Use of acoustic emission to identify the bonding status of a rocket motor case

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SUMMARY

Data analysis with strain data and acoustic emission (AE) signals was conducted to establish a nondestructive test method for the bonding status of a rocket motor case. Finite element analysis was performed to calculate the strain distribution of a motor case during inner pressure loading. From the various analyses, we selected the AE hit rate as a good parameter for the evaluation of the bonding quality of the motor case. The application method described here could be used as a bonding evaluation method for the structural integrity of a rocket motor case.

Keywords: acoustic emission, rocket motor case, bonding, debonding, composite

Introduction

In this paper, we present a method of using AE signals to evaluate the bonding of a rocket motor case. Finite element analysis (FEA) is used to verify the deformation of the motor case under an inner pressure loading for the evaluation of the bonding status. The accuracy of the stress analysis was confirmed by strain data measured from several strain gages attached to the surface of the motor case during the air pressure test. A method that combines AE testing with FEA is recommended for evaluating the structurally adhesive bonding state of motor cases.

Adhesive bonding status of the motor case

The motor case is composed of three parts; a steel case, a rubber layer, and a composite tube. The steel case sustains the high pressure generated during the firing test and the rubber layer prevents high temperature heat. The composite tube is important for protecting the rubber layer from the ablation caused by the high velocity flame flow. In the case of a poor bonding condition between the steel case and the rubber layer, debonding may be abruptly initiated from the split line during the inner pressure loading test. Any unbonding or debonding in the motor case will cause an unexpected failure of the motor case during operation as a result of the penetration of the hot gas.

Stress analysis

FEA was conducted to calculate the strain distribution of the motor case during the inner pressure loading and to identify the differences between the bonding status of the steel case and the rubber layer. By comparing the surface strain data analyzed from the FEA with the experimentally measured surface strain data from the inner pressure loading test, we can determine whether the bonding condition has the status of perfect bonding, unbonding or debonding .

Acoustic emission experiment

By analyzing the various AE signals with the strain data, we concluded that the hit rate is a useful parameter for evaluating the integrity of the adhesive bond in the motor case. The AE signals were classified as normal or abnormal signals on the basis of the strain data obtained from the strain gage attached on the surface of the motor case. Figure 1 shows the AE signal vs. pressure as well as hoop strain vs. pressure of the motor case for debonding condition

Conclusion

The FEA results show that the strain distribution on the surface of the motor case during an air pressure test is closely related to the bonding status between the steel case and the rubber layer. Normal and abnormal AE signals can be distinguished in terms of the AE hit rate behavior for an evaluation of the bonding and debonding. We continuously detected an even, normal signal from the initial stage to the final stage during the air pressure loading. However, an abnormal signal that represents debonding abruptly appeared at a hit rate signal and then suddenly disappeared during the test. Our test method can be used as an effective tool for evaluating the quality of adhesive bonding.

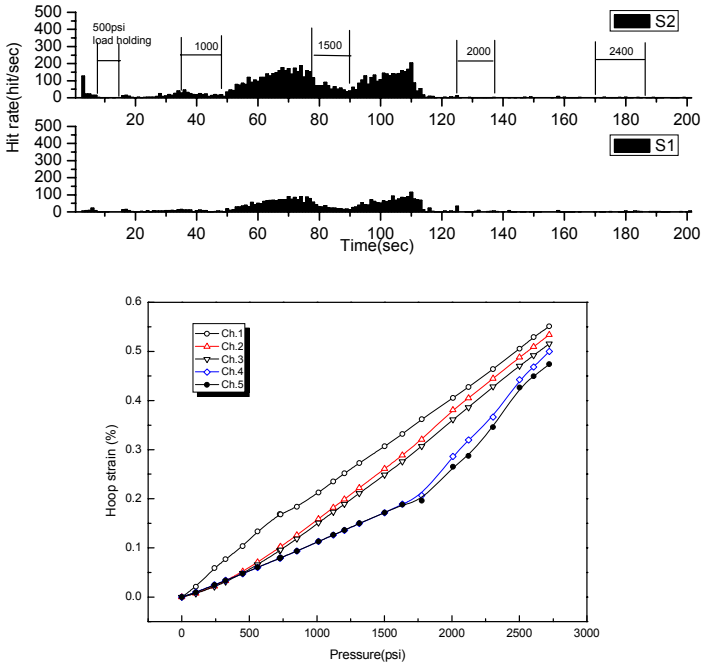

Figure 1 AE signal vs. pressure as well as hoop strain vs. pressure of the motor case for debonding condition