Structural Design Review of LCD-TV Module by Impact Analysis

Authors:

Seong-Sik Choi, Jeoung-Gwen Lee
Mechanical Development Team.
AMLCD Division, Samsung Electronics, Korea

Correspondence:

Seong-Sik Choi
San #24, Nongseo-Ri, Giheung-Eup, Yongin-City
Gyeonggi-Do, Korea

Tel: +82-(31)209-3741
Fax: +82-(31)209-2228
e-mail: sschoi@samsung.com

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ABSTRACT

Display performance of LCD is going to be continuously high definition, high brightness, wide viewing angle. On the other hand, outline dimensions are demanded to be slimer and lighter. As the result of above demand, the space of each part becomes gradually narrow and tight. Therefore, the importance of design to prevent weakness for impact is embossed greatly. LCD products have to be subjected to various impact test for consumer's using environments. During the design, tool-correction or modification caused by damage or large deformation of weak part give rise to time consumption and cost-up. For development of LCD-TV module, these problems become more important because of its large size and heavy weight.
To improve these problems, we performed impact analysis of 40 inch LCD-TV module using LS-DYNA and applied the results to the development. In this analysis, we found out the weak regions and obtained improved reliability after design modification.
Impact analysis using LS-DYNA is going to be applied in the all of LCD product developments hereafter, and development period reduction and reliability improvement are highly expected.

INTRODUCTION

As the importance of external appearance design of the recent TFT-LCD is embossed, thin thickness and light weight charateristics are observed greatly as competitive power of product. Research on new design and development on materials for parts to correspond on such request are progressing but it is difficult to satisfy shock reliability because of many limitations in part design and arrangement in confined space.

Also, higher adjustments of LCD's shock limit is required recently by customer’s reliability reinforcement. Shock reliability problem is becoming more and more serious in development and mass production of LCD. LCD's shock reliabilty until the latest was obtained by method of trial and error through shock test and design correction when problem was found.
However, because durability of LCD is weakened as its characteristics are becoming thiner and lighter, such tentative correspondance consumes much tool correction expenses and period of time in short development term.

Design of product through systematic CAE Process can improve such problem. In the meantime, it is very hard to get effective results through CAE method for LCD which has structure that small thin parts are assembled and such parts affects in reliability seriously. In this research, we have built systematic CAE process for LCD product which progresses simutaneously with design of LCD. Also verified analysis accuracy and applied this process to 40-inch LCD TV module development. We resolved design problems and improved shock reliability before tool ordering and confirmed that we could enhance quality competitive power of LCD products.

In early stage of LCD development, the most important thing is to accomplish shock reliability. Therefore we developed and applied following analysis process for effective and efficient analysis for LCD product. LCD's 3D design data is converted to finite element data for impact analysis through modelling work. After inputing material properties of each parts here, such data are changed to LS-DYNA format via universal file format conversion. After inputing contact condition between each parts and shock test condition, LS-DYNA computation is executed. Computation result is applied immediately to design and tools are ordered after problem of early design is modified.

Obtain material properties of each parts

To achieve exact material properties for LCD analysis, we executed tension test using specimens of each parts. Also, we got bending modulus of LCD-Panel in the bending test. Such data applied to finite element model so as to embody mechanical characteristics in the model.

Load condition in analysis

We composed following process to input G’ value of shock reliability estimation test to finite element model. LCD module is threaded to product basically, and shock force supposes to be inputed through User-hole which is combined with product. G’ value which is used in shock test is inputed to User-holes as presented in Figure 1. Shock acceleration is inputed in half-sine waveform as Figure 2. Also, we considered LCD’ motion before shocked as free-fall action.

