NASA - Langley

PARACHUTE PERFORMANCE AT SUPERSONIC SPEEDS

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The recovery of high speed vehicles created a new requirement in recovery operations, decelerators have to perform at very high altitudes and supersonic speeds. Although the requirements have changed, the basic considerations in the selections of drag devices essentially remain the same for the supersonic speed range as they were for subsonic. The following slide shows these basic requirements, they are:

Slide I

Based on these requirements, conventional parachutes appear to be well suited for this job, in view of the fact that they have been proven to be highly reliable in subsonic operations. They have an apparent weight advantage over other nonlifting types of decelerators and we were more familiar with parachutes than any other drag devices. For these reasons, they were a natural choice for supersonic speed range. However, tests at supersonic speeds revealed some problem areas of parachute performance. The three major problem areas are:

Slide II

We were primarily concerned with the first two of these problem areas at supersonic speeds, which we will consider at this time. The third one can be anticipated in the future.

Slide III

The experimental results of flexible ribbon-type parachutes indicate two major areas of parachute instability: oscillatory motion of the parachute about the point of attachment and shock pattern fluctuations accompanied by a violent canopy breathing along with reduced inflation and drag characteristics. The latter which is referred to as inflation instability has been the subject of considerable investigation. The basic problems involved in the inflation instability are high rates at which the shock is alternately swallowed and expelled (somewhat analogous to the inlet buzz phenomenon) and the interaction between the boundary layer on the individual shroud lines and the shock wave in front of the parachute canopy. This type of instability causes large variations in drag with frequencies exceeding 100 cps.

Slide IV

The next slide shows some parachutes employed in supersonic speeds. The bottom one is a typical ribbon parachute used in most of the investigations. Various means have been tried with this type of parachute to eliminate inflation instability such as varying porosity, varying number of shroud lines, extending the skirt, attaching an inflated tube to the skirt and others, but only limited success was achieved by these means. It was evident by now that the best we can hope for, in light of the fact that the fluctuations in shock pattern exist even for the rigid parachute models in the free stream as far as shock fluctutations are concerned, is to reduce their influence on the breathing of a parachute. I believe this has been achieved to a large degree with the parachute designed by Cook Research Laboratory, under an Air Force contract. These parachutes are radically different from most parachute designs. Their main features being low porosity conical inlet canopies and high porosity flat roofs. Both of these designs have performed satisfactorily in the Mach number range of 2.30 to 4.65. A high speed schlieren movies showing stability of these parachutes will be shown later.

Slide V

As far as the drag of parachutes is concerned, we would like to have a drag coefficient of 0.5 or better for parachutes at supersonic speeds. The next slide shows a drag level for various drag devices. Here the drag coefficient is plotted versus Mach number at ten base diameters downstream for parachutes and rigid types of drag devices. Drag coefficient for most ribbon type parachutes falls in this region. The conical inlet canopy has improved the drag coefficient of parachutes as shown in this slide. Even though considerable improvement in drag coefficient and stability was achieved with the conical inlet parachutes, the variations in drag still existed, though to a lesser degree than with ribbon type parachutes. Due to the problem areas encountered with parachutes operations at supersonic speeds, other drag devices were being developed concurrently and a comparison in drag coefficient between them and parachutes is made in this slide. It can be seen that the drag coefficient of parachutes can be exceeded by a factor of two to three by some rigid type decelerators. Thus there is a wide margin of drag coefficient that can be used as a tradeoff for weight. Rigid and inflatable types of decelerators will be discussed in more detail in the following paper.

In this investigation, no effort was made to establish regions of optimum performance; however, from visual observations of these and other tests and from high speed schlieren movies, it was evident that the performance of the parachutes was wake-dependent. A wake study for various bodies to about 15 base diameters downstream of the vehicle would be most helpful in analyzing and possibly explaining the variation instability and, at some Mach numbers, decrease in drag coefficient with increase in trailing distance. I think our biggest problem in the development of stable parachutes for the supersonic speed range has been the lack of adequate theory to guide the investigations. Consequently, most of the work has been done on a trial and error basis.

The wind tunnels are well suited for the research of decelerators because the parametric study under a wide variety of test conditions can be easily simulated. However, after a workable design has been evolved in the wind-tunnel testing, this should be augmented by free flight tests to check out the system under the actual test conditions. Free flight tests are being considered to check out parachutes that had satisfactory performance in the wind-tunnel tests.

NONCONVENTIONAL PARACHUTES

Some exploratory work has been performed on the nonconventional type parachutes in the wind tunnel at supersonic speeds. These are parachutes with high rotational speeds, typical representation of which are vortex ring parachute and rotafoil. Both of the above mentioned models were tested at supersonic speeds, but they failed before any significant drag measurements could be obtained. However, a visual check of drag indicator before failure occurred showed high drag values in some cases. Further research along these lines would be warranted.

High speed movies that were obtained in a few seconds of their operation will be presented at this time along with schlieren movies of the previously discussed parachute models.

BASIC CONSIDERATIONS IN SELECTION OF DECELERATOR DEVICES

1. Good stability
2. Effectiveness in producing drag
3. Minimum bulk and weight
4. Stowage or packageability
5. Capability of withstanding high temperature

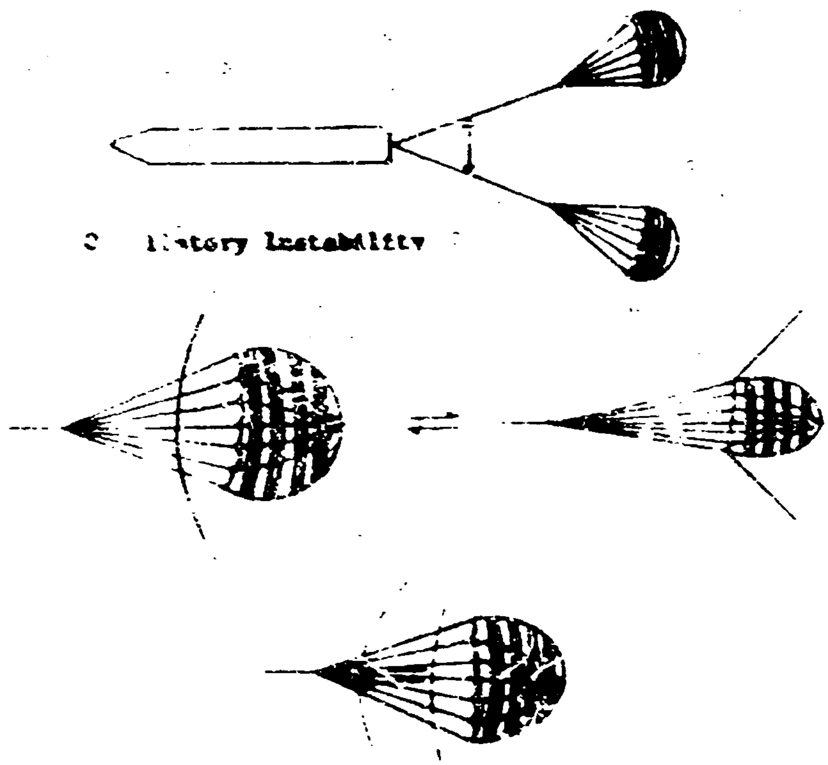
PROBLEM AREAS FOR PARACHUTES AT SUPERSONIC SPEEDS

1. Stability

2. Drag

3. Aerodynamic heating

TWO MAJOR TYPES OF PARACHUTE INSTABILITY AT SUPERSONIC SPEEDS



Inflationary Instability

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