CHAPTER 3

MOTIVATION AND OBJECTIVES OF RESEARCH

With the retirement of the conventional space shuttles, stationed for manned space travel for carrying out missions, and interest in space tourism and commercial high-speed intercontinental transportation system, a new dimension of the space age has opened its doors, motivating scientists and researchers to investigate newer designs for ensuring economic, safe and reliable means of faster travel. To safeguard the inner load carrying structure without any significant increase in the overall weight, a lifting-body configuration needs to be obtained by compromising the design favorable for aerodynamic forces and alleviation of aerodynamic heat loads.

Amidst a variety of design requirements, the reducing the aerodynamic heating as well as the aerodynamic drag is a major challenge for the design of hypersonic flight vehicles. For the escape of missiles from the atmosphere, the drag on the body should be reduced whereas during the descent the aerodynamic heating should be reduced. The aerodynamic drag shows substantial effects in the performance of the vehicle, owing to the bow shock formation, which results in a high pressure region at the nose of the blunt body. Lowering the aerodynamic drag on these vehicles ensures the desired range and also economizes the fuel usage. The aerospike substantially reduces forebody drag by creating a low dynamic pressure region of separated flow over the high volume nose fairing. From the cited compendium of literatures, it is found that the most of the research are oriented towards the flow around spike in last decade to substantiate the drag reduction and heat control over the hypersonic blunt body. In this line, another excellent configuration for above cause is introduced in form of aerodisk. It is a long, slender rod protruding from the flow stagnation region of a blunt body. It is carries a spike tip of varying shapes in form of disk like structure. The shape, position and number of aerodisk vary as per the configuration of blunt structure. The concept is carried forward on formation of bow shock with a series of weak conical waves and flow separation over the flying body, which in consequence reduces the net effects of drag produced by the body and surface heat transfer.

Further to investigate the above motivation, the position, number and size of the aerodisk are changed to find out the comparative values and sizable mitigation of heat effect and drag. Though the flow over the spike occurs through strong shock which detached and reattached to surface and separation of flow by shear layer, it is mere necessary to accurately predict numerically the features of flow over an aerodisk. As such, the hypersonic flow over aerodisk may be a benchmark problem on numerical simulation of compressible and turbulent flows. Apart from numerical validation, the comprehensive study of compressible flow around the aerodisk may be a benchmark on discovering a suitable device for aerodynamic drag reduction and heat neutralization phenomena. In this panorama, a methodological simulation for aerodisk on various conditions may be benchmark for future development of hypersonic vehicles.

In addition to a wide-ranging parametric space of geometry which is yet to be explored viz. position, shape, size and numbers, an affluence of related topics awaits analysis on drag reduction, surface heat conditions. All these analysis must be subject to the examination of the community in order to build a high fidelity database that may serve as reference to future studies and accommodation in design of hypersonic vehicle. On account to above motivation, the study focused on the areas like fundamental configurations of reusable vehicle, capable of travelling at higher speeds. In addition to an extensive parametric space of geometries that have not been fully explored for example varying the radius of the aerodisk, deploying multiple disks, varying intermediate position, an affluence of related topics awaits analysis. Because aerospikes are likely to re-surface for a particular class of future missile designs, it is important to understand their aerothermal performance and their effect on the aerothermodynamics of the carrying vehicle. Additional analysis must be subject to the scrutiny of the community in order to build a high-fidelity database that may serve as reference to future studies.

Most research focuses on the effect of *l/D* ratio of the aerospikes and only few papers reports the effect of aerodisk shape and size on the aerodynamic drag and aerodynamic heating of a blunt body. Investigations have shown that certain length and tip design the aerospike can reduce aerodynamic heating to some extent. However most researches are done with laminar assumptions or tested under laminar conditions. Some researches with turbulence considerations have reported detrimental reattachment heat fluxes and increased heat transfer rates to the main body. Aerospikes and aerodisks of certain length make the flow unstable and pulsating which is highly undesirable. The multi row disks or aerospikes with stabilizers or multidisk aerospikes can make the flow stable. However, very less work has been done for 2-disk or multiple disk aerospikes for reduction in drag and aerodynamic heating.

Keeping in view the above motivation an exhaustive investigation is warranted. In this respect the objectives of the current research can be listed as follows.

a. To analyze the flow structure and shock-shock interactions around blunt body with two and three disk aerospikes at a hypersonic speed.
b. To study the effect of two and three disk aerospikes of varying length, sizes, shapes and relative positions on the spike length on the aerodynamic drag of a blunt body at a hypersonic Mach number.
c. To study the effect of two and three disk aerospikes of varying length, sizes, shapes and relative positions on the spike length on the peak reattachment heat fluxes and the total heat transfer rates to the main body.