SPACE DEBRIS SYMPOSIUM (A6)
Hypervelocity Impacts and Protection (3)

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AN OPTIMIZATION METHOD OF BALLISTIC LIMIT EQUATIONS VIA CORRECTING THE VELOCITY REGIONS

Abstract

The number of orbital debris is rapidly increased as the human aerospace activities becoming more frequently, which throws a serious threaten to the safety of in-orbit spacecraft. In order to improve the protection capability, lots of shields have been developed, such as Whipple shield and some other enhanced structures. A large number of hypervelocity impact tests have been conducted by various research institutes. These results and analysis were used in developing the ballistic limit equations (BLEs) which could show the protection capability of the structures and as an important reference to design and assess the shields. The Christiansen equations are used more often for the Whipple Shield configurations. Based on the mechanism of protection, the equations were divided into three parts, the low velocity region (V<=3km/s), the middle velocity region (3km/s<V<7km/s) and the high velocity region (V>=7km/s). However, the boundary values were constant, which did not take the specific configuration of the structures into account. And according to the theoretical analysis, aluminum will begin to crash at 3km/s and to melt at 8 km/s. Therefore, a new optimization method is presented which is based on the Genetic Algorithm (GA) theory. In this paper, the Christiansen equations are optimized through the new algorithm program using 185 test data from the NASA JSC Whipple Shield HVI Database. Compared with the corresponding test results, the correct prediction rate of Christiansen equations is 67.57% while the new equations' is 68.65%. As the results show, the new equations could predict the failure more correctly. Then, with the boundary values of the velocity region considered as optimization parameters, we correct both the velocity region and the BLEs. The boundary value becomes 3.37km/s and 7.75km/s, which is correlated to the theoretical analysis. And the new correct prediction rate becomes 75.14%, which is much higher than the previous ones. Research in this paper shows that, method which optimizes both the velocity region and the BLEs is effective and could be also applied to other shields.

Key words: Whipple shield, ballistic limit equations, velocity region correction, Genetic Algorithm, optimization.