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Determination of heat flux on dual bell nozzle by Monte carlo method

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ABSTRACT

Dual bell nozzle has a wide scope in the field of high speed engines. The dual bell nozzle well renounced for its operating conditions on both high and low altitude conditions by changing their area ratio. The distribution of heat is a major problem in high temperature operating nozzle. This paper investigates the heat flux gradient at different Mach number. This paper also discusses the complexity of solving heat flux problem on the dual bell nozzle computationally based on available radiation models and how they affect the performance of the engine exhaust. We have chosen two models for this sophisticated analysis Adiabatic and Monte Carlo. These two models are applied in preprocessing to derive the results on the dual bell nozzle. The results are tabulated to make detail study on the two radiation models and they compared with each other. In this analysis the flow is taken to be isentropic with the inlet subsonic and supersonic flow field. The Accuracy of the results are compared and discussed to elevate the performance of the nozzle. We can implement the Monte Carlo method in all kinds of thermal problems to derive the better results.

KEY WORDS: Dual bell nozzle, Adiabatic, Monte carlo method, Supersonic, subsonic

1. INTRODUCTION

The Dual bell nozzle is a combination of two bell nozzle. At lower altitude, the first bell starts its work; it allows the flow from it leaves at same area ratio without getting attached to second bell. Dual bell nozzle strongly depends on the type of contour nozzle extensions. The base of nozzle is designed as a parabolic else truncated for high sea level performance. The dual bell nozzle is designed by reverse method of characteristics. The objective of this study to find the best radiation model to solve the thermal problems and to derive the better optimized results.

Dual bell 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)

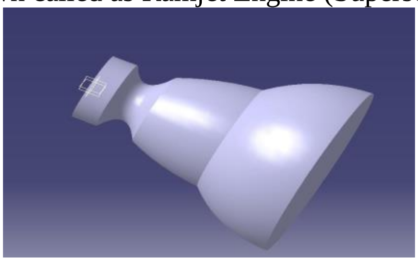

Fig.1. Dual Bell Nozzle

Domain taken as to be shear stress transport. The turbulent flux closure of heat transfer is eddy diffusity of 0.9. The transitional turbulence is fully turbulent and we take discrete transfer method for analysis. The boundary conditions are taken based on the fluid flow field.

2. 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: Subsonic Analysis (Monte Carlo Radiation Model)
- Case2: Supersonic Analysis (Monte Carlo Radiation Model)
- Case3: Subsonic Analysis
- Case4: Supersonic Analysis

3. RESULTS AND DISCUSSION

The Analysis has been done based on initial parameters with respect to desired boundary conditions. The boundary conditions of the model are taken based on the flow medium in the inlet and outlet. We assumed the wall is adiabatic type without slip.

Table.1. Radiation intensity of Dual Bell Nozzle

Radiation Model	RadiationIntensity (Wm^-2sr^-1)
Adiabatic Model	8.72×10^6
Monte Carlo	4.40×10^6

