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MARS ENTRY PARACHUTE DESCENT PHASE MODELING AND SIMULATION

Abstract

As we know, Mars Entry, Descent and Landing (EDL) is the stage of great technology challenge and failure rate in a Mars exploration mission, which is always called black seven minutes. Capsule enters the atmosphere of Mars at a speed of 5km/s, suffers atmospheric entry phase, parachute descent phase, powered descent phase and eventually lands on the surface of Mars. Parachute descent phase is one of the most important phase during EDL. In parachute descent phase, the speed of capsule needs to be reduced from 2Ma to the speed and height required by the initial condition of powered descent phase. What's more, a series of complex technological operations will be done in this phase, such as heatshield separation, radar initiation, backshell separation, etc.

The previous Mars exploration missions all took parachute deceleration system as a vital part of a mission. A lot of tests had been conducted to qualify the performance of the Viking decelerator system, such as wind-tunnel tests, Low Altitude Drop Tests (LADT), Balloon Launched Decelerator Tests (BLDT). A six-degree-of-freedom model was established to verify the validity of the parachute model. The following missions had reconstructed the returned flight data which matches well with the pre-flight performance data. For the design, development, and operation of the EDL system, an end-to-end simulation was created using the Program to Optimize Simulated Trajectories II (POST II). The EDL simulation was successful in predicting the capsule dynamics within reasonable bounds.

In this paper, a six-degree-of-freedom rigid-flexible coupled multi-body dynamic model is established firstly. This model includes planet model, atmospheric model, rigid models and aerodynamic models for capsule, parachute, heatshield and backshell, six-degree translational and rotational dynamics models. In the secondly place, the translational and rotational movement law of capsule and parachute ensemble are analyzed. The spiral movement law and trajectory is also given. Lastly, the statistics of total parachute force, single bridle force and capsule dynamics is given, which provide support for the design of parachute and capsule structure.