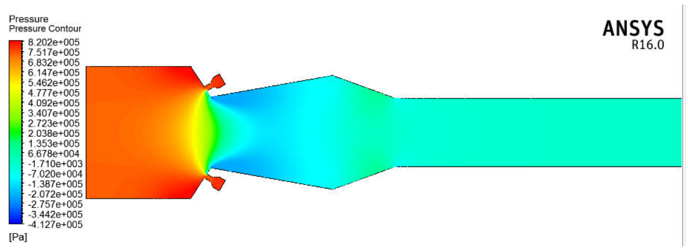

Fig 3.1.7: pressure contour of DTN of back offset of dual 150^0 ejector

The total pressure produced in the dual throat nozzle of of back offset in dual 150^0 ejector at 1.5 mach number is at the ejector throat region is 477700 pa and the exit region is -1710 pa.

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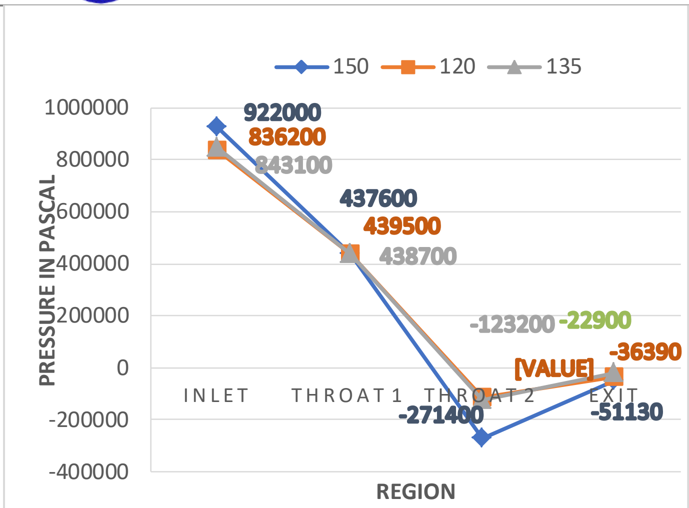

Fig 3.1.8: pressure contour comparsion of DTN with single ejector.

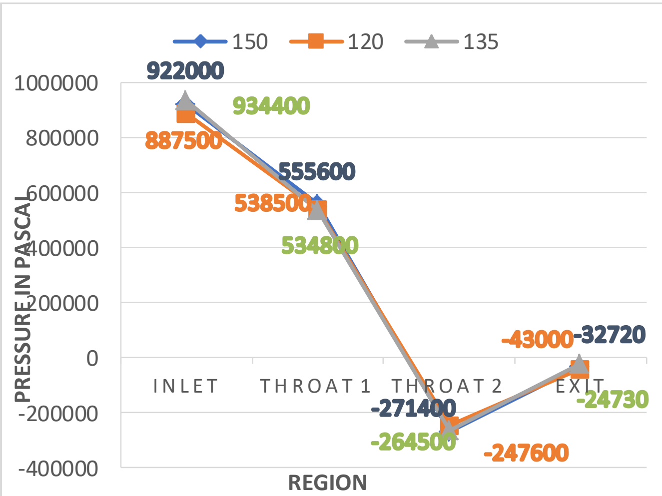

Fig 3.1.9: pressure contour comparsion of DTN with dual ejector.

The fig 3.1.8 and fig 3.1.9 shows the pressure contour comparison of the results for different angles (150^0, 120^0, 135^0) of ejector in the dual throat nozzle.

The pressure at the first throat region is high since the secondary airflow disturbs the primary airflow.The pressure at the throat region varies among the DTN's studied though the study parameters are same except the angle. The pressure does not vary in a high proportion but the concerned variation could behave in better manner than the other.

Unlike dual throat nozzle with single ejectors, there occurs difference in the nozzle with dual ejectors.

3.2 Velocity contour

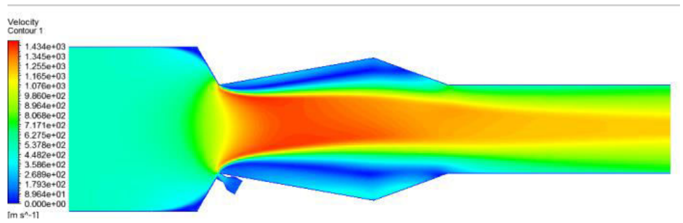

Fig 3.2.1: velocity contour of DTN of single 150^0 ejector

The velocity of the air coming out from the single 150^0 dual throat nozzle at ejector throat region is 1076 m\s and at the exit region is 1255 m/s.

