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Investigation of Dual Mode RJ Nozzle by Discrete transfer method

P.Gunasekar*, S.Manigandan, J.Devipriya, WSR.Saravanan
Department of Aeronautical, Sathyabama University, Chennai, Tamilnadu, India,
***Corresponding author: E-Mail:manisek87@gmail.com**

ABSTRACT

The Dual Mode Ramjet (DMRJ) nozzle has a wide application in Aerospace applications. DMRJ Nozzle designed to operate at high speed mode at different altitudes. The Performance of DMRJ nozzle is depending on the thermal behavior, when it is exposed to the real time conditions. This paper investigates the heat flux and thermal backdrop of the DMRJ nozzle at various Mach number and different temperatures. The time dependent, explicit discrete transfer scheme is applied to explore the accuracy of the results. The DMRJ nozzle designed as a solid model and analyzed based on Isothermal process computationally.

KEY WORDS: Dual mode ramjet, discrete transfer, Isothermal.

1. INTRODUCTION

The nozzle is the rear part of the engine. It is a work consuming device. The main function of the nozzle is to accelerate the flow with high velocity and less pressure loss. It also helps to operate the afterburner without any technical error. The second function is to operate thrust reversing and thrust vectoring. The nozzle divides the power available from the main burner exit gas between the requirement of turbine and jet power.

Dual mode ramjet is applied on combined cycle. The combined cycle means a turbine combined with a ramjet to enable combined with a ramjet to enable operation from static to hypersonic speed. It also called turbine based combined cycle (TBCC). The DMRJ nozzle can't operate of its own so we are using the jet engine which has ability to provide thrust using thrust ejectors up to mach 2. The DMRJ nozzle comes to picture when desired mach no achieved. Then the exhaust velocity is busted from 2 to 6 mach. This arrangement has a high advantage when compared to jet engine is that ramjet becomes one efficient at high mach numbers, because the energy degradation of turbine and compressor is eliminated. Simply saying ramjet mode at supersonic and turbojet at subsonic. The trust generated at ramjet mode by increasing mass flow rate through variable area inlet.

DMRJ NOZZLE Specifications: This nozzle combined between turbojet and ramjet nozzle. These two inlets are connected by a single outlet to provide energized thrust which creates the forward motion of object.

- The top inlet is Turbojet Engine (Subsonic velocity)
- The Inlet which is placed at down called as Ramjet Engine (Supersonic velocity)

Domain taken as to be shear stress transport. The turbulent flux of heat transfer on eddy diffusity taken as 0.9 to 1. The transitional turbulence is fully turbulent and we take Discrete transfer method for analysis.

Modes of Analysis: Three different types of analysis are done to describe how the exhaust velocity changes with ramjet and without ramjet nozzle. These results are compared each other.

Case1: Dual mode nozzle
Case2: Ramjet nozzle
Case3: Turbojet nozzle

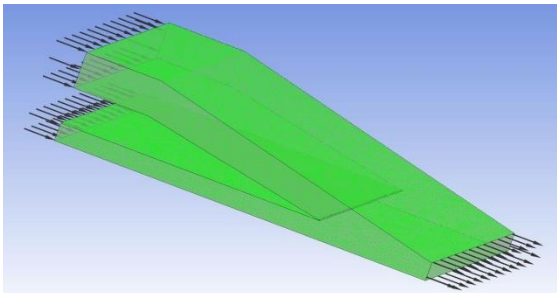


Figure.1. DMRJ Nozzle with Boundary Conditions

2. STUDY OF COMPUTATIONAL-CFX MODELS

There are several radiation and turbulence models to solve the problem with better interruption control and high order resolution, these are the turbulence model available for the analysis, we have opted for SST model since the problem involved supersonic flow field

1. Spalart–Allmaras (S–A)
2. k–ε (k–epsilon)
3. k–ω (k–omega)
4. SST (Menter's Shear Stress Transport)
5. Reynolds stress equation model

The discrete transfer method radiation model is chosen for the heat flux wall study among the four available models since the effectiveness of heat flux is high.

1. Rosseland
2. P1 tansfer
3. Discrete transfer
4. Monte carlo

3. RESULTS AND DISCCUSION

The Analyzed results are picturized with Figurer's and chart. The required taken from gradient.

