International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

A Review on Finite Element Analysis of Free Fall Drop Test on Mobile Phone

Gurjinder Singh[1], **Jaswinder Singh**[2]

[1]Master Student, Production Engineering Department, PEC University of Technology, Chandigarh, India

[2]Assistant Professor, Production Engineering Department, PEC University of Technology, Chandigarh, India

Abstract: ***Present paper discusses the working methodologies used for drop test. Engineers widely used physical testing method to investigate the behaviour of cellular phone during drop test. It is very costly, time consuming and complex. Finite element analysis provides numerical models without spent so much money on physical testing methods. Drop test simulation is one of the important tool uses for the impact behaviour study of cellular phones. It identifies weak design points during the impact behaviour of cellular phone.***

Keywords: Finite Element Analysis, LS – Dyna, Product & Broad Level, Explicit vs. Implicit**.**

1. Introduction

Due to the great popularity of handheld and portable electronic products, the reliability and performance of microelectronics packages during drop and impact has become a major concern. The accidental drop of mobile phone in daily life is probably the most common failure. Mobile phone is expected to continue functioning after suffering a drop with minimal cosmetic damage. In the last years, work is already done on the mobile phone to develop highly impact tolerant. Several forces and accelerations acts on mobile when it fall, forces depends on the drop height, material, weight, shape orientation at impact surface and several other factor.

Therefore it is important for designer point of view that what actual facts of drop test on mobile phone at the end of the design stage. Physical drop test may be conduct for feedback to little bit change in product. Inside the assembly of mobile it is also difficult to understand what the component changes taken place. Recently, significant attention and research efforts have been devoted to improve the both board-level and product-level drop reliabilities of mobile phone. Therefore, the interest has turned toward finite element analysis. FEA can conduct starting on the development cycle and helpful in improvement of product. Drop test is also important because of it is less time consuming and less expensive.

1.1 FEA (Finite Element Analysis) is an analytical engineering tool developed in the 1960's by the Aerospace and nuclear power industries to find usable, approximate solutions to problems with many complex variables. FEA consists of a computer model of a material or design that is stressed and analyzed for specific results. It is used in new product design, and existing product refinement. A company is able to verify a proposed design will be able to perform to the client's specifications prior to manufacturing or construction. Modifying an existing product or structure is utilized to qualify the product or structure for a new service condition. In case of structural failure, FEA may be used to help determine the design modifications to meet the new condition.

There are generally two types of analysis that are used in industry 2-D modeling and 3-D modeling. While 2-D modeling conserves simplicity and allows the analysis to be run on a relatively normal computer, it tends to yield less accurate results. 3-D modeling, however, produces more accurate results while sacrificing the ability to run on all but the fastest computers effectively. Within each of these modeling schemes, the programmer can insert numerous algorithms (functions) which may make the system behave linearly or non-linearly. Linear systems are far less complex and generally do not take into account plastic deformation. Non-linear systems do account for plastic deformation, and many also are capable of testing a material all the way to fracture.

A typical work out of the method involves dividing the domain of the problem into a collection of sub domains, with each sub domain represented by a set of element equations to the original problem, followed by systematically recombining all sets of element equations into a global system of equations for the final calculation. The global system of equations has known solution techniques, and can be calculated from the initial values of the original problem to obtain a numerical answer.

FEA is a good choice for analyzing problems over complicated domains, when the domain changes, when the desired precision varies over the entire domain, or when the solution lacks smoothness. For instance, in a frontal crash simulation it is possible to increase prediction accuracy in "important" areas like the front of the car and reduce it in its rear. Another example would be in numerical weather prediction, where it is more important to have accurate predictions over developing highly nonlinear phenomena rather than relatively calm areas.
(www.sv.vt.edu/classes/MSE2094_NoteBook/97ClassProj/num/widas/history.html)

1.2 LS- Dyna

LS-DYNA is a general-purpose finite element program capable of simulating complex real world problems. It is used by the automobile, aerospace, construction, military, manufacturing, and bioengineering industries. LS-DYNA combined Implicit/Explicit solver. One scalable code for solving highly nonlinear transient problems enabling the solution of coupled multi-physics and multi-stage problems. It reduces customer costs by enabling massively parallel processing. Multicore processors have resulted in a drastic reduction in computer hardware costs and a huge increase in LS-DYNA licenses worldwide. LS-DYNA affords increased computation speed thereby improving scalability. The developer of LS-DYNA, LSTC, continuously recodes existing algorithms and develops more efficient methodologies. The code's origins lie in highly nonlinear, transient dynamic finite element analysis using explicit time integration.