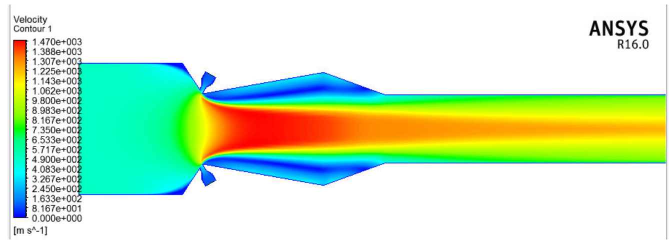

Fig 3.2.2: velocity contour of DTN of dual 150^0 ejector

The velocity of the air coming out from the double 150^0 dual throat nozzle at ejector throat region is 1076 m\s and at the exit region is 1185 m/s.

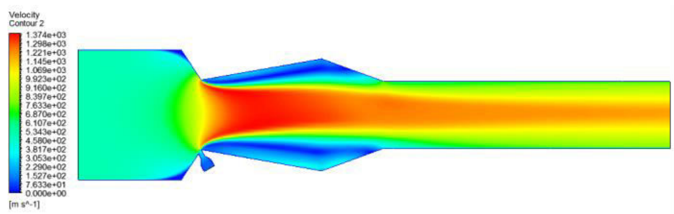

Fig 3.2.3: velocity contour of DTN of single 120^0 ejector

The velocity of the air coming out from the single 120^0 dual throat nozzle at ejector throat region is 1021 m\s and at the exit region is 1221 m/s.

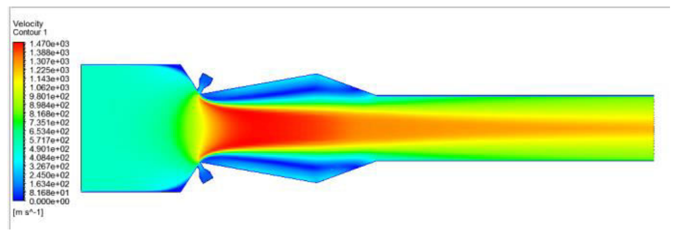

Fig 3.2.3: velocity contour of DTN of dual 120^0 ejector

The velocity of the air coming out from the double 120^0 dual throat nozzle at ejector throat region is 1102 m\s and at the exit region is 1225 m/s.

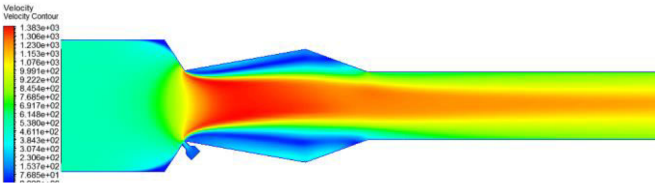

Fig 3.2.4: velocity contour of DTN of single 135^0 ejector

The velocity of the air coming out from the single 135^0 dual throat nozzle ejector throat region is 1056 m\s and at the exit region is 1153 m/s.

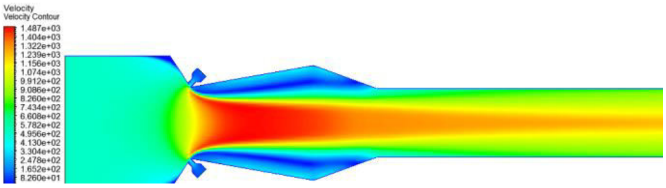

Fig 3.2.5: velocity contour of DTN of dual 135^0 ejector

The velocity of the air coming out from the double 135^0 dual throat nozzle ejector throat region is 1132 m\s and at the exit region is 1172 m/s.

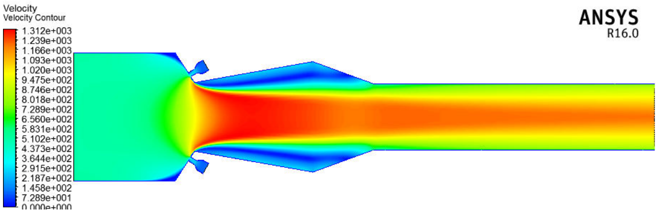

Fig 3.2.5: velocity contour of DTN of back offset of dual 150^0 ejector

The velocity of the air coming out from the double 135^0 dual throat nozzle ejector throat region is 947.5 m\s and at the exit region is 1166 m/s.

