As shown in Fig. 3, the designed airfoil inclined 2 deg as specified in the target pressure distribution.

Conclusions

In this investigation, Takanashi's inverse design method is extended to supersonic airfoil design. Numerical results show that the present inverse code can be used to change not only geometries but also the angle of attack of airfoils. The extension to three dimensions is straightforward because the present formulation is derived in the three-dimensional form.

When using the inverse method as a design tool, designers must translate their design criteria of supersonic wings into target pressure distributions. The determination of optimal target pressure distributions will be studied in the future.

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New Technique for Preventing Payload-Airbag Overtipping

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Nomenclature

F = retarding force, N
F_m = maximum retarding force, N
h = stroke, m
h_e = height of airbag, m

Introduction

AIRBAGS have increased in popularity for the impact attenuation of target, reconnaissance drones, and training missiles, as well as for the landing of aircrew escape modules.[1] The airbag technique has many advantages such as high energy absorption capability and good adaptability to landing surface conditions. Because of the existence of the airbags, however, the c.g. of the recovery system will be raised, which leads to low stability and more chance of tipover. The stability of airbags in windy landings or when suspended from an oscillating parachute is a problem. For example, the encapsulated seat bags used on the B-70 were unsatisfactory in a side-wind landing because of the poor relationships between the bag diameter and the vehicle. To improve stability, two sausage-shaped airbags were used on the Matador/Mace,[1,2] whereas several bags were mounted on the F-111 and B-1 crew modules.[1] These airbags have pressure-relief valves. In some cases, gas-relief valves are not considered. An example of this application is in the Pathfinder mission, where the spherical airbags were designed to protect the lander from impacting with the Martian surface.[3]

In this work a new multicompartment structure design technique that prevents the payload-airbag recovery system from tipover is presented. The airbag with a constant venting area, divided into several compartments by internal membranes with several linking holes, is distinguished in function from the dual-compartment structure bags used on the BQM-34V.[1] By controlling the gas flowing rate to get different stiffnesses in different parts of the bag at ground contact, the payload can drop steadily on the bags. Using a special internally designed structure, the present bags can provide better protection than the single-compartment bag.[2,4] Experiments on the simulated model–airbag system show that the new technique is effective in stopping the payload from tipover.

Multicompartment Airbag

For the purpose of increasing the landing stability and preventing a payload–airbag system tipover, several compartments are considered in the internal structure of the airbag. The number of compartments depends on the attenuation requirement. Two kinds of airbags were designed for the simulated missile and capsule, respectively.

Consider that the recovery payload is a training missile and that the airbag has a cube-like form divided into three compartments connected to each other by the linking holes at the membranes. The sketch of the missile–airbag system is shown in Fig. 1a. At a predetermined level, pressure-relief valves open and allow the gas of the center compartment to escape. At the same time, the gas of the two side compartments passes the holes into the center part and then flows out. The flowing rate depends mostly on the linking hole's dimension, and so by adjusting the hole's dimension, the side parts have a greater stiffness than the center part. Support from the side parts restrains the missile on the center of the bags, and tipover is avoided. Another kind of airbag is used for the landing attenuation of a conic capsule (Fig. 1b). It has a circular shape and is divided into two compartments by means of a cylindrical membrane with several linking holes. During the landing impact, the open orifices allow the gas of the inner compartment to blow out and the gas of the outer compartment then flows out of the airbag. This results in a higher instantaneous stiffness in the outer compartment than that in the inner one, which contributes notably to the stability of the landing capsule.

Experiments and Results

The cube- and circular-formed airbags used for the simulated missile and capsule were investigated, respectively. Because of the siender characteristic of the missile, a cluster of bags consisting of two cube-shaped and two cylindrical bags were fabricated. The

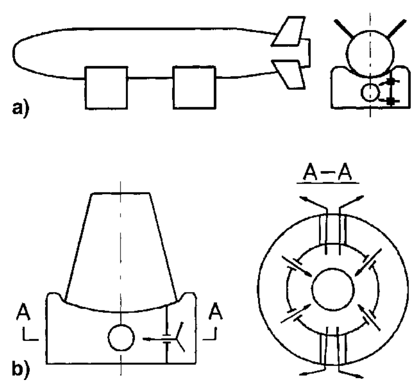

Fig. 1 Sketch of payload–airbag systems.

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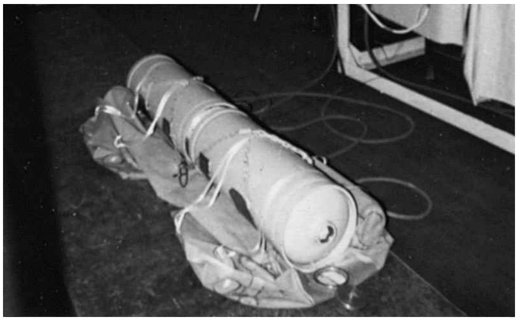

Fig. 2 Typical model–airbag system at the end of the drop test.

