

IAF SPACE PROPULSION SYMPOSIUM (C4)
Interactive Presentations - IAF SPACE PROPULSION SYMPOSIUM (IP)

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RESEARCH ON FAILURE CRITERION OF HIGH ENERGY SOLID PROPELLANT UNDER
COMPLEX STRESS STATE

Abstract

At present, the failure assessment of solid rocket motor (SRM) grain is mainly based on uniaxial tensile properties, and the safety factor is estimated based on the maximum tensile strength and elongation; the combustion chamber grain is under multiaxial stress state during the storage or working process of the motor, the evaluation accuracy is limited by using the maximum elongation of uniaxial tension as the failure criterion. In order to improve the evaluation accuracy and reduce the failure probability, the multi-parameter failure criterion is needed to introduce the influence of tensile strength and stress state on the failure performance.

In this paper, the stress states of four typical specimens, including uniaxial tensile, biaxial strip tensile, cruciform biaxial tensile and uniaxial tensile under confining pressure, were analyzed by finite element method, and the relationship between the equivalent strain and the main strain of each specimen was obtained. By comparing the relationship of each specimen with that of uniaxial tensile specimen, the failure factors of the effect of the stress state on the failure performance of propellants were determined, and then the failure factors were introduced to correct the failure criterion in the failure assessment. The finite element analysis, integrity evaluations and ground test of a SRM, with a diameter 200mm, under the curing cooling and internal working pressure load were carried out to verify the rationality of introducing the failure factor and threshold.

The results indicate that 1) the center area of the biaxial strip and the cruciform biaxial tensile specimen and the inner bore of the grain under the cooling load are all in biaxial stress state. In addition, the cruciform specimen is relatively better to meet the demand for the different stress ratio of the inner bore of grains under the curing cooling load. 2) In the same pressure environment, the central part of uniaxial tension specimen under confining pressure can basically characterize the stress state of the inner bore of grains under operation pressure. 3) After introducing the failure factor which considers the biaxial stress state, the predicted results are in good agreement with the test results of the SRM of a diameter 200mm.

To sum up, introducing the influence of stress state on propellant's failure performance in the failure criterion can improve the estimation accuracy, which is of certain reference value to the design, manufactures and service of SRM.