Drop Simulation for Portable Electronic Products

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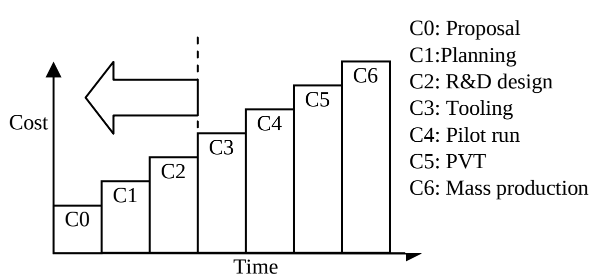
Abstract

The portable electronic devices are becoming smaller and lighter in recent years, and hence these products are easily damaged under the drop and impact conditions. Traditionally, manufacturers must have lots of mockups and samples to simulate the impact behavior through experiment. To minimize the development period and the try-and-error costs, ODMs in Taiwan begin to predict the impact behavior by LS-DYNA. For ODMs who want to establish CAE capability, there are two main challenges: (1) First challenge is to determine the opportune moment to introduce the CAE tools, which also implies the traditional design flow should be rearranged. (2) The maximum dimension of portable electronic devices is usually less than 30 cm, so mechanism features are relative small and difficult to build up a complete FEM model.

The main theme of this present is to provide a prediction about drop behavior of the portable electronic products in the early design stage and verified with the experiment.

Introduction

Most of popular electronic products, like notebooks and cellular phones, have similar structure system. These products can be roughly divided into two parts: the upper structure and the lower structure which are connected by hinge device. The upper structure usually includes LCD module, covers, metal frames. The lower structure would include keyboard, housings, battery, motherboard and chip sets. Besides the main components mentioned above, there are also many tiny mechanical features, like ribs, clips, snap fit, knobs…etc.



Traditionally, manufacturers would start CAE simulation after C3 stage (tooling stage) in the design flow chart (fig 1.). The available time period left for CAE engineers is only 1 to 3 weeks in 3C industry. In fact, the suggested moment to introduce CAE technique is between C0 to C2 stage (fig 1.). Simulation in early stage would extremely reduce try and error costs for manufacturers.

The electronic dictionary is probably the most representative of 3C products. Dimensions of electronic dictionary is around 15 x 5 x 3 cm^3, and could be imaged as a small notebook (fig.

2.). Due to the small size and complicated geometry of products, it is difficult to take all these tiny features into consideration. Reasonable simplification of FEM model is necessary.

One of the design criteria about electronic dictionary is that the battery cover should not detach from main structure, being dropped at a height of 100 cm. At the tip of battery cover, there is a snap fit to clutch the base cover of the product. However experience tells that the battery cover would sometimes separate from main structure during the impact moment.

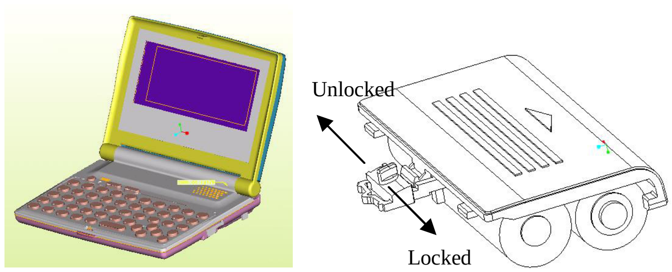


Figure 2: The electronic dictionary can be imaged as a small notebook. To evaluate the performance of battery cover, the knob should be taken into consideration.

Approaches

Analysis Model

On the basis of the concept of early prediction, all the small features like ribs, keyboard buttons, and the front knob are ignored before C3 stage, except the battery knob. Also, the mass of chip sets and electronic components are assumed to be uniformly distributed on the motherboard, only the speaker (SPKR) mounted on the motherboard is taken into the FEM model. This electronic dictionary model can be divided into 16 main parts and the material constants are listed below:

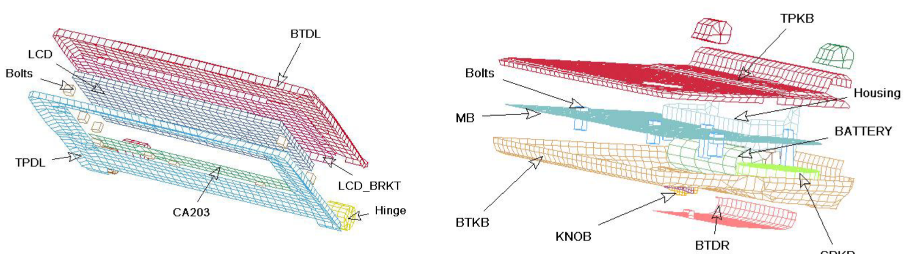


Figure 3: FEM model of electronic dictionary: the upper structure (left side) and the lower structure (right side)

Material Properties:

Most structural parts of electronic devices are made up by shells, such as covers and housings. It's adequate to simulate these components in shell elements.

