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APPLICATION OF TELESCOPIC GEAR TO LUNAR/PLANETARY EXPLORATION SPACECRAFT WITH BASE-EXTENSION SEPARATION MECHANISM

Abstract

For further lunar/planetary explorations, soft landing methods are required in order for a lander to land on any terrain. But previous landing methods have drawbacks such as high rebound and excessive resource consumption. As a solution, the authors proposed a novel landing mechanism called BESM (Base-Extension Separation Mechanism). The BESM realizes soft landing focusing on energy conversion with springs and three separable units (lander, extension and gear). The gear unit touches ground antecedently to the lander. The lander's energy is absorbed by the spring mounted on the gear, then the lander is released at small height with less energy. Its rebound and acceleration suppression performance was demonstrated in the previous works; its reusable mechanism also contributes to resource saving. However, the BESM has issues: (i) Its soft landing performance is not assured when it lands on uneven grounds; the energy is not ideally absorbed by the spring with the inclined gear. (ii) Its performance is sensitive to spring parameter tuning. The improperly tuned BESM releases the lander at large height; accurate parameter tunings are required for performance assurance. For these issues, this paper proposes a fundamental solution using telescopic gear. The telescopic gear is composed of movable gear units and stopper units; the motion of the movable gear units are controllable by stopper units. When it is mounted to appropriate positions with the ideal stopper control, the telescopic gear can fundamentally solve the BESM's issues; it flexibly compensates the gear inclination and the release height error caused by uneven ground and/or improper parameter tunings. As an analytical confirmation of the effectiveness of the telescopic gear, this paper analyzes its soft landing performance with uneven ground and/or improperly tuned parameters by simulations. The modeling of the BESM with the telescopic gear is obtained; the effective stopper control method is explained. The results clarify that the issues of the BESM are remarkably solved by the telescopic gear. It is analytically revealed that the ideally controlled telescopic gear compensates gear inclination and releases height error; the BESM performs as if it lands on a flat location with properly tuned parameters. To conclude, this paper reveals that the telescopic gear improves the BESM's performance remarkably. It enables the BESM to land on more extreme terrain. It also contributes to performance assurance. Therefore, the telescopic gear is a promising device for further lunar/planetary explorations.