IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Space Structures I - Development and Verification (Space Vehicles and Components) (1)

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A PSEUDO METHOD FOR ESTIMATION OF ELASTIC PLASTIC BURST PRESSURE OF CYLINDRICAL PRESSURE VESSELS AND ITS EXPERIMENTAL VALIDATION.

Abstract

Elastic plastic burst pressure is an important design parameter for design of motor case thickness of Solid Rocket Motors. Conventionally, they are estimated from empirical relations that are derived from closed form solutions based on failure theories. Finite element analysis can also be used to estimate the elastic plastic burst pressure by finding the pressure corresponding to net section yielding. Burst pressure estimated with finite element analysis will be closer to reality as it considers the geometric and material non linearities. Under internal pressure, the radius of the cylindrical shell increases whereas the thickness of the cylindrical shell decreases. During the loading process, two contrary effects occur due to this. Firstly, as thickness reduces the load carrying capacity of the shell decreases. Secondly, the load carrying capacity of the material increases due to strain hardening of material due to deformation. Initially, the second effect dominates and hence the shell is in stable condition. However, at a pressure corresponding to instability point, i.e. at elastic plastic burst pressure, increase in stress due to decrease in the thickness becomes greater than the increase in the load carrying ability of material due to strain hardening. This is the Considère's condition when applied to a cylindrical shell under internal pressure. Based on this, an algorithm is developed which closely estimates the elastic plastic burst pressure of cylindrical shell. The method considers the geometric and material nonlinearities of the cylindrical shell and accurately predicts the burst pressure. Results show that the burst pressure predicted using this method is consistently close to that estimated using finite element analysis (FEA) for different size cylindrical shells. This method is successfully validated through two burst tests. In both cases, motor cases failed in classical manner with longitudinal opening of the cylindrical shell. First test is the qualification test carried out with one of the solid motor cases (ϕ346mm) of crew escape system for human space flight programme. For this test, the percentage error in the prediction of the elastic plastic burst pressure was 2.4%. Second test is the qualification test done with a retro motor case (ϕ204 mm). The percentage error in the prediction of the elastic plastic burst pressure in this case was 1.9%. Thus, using this method, it is possible to predict the failure pressure of pressure vessels accurately considering the actual behavior of material without resorting to finite element procedures or relying on other empirical relations.