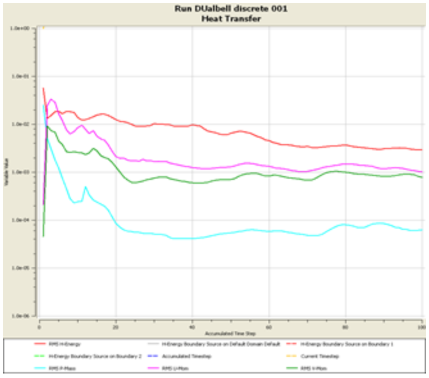

Fig.2. Dualbell Nozzle Discrete transfer

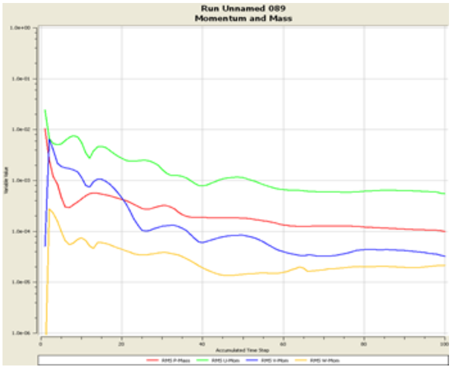

Fig.3. Dualbell Nozzle without radiation

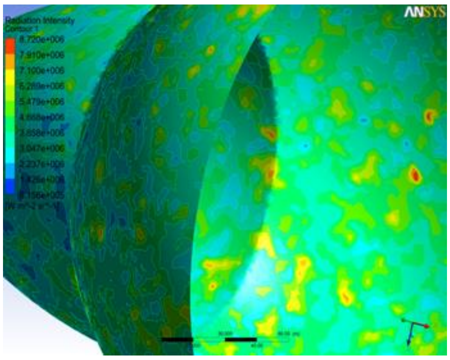

Fig.4. Radiation Intensity

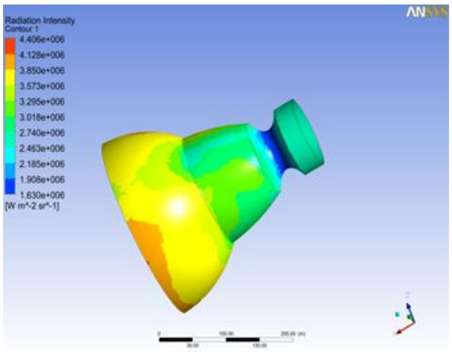

Fig.5. Radiation Intensity monte carlo model

From this tabulation we can understand the effect of radiation intensity on both the models. The Radiation intensity in monte carlo method provide the low intensity when comapred to the adiabatic model.This show the heat flux reflection and distribution is less in Monte carlo method when comapred to other type.

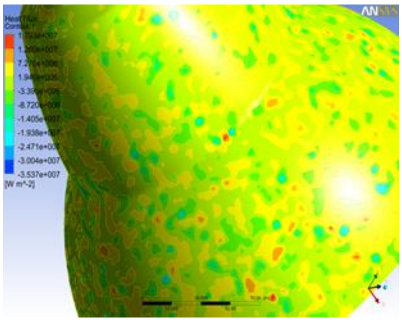

Fig.6. Heat flux

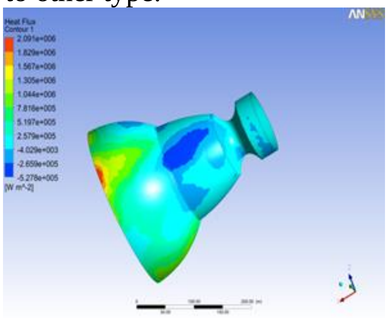

Fig.7. Heat flux at monte carlo model

Table.2. Radiation intensity of Dual Bell Nozzle

Radiation Model	Heat flux (W m^-2)
Adiabatic Model	1.72×10^{7}
Monte Carlo	2.09×10^{6}

From this tatbulation it is evident the heat flux distribution of the dual bell nozzle is low in monte carlo radiation model when comapred to adiabatic model.The heat energy transfer in Monte carlo is very good when they compared to other model. The performnace of the nozzle is increased based on the energy transfer.

Table.3. Pressure distribution of the nozzle

Radiation Model	Pressure (Pa)
Adiabatic Model	2.239×10^{6}
Monte Carlo	2.239×10^{6}

Table.4. Wall heat flux

Radiation Model	Wall Heat flux (W m^-2)
Adiabatic Model	1.739×10^{7}
Monte Carlo	2.091×10^{6}

From this tatbulation it is evident wall heat flux in the adiabatic model is less when compared to the monte carlo method. The results are better in monte carlo radation model which lead us for better understanding of the distribution and transfer of heat in boundary.

Table.5. Temperature distribution in the wall

Radiation Model	Temperature (Kelvin)
Adiabatic Model	3986
Monte Carlo	5235

The temperature contour of the dual bell nozzle is plotted from the results. The temperature difference between the both methods adiabatic and montecarlo is around 1300k. The Monte Carlo provide better result when compared to adiabatic and P1 transfer methods.

4. CONCLUSION

From the tables and Figures it is understood that the performance of the dual bell nozzle depends on the pressure and heat flux generated around the surface. The Monte Carlo radiation model shows the better results when compared to the adiabatic model. The heat flux and the radiation values are less in Monte carol method when compared to the other radiation model. The pressure values remains constant in all case of models since it depend on the environment temperature. To the conclusion we state that the Monte Carlo radiation model if we want to solve the thermal problems to provide the better results on heat flux.

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