

# Chapter 13

## Study of Drag Reduction on a Hypersonic Vehicle Using Aerospike

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### ABSTRACT

*Humans longing to fly higher and quicker have prompted the improvement of hypersonic vehicles. Typically, hypersonic streams are described by high temperature fields and a thin layer of shock close to the object wall or the body surface. To ease the reduction of thermal loads, a blunt nose is forced in a hypersonic vehicle which is more imperative. In any case, increase in the wave drag is one of the quick outcomes of a constrained bluntness. Consequently, investigation in the hypersonic field is constantly fixated on the wave drag decrease. The flow features around the blunt body get changed because of the attachment of spike in front of the vehicle. This chapter aims to give a detailed review of a hypersonic vehicle that involves an aerospike design in front of the blunt body, which tends to reduce the drag at the forebody. Views of various researchers are investigated, and efforts are taken to summarize the reported results on how the drag has been reduced using aerospike technique.*

### INTRODUCTION

The speed of an aircraft is usually denoted in Mach Number,  $M$ . Based on the speed regime the aircraft can be classified into different types (i)  $0 < M < 0.8$  subsonic, (ii)  $0.8 < M < 1.2$  transonic, (iii)  $1.2 < M < 4$  supersonic, (iv)  $M \geq 5$  hypersonic. If  $M = 1$  it is called as sonic condition. In hypersonic flows, the

DOI: 10.4018/978-1-6684-4230-2.ch013

flow velocity is much greater than the sound velocity, which is the velocity of propagation of small disturbances. Hypersonic vehicles in general fly at higher altitudes where the density and Reynolds numbers are considered to be low and where the boundary layer formation is found to be thick. Reducing the drag and aerodynamic heating are the two main factors in critically designing a hypersonic vehicle. Reducing the drag in the hypersonic vehicle is necessary as it helps in saving the fuel, extending the range, simplifying the propulsion unit and increasing the payload to take-off the gross weight ratio. A hypersonic vehicle creates a bow shock in front of the blunt body which leads to a higher surface pressure load and aerodynamic drag. This surface pressure can be reduced if the conical shock wave is created rather than a bow shock wave. This can be achieved by using a spike in front of the blunt body. This chapter aims to review various papers related on drag reduction techniques by using aerospike passive method. The objects moving at high speed experience forces that will in general tend to slow objects down. This confrontation withinside the considered volume is named such as a drag that is a solitary significant concern throughout the time of planning in designing a high speed vehicle. Hypersonic vehicles are those that travel at Mach above 5. Usually, missiles, rockets, reentry vehicles travel at hypersonic speed. It is often planned to reduce surface heat flux by designing hypersonic space vehicles with blunt noses. By any means, this detached shock increases the wave drag, making space flights more expensive. Thus, the spaceship configuration should consider the best balance between wave drag and surface heat flux. Subsequently, in the future, there will be more development and improvement of the hypersonic drag reduction technique as it becomes a significant research area within the hypersonic field. A number of strategies have been put forth in this area.

The streamlined aerodynamic layout of hypersonic vehicles must be completed considering the intricacies associated with the hypersonic flow. Typically, hypersonic flows are described by high temperature field and a thin layer of shock close to the object wall or the body surface. Such shock and viscous dissemination came about raised temperature close to the space vehicle surface which led to inordinate warming of vehicles flying at speeds above Mach 5, which are considered as hypersonic speed regimes.

The nose area of a space vehicle which is considered as the most serious place of space vehicle that undergoes most noteworthy heat flux, blunt nosed plan of the equivalent design has been recognized as a powerful strategy to drive the shock layer away from the body, to lessen the surface heat flux. (John D Anderson, 1989). In the meantime, the aerodynamic heating appearing in the spot of stagnation changes conversely which is equal to the blunt nose radius root, possessing a huge blunt nose area is worthwhile all things considered. Besides this design measure improves the drag reduction. For space missions increase in drag makes higher fuel utilization and lesser payload limit. In this manner, the expense of space missions increments radically. Along these lines, the decrease of wave drag has stayed as a significant field of exploration in the field of hypersonics. Wave drag is triggered by the development of shock waves around the vehicle in supersonic flight and hypersonic flight. Also, to reduce fuel usage and to expand the payload limit of the space vehicle, decreased heat load or lower drag is required for a hypersonic flight or mission.

To ease the reduction of thermal loads, a blunt nose is forced in a hypersonic vehicle which is more imperative. In any case, improving the wave drag is a quick outcome of constrained blunt body. Consequently, investigation in hypersonic field is constantly fixated on the wave drag reduction. In order for hypersonic vehicles to succeed, reducing drag is a vital component. Extreme aerodynamic heating and aerodynamic forces are imposed at the blunt-nosed surface, owed to the drastic bow shock to be found at the forefront of the nose when a vehicle travels at hypersonic speed.

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