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THE CHINESE FIRST PROPOSED INVERTED REUSE SCHEME FOR A LAUNCHER'S FIRST-STAGE USING PARACHUTES BASED ON LANDING TOPOGRAPHY AND TAIL RUDDER CONTROL SYSTEM

Abstract

The only commercial reusable launch system in use is the SpaceX's Falcon 9 rocket, with its first stage reusable and the second expandable. It adopts a vertical landing scheme which involves multiple engine starts and large-scale thrust change techniques, as well as an extra landing supporting system. For adoption of such scheme, most of the existing launch vehicles need tremendous works for rocket redesign.

In this paper, a launcher's first stage inverted recovery scheme with parachutes is presented for the first time in China. A model was then built up based on the scheme for rocket structural strength analysis, control simulation, trajectory calculation and optimization. The landing process was then tested, providing further insights for landing sites construction. The result shows that such scheme can be easily adopted by the existing liquid-propellant engine and rockets, without massive works for redesign.

The inversion of the first stage is achieved by nitrogen attitude control system after stage separation. Parachute release at the bottom of the rocket engine provides the necessary velocity reduction for rocket return while the tail rudders are used for landing steering control. The precise adjustment of the rocket at the end of landing process utilizes the attitude control system. The implant rods on the first stage provides the final deceleration and landing support. For a successful first stage recovery, the rocket needs to be landed in the Gobi Desert adjoining the highway in west of China. A 10,000m2 fine sandy land is suggested to prepare in advance as the landing site in the mountains.

The calculation indicates that for a first stage which is around10t dry mass, the landing scheme can achieve successful first-stage reused with a 1.5t mass increase and a capacity loss ranging from 5percent to 20percent. Rocket engine can be also preserved during possible landing failure, with only the tank damage. This scheme can create significant cost reduction and an available reusable method for the major currently in-service launch vehicles.