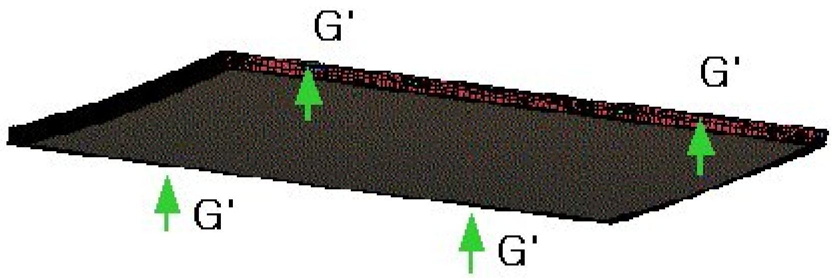

Figure 1. Acceleration input through User-holes

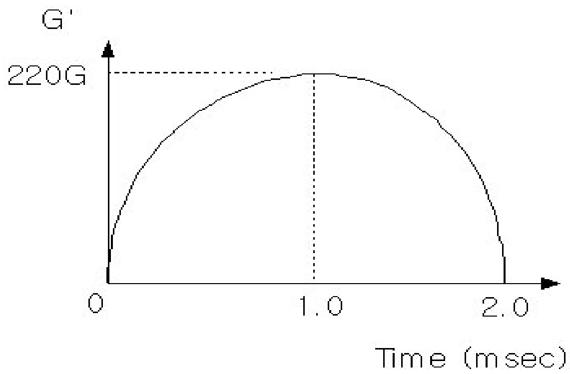

Figure 2. Half-sine shock acceleration in the case of 220G’-2msec

Computation and analysis of results

If finite element model's creation and input of boundary condition are completed, impact analysis is performed. If computation ends, results are analyzed immediatly and analysis of stress distribution, deformation state, displacement amount and weak region are available. For analysis accuracy, as appeared in Figure 3, detail experiments about LCD basis model attaching strain gauge and accelerometer have been executed. We applied this experiment data to enhance analysis reliability.

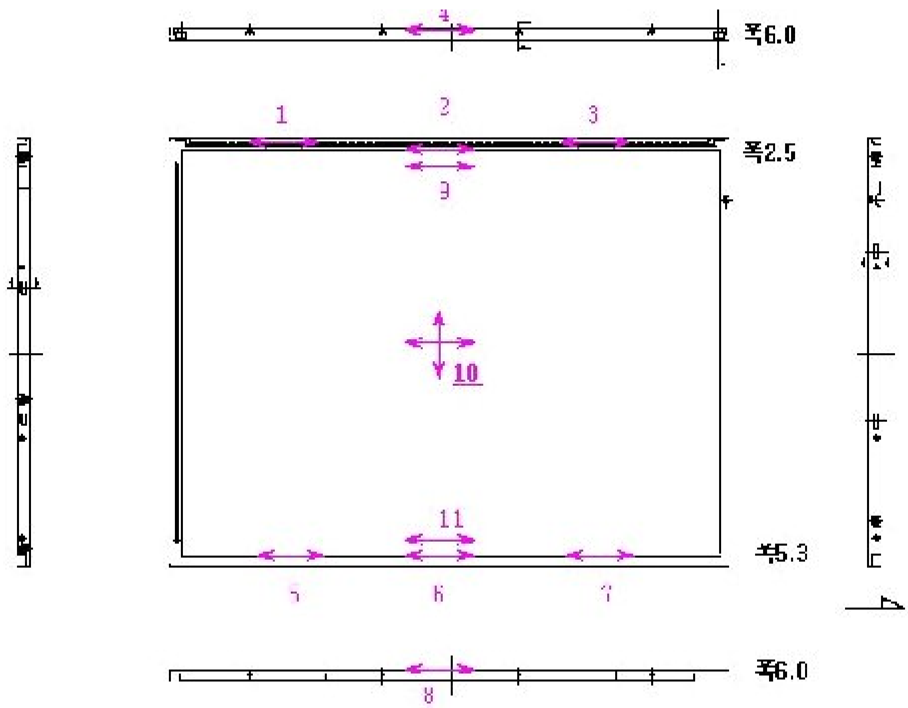

Figure 3. Strain gauges attached to LCD model for detail experiment

Application to 40" LCD-TV development

We applied impact analysis process to investigate mechanical behavior of each parts, contact/crack possibility, stress/displacement and executed shock reliability/design evaluation in 40 inch LCD-TV development. With this result, we have found problem of early design and corrected before tooling ordering. Shock reliability improvement of product in early stage was accomplished as the result of the analysis.

EXAMINATION AND IMPROVEMENT OF LAMP BREAKAGE

In the case of TV, to achieve high brightness, lamp is arranged justly below LCD-Panel. It is one of important problems to be considered necessarily that the lamp breakage possibility is raised seriously by contact with other parts in shock test. Figure 4 shows analysis result of lamp-assembly which was proposed at early design step. Central area of lamp where not fixed is deformed maximum 24mm to +Z direction and it was found that high stress happens thereby.

Its stress distribution is displayed in Figure 5. Lamp breakage is expected where not fixed by lamp supporter because stress maximum 110MPa that passes over ultimate stress of glass (70MPa) happens there by large deformation in +Z direction shock. Therefore, it is necessary to prevent breakage of lamp central part through lamp supporter's addition and rearrangement.