"Nonlinear" means at least one (and sometimes all) of the following complications:

- Changing boundary conditions (such as contact between parts that changes over time)
- Large deformations (for example the crumpling of sheet metal parts)
- Nonlinear materials that do not exhibit ideally elastic behaviour (for example thermoplastic polymers)

"Transient dynamic" means analyzing high speed, short duration events where inertial forces are important.

- Automotive crash (deformation of chassis, airbag inflation, seatbelt tensioning)
- Explosions (underwater Naval mine, shaped charges)
- Manufacturing (sheet metal stamping)

http://en.cyclopaedia.net/wiki/LS-DYNA
http://www.lstc.com/products/ls-dyna)

2. Literature Review

Lim & low (2002) examined the drop impact response of portable electronic products at different impact orientations and drop heights. The drop impact responses examined. The impact force, strains and level of shock induced at the PCB. The shock induced at the electronic components and packages in the products. It can assist manufacturers not only in designing better components and electronic packages but also products which are more robust and reliable, to handle shock and impact loading. Kim & Park (2004) investigated impact behavior and identify failure mechanisms of small-size electronic products. Strict drop/impact performance criteria for hand-held electronic products such as cellular phones play a decisive role in the design because they must withstand unexpected shocks. The design of product durability on impact is heavily relied on the designer's intuition and experience. They studied the reliable drop/impact simulation for a cellular phone is carried out using the explicit code LS-DYNA. Tee et al. (2005) studied development and application of innovational drop impact modeling techniques due to demand for short time-to-market. Drop testing has become a bottleneck for semiconductor and telecommunication industry. Various advanced drop test modeling techniques developed. They are introduced, integrated, compared, and recommended for various applications. It consists of analysis type (dynamic vs. static), loading method (free-fall vs. input-G), and solver algorithm (explicit vs. implicit). Each combination of modeling techniques has its unique advantages, depending on applications. All the models are validated to show excellent first level correlation on the dynamic responses of PCB, second level correlation on the solder joint stress and failure mode, and third level correlation on impact life prediction. Gu et al. (2006) focused on different levels (e.g. product- and board-level) of reliabilities for microelectronics packages. Based on finite element modeling and design of experiment (DOE), a novel approach was discussed in detail to investigate the impacts of all possible key factors. The DOE model was set-up through 3D full parametric modeling from which every key factor can be adjusted easily. The simulations were conducted through LS-DYNA explicit finite element analysis and the DOE analyses were carried out through JMP. Two rounds of DOE and totally 20 drop simulations were carried out to deliver the valid analysis. Deiters et al. addressed methods for understanding the design implications of shock loading on electronics and consumer products during the early stages of product development. Procedures to fit analytical simulations of shock response of products into the early design activities of typical consumer products were developed. These were based on the assumption that new products will have some similarity to existing designs. Seah et al. investigated the mechanical response of PCBs inside portable consumer electronic products which were subjected to drop impact. Drop tests performed on two portable electronic products at various drop heights and orientations. The loading on the PCB was found to be effectively described by orthogonal components of acceleration and strain. This aided in understanding how these measurements are affected by factors such as product structure, drop orientation and location on the PCB. Lee et al. (2010) investigated the response of printed circuit board (PCB), when it is subjected to drop impact, a major concern to electronic manufacturers as it relates to the maximum stress causing failure for the solder balls. The full-field dynamic responses of printed circuit boards (PCBs) of product level are measured and analyzed in detail with the aid of Digital Image Correlation (DIC) method. The product-level drop test requires great effort in controlling the impact orientation, which is critical to ensure the consistency of test results. Several effects of test variables, such as drop height, PCB supports, casing shape, and battery weight distribution, are carefully studied case by case. Along with the free drop impact experiments, the 3D FEA models are analyzed using ANSYS/LS-DYNA. Another research done by Tempelman et al. (2012) examined the load cases taken into account, which occurs due to the drop impact of portable products, for the conceptual and detailed design phase of product. Using a special drop tower with guiding frame for controlled-angle free-fall drop impact, representative products are dropped at different angles and the acceleration is recorded both on the outer case and on an internally-mounted plate. A simplified analytical procedure, suitable for conceptual design purposes, is proposed for predicting the resulting dynamic response. Mattila et al. (2014) explained the product level drop response evaluation provide goals and guidelines for the development of a board-level drop test methodology that would better reproduce the field use loading conditions of modern portable electronic devices. Eight commercially available smart phones from different manufacturers were evaluated for their free-fall drop response. For this purpose, miniature accelerometer and strain gauges were attached to various locations on the component board inside the product covers. Liu & Li (2011) presented the impact study of a new cell phone design with split steel bands. The finite element model of the assembly was developed by using ANSA, the state-of-the-art pre-processor, and analyzed with LS-DYNA. The unit was dropped on a granite floor from the height of 1 meter with different orientations, such as face drop, edge drop and corner drop. Focus was paid on some key components. The integrity of the split band was investigated carefully, the stresses for cover glass and LCD layers were evaluated numerically and the shock absorbing performance of different visco-elastic pads attached on camera was compared in details. Wang et al. (2010) established practical platform and simulation tool for drop test study. It was found from simulations that a small angle variation (±5°) may result in up to 36% difference in predicted internal stress. Accurate identification on the impact angle, therefore, is recommended as an important parameter on internal component stress calculation. Good consistency between measured acceleration data and simulated results verifies the practicality of the developed data processing procedure and numerical methodology.