Upper structure (units: ton/mm/sec)

PID	Name	Density	E	Yield Stress	Thickness
1	BTDL	1.2E-9	2350	60	1.6
2	TPDL	1.2E-9	2350	60	1
3	Hinge	1.2E-9	3500	Rigid	Solid
4	LCD_BRKT	2.63E-9	50000	250	0.8
5	LCD	1.7E-9	64500	100	Solid
6	CA203	4.2E-9	10000	60	0.5
7	Bolts	7E-9	2E+5	Rigid	Solid

Lower structure (units: ton/mm/sec)

PID	Name	Density	E	Yield Stress	Thickness
1	TPKB	1.1E-9	2350	60	1.5
2	BTKB	1.2E-9	2350	60	1.8
3	BTDR	1.2E-9	2350	60	1.3
4	BATTERY	3.5E-9	2E+5	200	Solid
5	MB	2.8E-9	1E+4	40	1.0
6	SPKR	1.4E-9	2E+5	Rigid	Solid
7	BOLTS	7E-9	2E+5	Rigid	Solid
8	KNOB	1.2E-9	3500	Rigid	Solid
9	HOUSING	1.1E-9	2350	60	0.6

Impact Conditions:

To evaluate the performance of battery knob, at least two impact conditions should be performed: the *front drop* and the *bottom drop*.

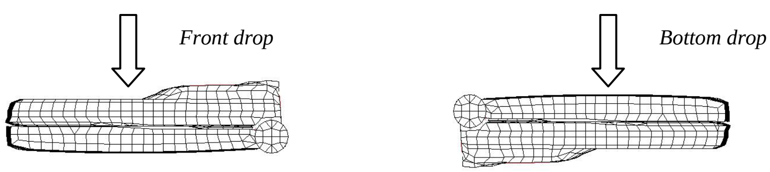


Figure 4: Definition of front drop and bottom drop

Results and Discussions

Front drop

The battery cover will not detach from the main parts with battery knob locked nor unlocked.

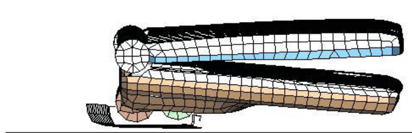


Figure 5: The battery cover would separate from main parts without fail of material after bottom drop

Bottom drop

The whole battery cover will separate from main structure with knob unlocked (see fig 5.). Observing the separation of battery cover through LS-Pre/Post, the mechanism causing the detachment of battery cover is that the cover sustained the upward impact from rigid ground, which leads the vertical displacement at the tip of the battery cover. At that moment, any transverse disturbance will force the battery cover to leap from the main structure. It's the reason that the battery cover separated from main structure without failure of material.

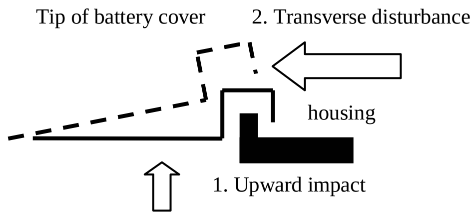


Figure 6: The mechanism of separation in battery cover

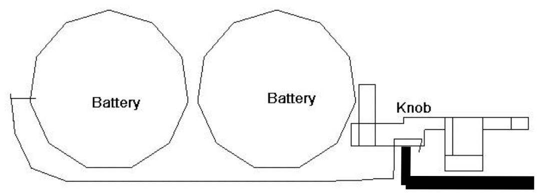


Figure 7: The knob can successfully confine the motion of tip of battery cover.

To prevent the separation of battery cover, the knob should be locked to provide extra strength for the tip of the battery cover resisting the upward and transverse motion (fig 6). As show in fig. 7, the tip of the battery cover would successfully clutch the housing with locked knob, and only the rear part of battery cover will open after impact (fig 8 and fig 9).

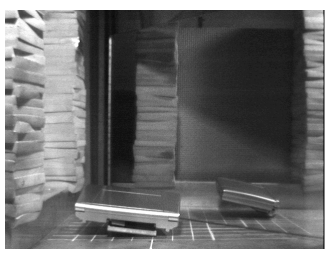


Figure 8: The impact moment in drop test

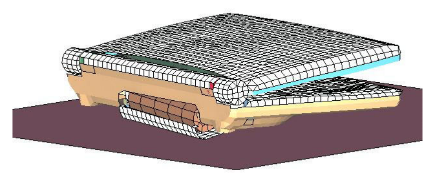


Figure 9: Bottom drop simulation.

Additional verification is increasing the drop height from 100 cm to 130 cm. The tip of battery cover will still clutch the housing. However, the plastic strain in the rear corner of battery cover will become larger and even fail.

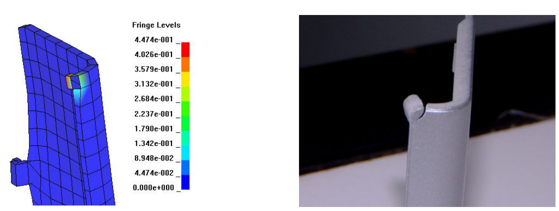


Figure 10: Large plastic strain in the rear corner of battery cover.

Conclusions

(1) More than 90% parts of electronic devices are made up in shell (or plate) structure. It's encouraged to mesh these parts into shell elements to get better results.

(2) It is difficult to control the drop and impact conditions precisely in experiment. There must be sufficient samples to increase the reliability of experiment data. Differ from traditional design

flow, LS-DYNA can successfully predict the drop and impact behavior for mechanical designers before C3 stage (tooling stage) in the design flow, and extremely reduce the try & errors costs for 3C manufacturers.

(3) Usually, snap fits in 3C products would disconnect from main parts without fracture. In this case, the battery knob can successfully confine the tip of battery cover and prevent separation.

Acknowledgements

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