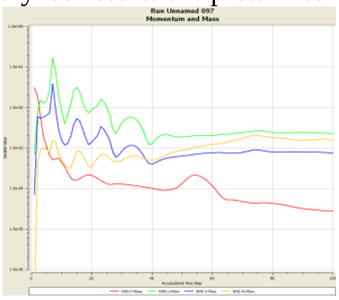


Figure.2.Turbojet Subsonic Index

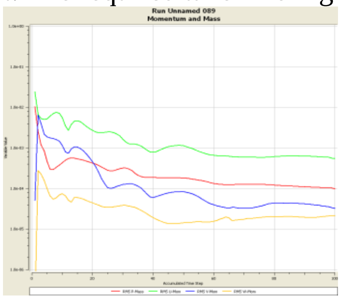


Figure.3.Ramjet Supersonic Index

Table.1. Total Pressure of Exhaust nozzle

Mode	Total Pressure (Pa)
Turbojet	$4.06x10^5$
Ramjet	$4.3x10^5$
DMRJ	$9.76x10^6$

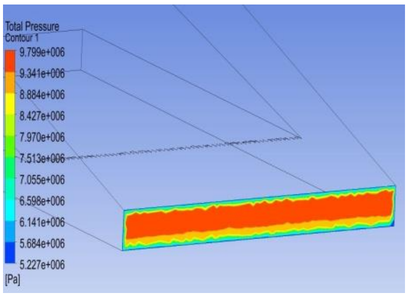


Figure.4. Total pressure at Dual mode

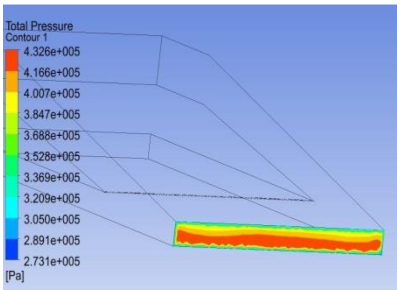


Figure.5. Total Pressure at Ramjet

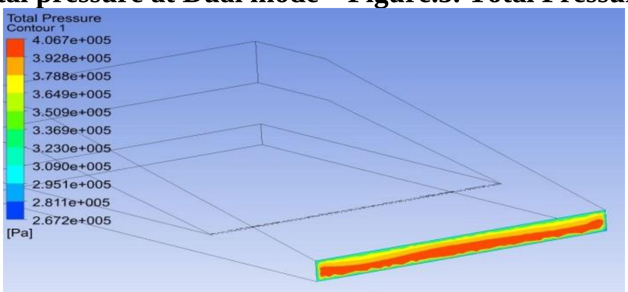


Figure.6. Total Pressure at Turbojet Engine

From this tatbulation it is evident that the DMRJ nozzle performs better than the ramjet and turbojet nozzle.

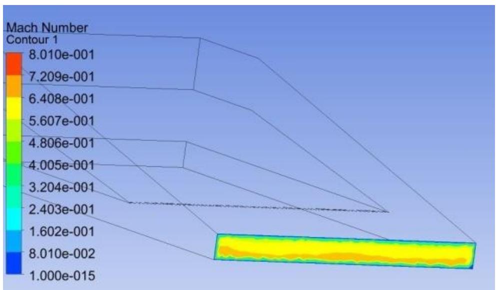


Figure.7. Mach number for Ramjet

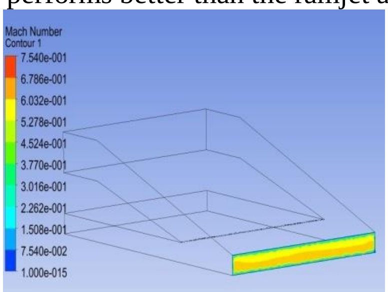


Figure.8. Mach number at Turbojet

Table.2. Total Pressure of Exhaust nozzle

Mode	Mach Number
Turbojet	7.54
Ramjet	8.01
DMRJ	9.76

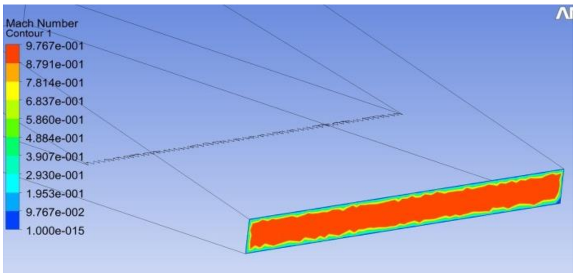
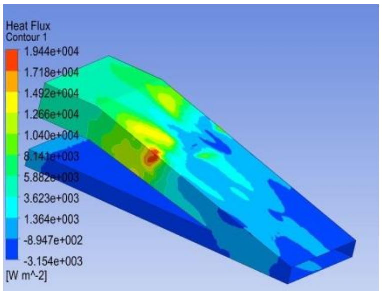


Figure.9.Mach at exit for Dual Mode

From this tabulation it is evident that the DMRJ nozzle has high velocity exhaust when compared to the ramjet and turbojet nozzle.



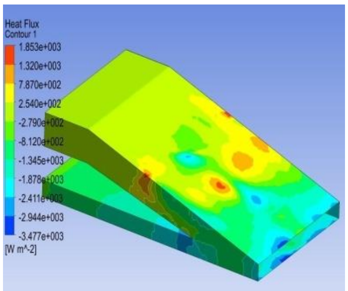


Figure.10.Heat Flux for Ramjet **Figure.11.Heat Flux at Turbojet**

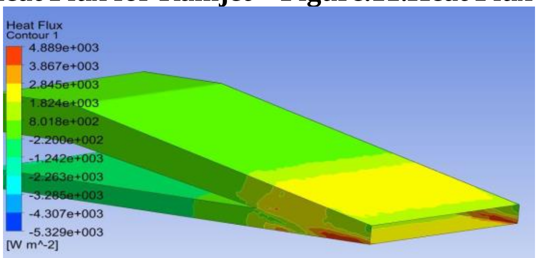


Figure.12.Heat Flux for Dual Mode Ramjet Nozzle

Table.3. Total Pressure of Exhaust nozzle

Mode	Heat Flux W/m2
Turbojet	1.835
Ramjet	1.944
DMRJ	4.88

From this tabulation it is evident that the DMRJ nozzle has high velocity exhaust when compared to the ramjet and turbojet nozzle.

4. CONCLUSION

From the analysis it is evident that the performance of the Dual mode ramjet engine has high efficiency when compared to the turbojet and ramjet nozzle. Thereby this nozzle can be applied to high speed applications. The Discrete transfer radiation model is applied in order to visualize the mode of heat flux in detailed manner. The tables and Figurers show that the Ramjet nozzle has performed better than turbojet in certain conditions of flight. We can conclude that in subsonic speed turbojet nozzle perform better, where else in supersonic stage the DMRJ and Ramjet nozzle performs well exceed. The modification can be done on design of DMRJ nozzle in order to enhance the performance of the engine. The mathematical modeling can be also done based on the results of this investigation.

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