When the velocity contours are studied for the various angles and location of the secondary ejector in the dual throat nozzle, the variation among the different configuaration of the secondary ejectors are not huge but the concerned variation could help us the better among the others.

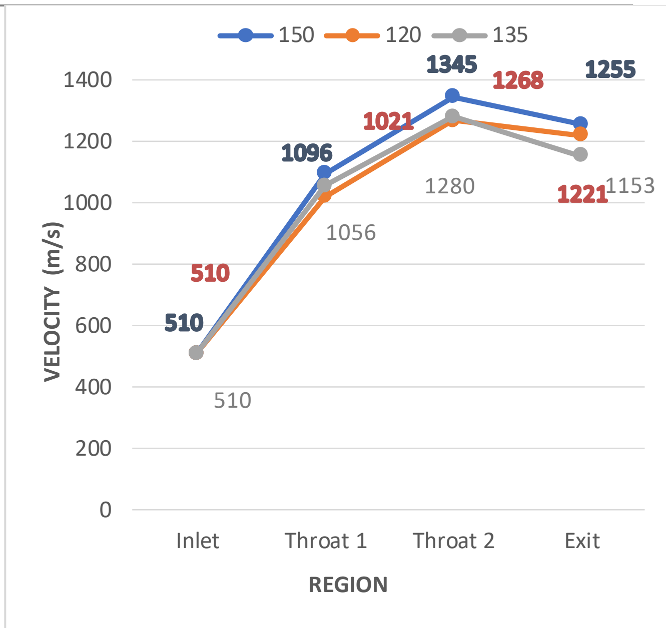

Fig 3.2.6: velocity contour comparsion of DTN with single ejector.

The fig 3.2.6 and fig 3.2.7 shows the velocity contour comparison of the results for different angles (150^0, 120^0, 135^0) of ejector in the dual throat nozzle

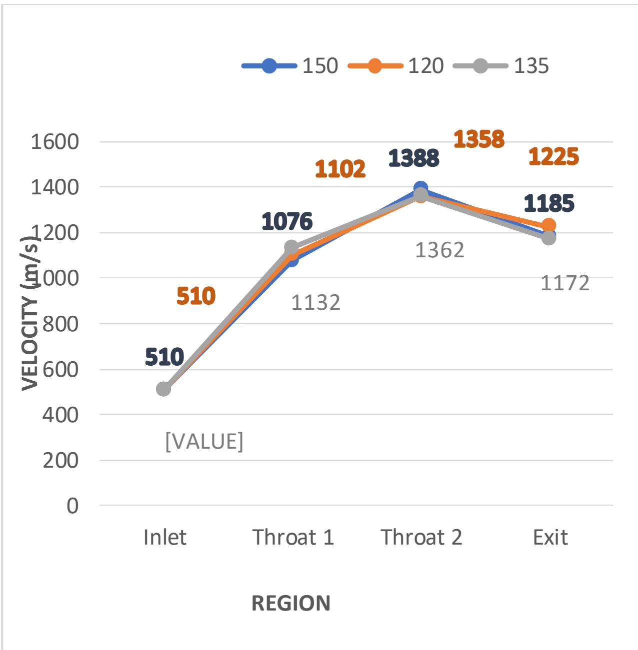

Fig 3.2.7: velocity contour comparsion of DTN with dual ejector

4. RESULT

Among the studied DTN's, the dual throat nozzle with single 150^{0} ejector has the least pressure value of 437600 pa at the throat region and -51130 pa at the exit. In the DTN with dual ejectors 120^{0} angled DTN has the least pressure value of 538500 pa and -43000 pa. At the throat region 120^{0} and 135^{0} has minute difference in the pressure. But at the exit 120^{0} has the least pressure value. Among the DTN with single ejectors, DTN with 150^{0} ejector was found to have the highest velocity of 1255 m/s among the others. In this DTN the velocity in the throat region was also found to be performing with high velocity of 1076 m/s among the others.Among the dual ejector DTN, the dual throat nozzle with dual 120^{0} ejector has been found to be performing with the highest velocity of 1255 m/s and 1102 m/s at the exit and the throat region respectively. Thus the design with high velocity can perform efficiently in terms of deflection of the thrust. The deflection of thrust which is nothing but the thrust vectoring can perform better in the pitch up and down condition of the aircraft.

5. REFERENCES

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