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Simulation of drop/impact reliability for electronic devices

Y.Y. Wang*, C. Lu, J. Li, X.M. Tan, Y.C. Tse

Institute of High Performance Computing, 1 Science Park Road, #01-01 The Capricorn, Singapore 117528, Singapore

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Abstract

The drop test simulation had been adopted by industries for years, it is still a challenging problem to replace the physical test, which requires the drop test simulation to supply reliable results and sufficient information. Another challenging requirement is to detect the failure inside small components during the product level drop test simulation. In this paper, the finite element method (FEM) is used to simulate drop test numerically, while the attention is paid to the methodology for analyzing the reliability of electronic devices under drop impact. Modeling and simulation method for such kind of complex structure is discussed. Some important issues, such as control of the simulation and material model, are addressed. Numerical examples are presented to illustrate the application of FEM on virtual product development. Effective modeling and simulation method are concluded from the numerical example and authors' experience accumulated from serial industry projects on drop impact simulations.

Keywords: Drop test; Finite element method; Reliability; Packaging material; Modeling and simulation; Virtual product development; Virtual test

1. Introduction

Various electronic devices, such as PDA and mobile phone, have been widely used in the daily life. The drop impact reliability is a key requirement as they will undergo suddenly drop unavoidably. Besides the behavior of the products, the packaging becomes increasingly important as damages may occur during transportation.

* Corresponding author. Tel.: +65 64191260; fax: +65 64191280.
E-mail address: wangyy@ihpc.a-star.edu.sg (Y.Y. Wang).

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In order to ensure the products quality and reliability, the traditional way is to carry out physical tests using prototype. However, it is difficult to catch the drop phenomenon, especially the inside response, as the impact is of very short duration. When damage/failure occurs, engineers can only analyze the causes based on the final failure and hence to improve the design. The general ways to modify the design are to increase the strength of the products and/or to improve the shock absorption ability of the packaging. However such design entirely depends on the experience of the engineers and undergoes lots of trial and error testing, which causes a delay of the product development and uncertain quality of products.

As the rapid development of the state-of-art computer hardware and software, simulation-based virtual test can be performed for the complex electronic devices, which can be used to replace expensive and time-consuming physical tests. More importantly, virtual test can be carried out during design stage and be used to investigate the insight failure mechanism. The finite element analysis (FEA) has been applied to simulate the drop tests of various products [1–4], packaging material are also considered in the drop test simulations [5–7]. Most of the commercial software with explicit solver can be applied to simulate the drop impact responses, such as PAM-CRASH [1,3–5], ABAQUS [7] and LS-DYNA. Some drop test modules are also developed to fulfill the increasing demands of industry, for example, the ANSYS drop test module, MSC/PATRAN drop test simulator [8]. However, these drop test modules are kinds of general drop test simulation software, and may not be suitable for the various requirements.

To replace the physical test, it is required that drop test simulation supplies reliable results and sufficient information. Thus, it is a vital step to set up the simulation model properly, which includes the geometry simplification, FE model, material model and boundary conditions, etc. Another challenging requirement is to detect the failure inside small components during the drop test simulation in product level. The difficulty is to obtain the drop-induced response in the components, which needs very fine mesh for the tiny structures. The fine mesh may cause the simulation very expensive and even make the simulation impossible.

In this paper, the FEM is applied to the numerical simulation of drop test. Detail discussion is presented to imply the method properly. Emphasis is on the methodology of analyzing the reliability of electronic devices under drop impact. Modeling and simulation method for such kind of complex structure is discussed. Some important issues, such as control of the simulation, material model, etc. are addressed.

Numerical examples are presented to demonstrate the application of FEM on virtual product development. Firstly, the drop test simulation for a TV set including packaging material is considered. In this application, the packaging material takes a crucial function during the drop impact. As the packaging material (foam) is much softer than TV cabinet, the contacts between foam and other structures, TV cabinet and the ground, becomes very complicated. Therefore, the drop test simulation for the TV set with packaging material is a challenge and cannot be analyzed by the general drop test modules. Another crucial part is the connection structure between the heavy tube and the cabinet, which is also discussed. Secondly, the reliability and robustness under consecutive drops is illustrated for an electronic device with aluminum housing. The procedure is described to simulate the damage accumulation in the part. Another example is presented to demonstrate the reliability analysis of interconnection in a device, which is an interference fit by inserting a part to another part.

Conclusions are drawn from the numerical example and authors' experience accumulated from serial industry projects on drop impact simulations.