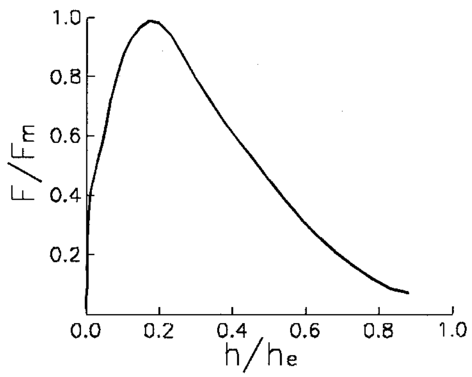

Fig. 3 Relationship between the retarding force and stroke.

cylindrical bags were not used for dissipating the impact energy, but instead were used for combining the two cube bags. Shear pin-type vents were applied to release gas to avoid rebounding at ground impact. The vent area was calculated with the method presented by Idomir.[2] The parameters of the circular-shaped bag were determined by the same procedure.

A photoelectron-quick-release and cable-suspension system suitable for an indoor test was used. With this equipment, the vertical- and horizontal-velocity components could be obtained. Accelerometers were glued near the model's c.g. to measure the vertical and horizontal acceleration. To monitor the dynamic pressure during impact, a pressure sensor was installed in the airbag. Test data were recorded on the oscillometer and processed by a computer.

In the case of vertical drops in various initial yaw or/and roll conditions, it is shown that the multicompartment airbag can provide better attenuation. A slight tipover occurs only under the poorest test conditions, 19-deg roll and 16-deg yaw. When the horizontal velocity component is in a given range. (<2 m/s, limited by the room size), the payloads drop steadily. The range is related to the width of bag and the height of the payload. Figure 2 shows a photograph of the typical model–airbag system at the end of the drop test.

The dynamic properties of the bags are also studied systematically. It is found that several factors affect the impact deceleration. Among these factors, the drop velocity and initial pressure have significant effects on the peak deceleration. Experiments indicate that the retarding force-stroke curve (Fig. 3), is different from the curve presented by Knache.[1]

Conclusions

A multicompartment structural airbag for preventing the payload–airbag system from tipover has been designed. Drop tests show that when the horizontal velocity component is in a given range, the new technique is very effective.

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Application of the Subsonic Doublet Lattice Method to Delta Wings

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Nomenclature

C_l = lift coefficient of wing
C_m = pitching moment coefficient about wing root midchord
C_p = pressure coefficient difference across wing
k_r = reduced frequency based on mean wing semichord
M = Mach number
n = number of boxes on wing

Introduction

THE subsonic doublet lattice method (DLM)[1–3] is commonly used for the calculation of unsteady airloads on aircraft. This method can be regarded as an extension of the vortex lattice method (VLM) that is widely used for steady load calculation. In both of these methods a lifting surface is divided into a number of smaller panels or boxes. A lifting line and a collocation point is associated with each box. The lift force acting on each box is assumed to act at the lifting line, whereas the boundary condition of tangential velocity is enforced at the collocation point. The lifting line is located along the box quarter-chord and the collocation point at the spanwise center of the box at three-quarter-chord. Downwash factors are calculated for each lifting line/collocation point combination. The set of lift forces that satisfy the boundary condition at all of the collocation points is solved from a set of linear equations.

The downwash factors in the DLM are calculated as the sum of a steady component, identical to that of the VLM, and an unsteady component. Whereas the steady component is exact, the unsteady component is approximated. The error introduced by the approximation increases as the box aspect ratio, i.e., the ratio of the box span to the box chord, is increased. Upper limits to the box aspect ratio have consequently been suggested to ensure acceptably accurate results.[3]

It is not difficult to panel wings with moderate taper ratios so that the box aspect ratio is fairly constant over the wing. Delta wings are different in this respect because the aspect ratio of the boxes in the outboard spanwise strip depends only on the number of chordwise divisions and the wing leading-edge sweep angle. If sufficient chordwise boxes are used to satisfy the convergence criteria with respect to the maximum box chord at the wing root, excessive box aspect ratios usually occur at the wing tip. It has been suggested[4] that the DLM totally breaks down for root-to-tip paneling schemes of delta wings. Delta wings are often divided into a number of spanwise sections with different numbers of chordwise divisions, as illustrated in Fig. 1. In the case of large models, this practice has the advantage of reducing the number of boxes in the model, and consequently, the computational effort required for a solution. In

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