3. Conclusions

FEA has become a solution to the task of predicting failure due to unknown stresses by showing problem area in a material, thus allowing designer to see all of the theoretical stresses within the product failure criteria and help to select the correct materials, component shape and fixture methods. This method of product design and testing reduces the manufacturing costs by eliminating actual prototype testing.

References

[1] Wu j., Song G., & Wyatt K., (1998), "Drop/impact simulation and test validation of telecommunication products." Thermal and Thermo mechanical Phenomena in Electronic Systems, pp. 330 – 336.
[2] Yu D., Kwak J. B., Park S., & Lee J., (2010), "Dynamic responses of PCB under product-level free drop impact." Microelectronics Reliability, pp. 1028 – 1038.
[3] Mattila T.T., Vajavaara L.,Hokka J.,Hussa E., & Halkola V., (2014), "Evaluation of the drop response of handheld electronic products." Microelectronics Reliability, pp. 601 – 609.
[4] Tempelman E., Dwaikat M.M.S., & Spitas C., (2012), "Experimental and Analytical Study of Free-Fall Drop Impact Testing of Portable Products." Experimental Mechanics, pp. 1385 – 1395.
[5] Deiters T.A., Baker M., and Engelhardt C.W., "Using analysis to design for drop or other shock environments." Structural dynamic research corporation, pp. 523-528.
[6] Gu Y., and Jin D., (2006), "Drop Test Simulation and DOE Analysis for Design optimization of Microelectronics Packages." Electronic Components and Technology Conference, pp 422-427.
[7] Tee T.Y., Luan J., and Ng H.S., (2005), "Development and Application of Innovational Drop Impact Modeling Techniques." Proc 55th Electronic Components and Technology Conf, Orlando, FL, pp. 504-512.
[8] Kim J.G. & Park Y.K. (2004), "Experimental Verification of Drop/Impact Simulation for a Cellular Phone." Society for Experimental Mechanics, vol. 44.
[9] Lim C.T. & Low Y.J. (2002), "Investigating the drop impact of portable electronic products," Electronic Components and Technology Conference, pp. 1270 – 1274.
[10] Liu W., & Li H., (2011) "IMPACT ANALYSIS OF A CELLULAR PHONE," 4th ANSA & μETA International Conference, June 1-3 2011.
[11] Wang H.L.,Chen S.C.,Huang L.T., and Ying Chieh Wang Y.C.,(2010), "Simulation and Verification of the Drop Test of 3C Products," 8th International LS-DYNA Users Conference, May 2,2010.
[12] www.sv.vt.edu/classes/MSE2094_NoteBook/97ClassProj/num/widas/history.html
[13] http://en.cyclopaedia.net/wiki/LS-DYNA
[14] http://www.elsevier.com/books/finite-element-analysis-and-design-of-metal-structures/ellobody/978-0-12-416561-8
[15] http://www.lstc.com/products/ls-dyna

Author Profile

Gurjinder Singh received the B.E degree in mechanical engineering from Chitkara University, Punjab. He is currently pursuing the M.E degree in Industrial Design at PEC University of Technology Chandigarh, India.

Jaswinder Singh is working as Assistant Professor in the Production and Industrial Engineering department of PEC University of Technology. He has work experience of 7 years. His area of research is Ergonomics.