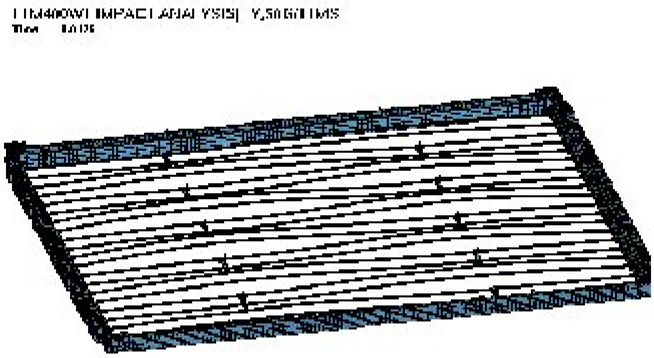

Figure 4. Deformation of lamp central area

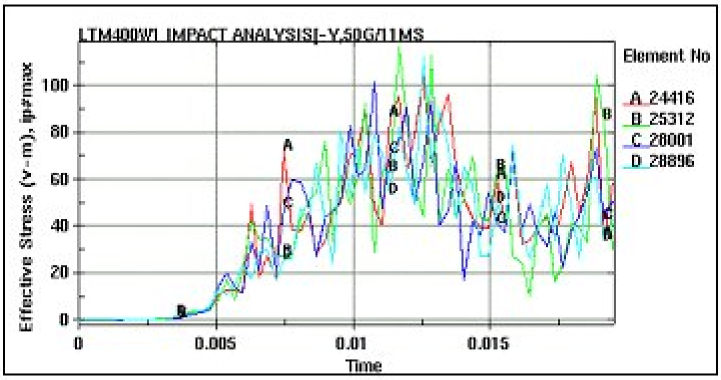

Figure 5. Stress distribution in maximum deformation area of lamp

Also, as appeared in Figure 6, it happened that electrode department of lamp's left and right side which is combined with PCB is broken by lamp's large deformation.
Such phenomenon happens because electrode department comes to have inflection point being combined strongly to PCB while there is a large deformation in the central area of lamp where not fixed by supporters.
Stress distribution at electrode department is presented in Figure 7. Because of maximum 200MPa high stress, electrode department's breakage is expected before lamp central area hangs. Therefore, design should be modified to reduce deformation of lamp central area through addition and rearrangement of supporters so as to prevent lamp electrode department's breakdown.

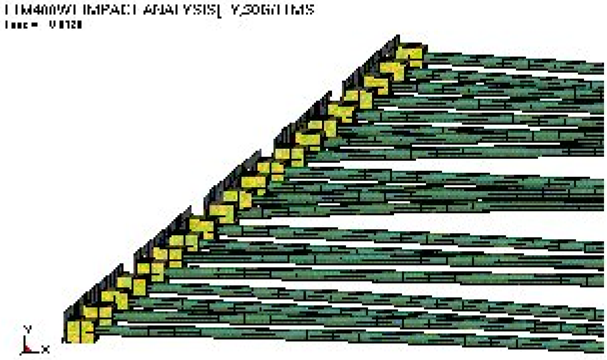

Figure 6. Deformation of lamp electrode department

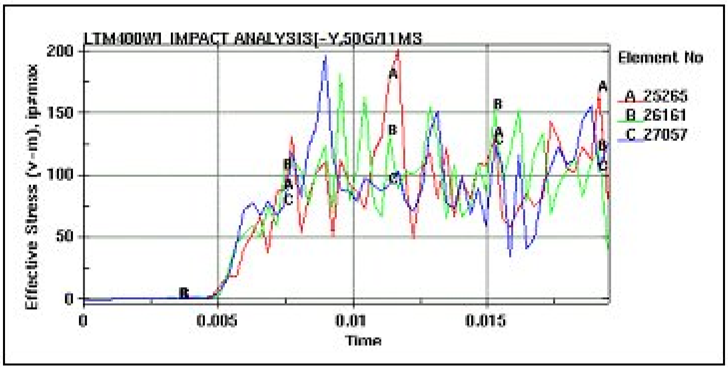

Figure 7. Stress distribution in maximum deformation area of electrode department

Assembly structure of lamp was improved as Figure 8 among various kinds of proposed design modification according to analysis result about lamp-assembly such as preceeding descriptions. Accordingly, Reflector-sheet and Chassis-bottom's hole position were modified also because they are assembled with lamp-suppoter.

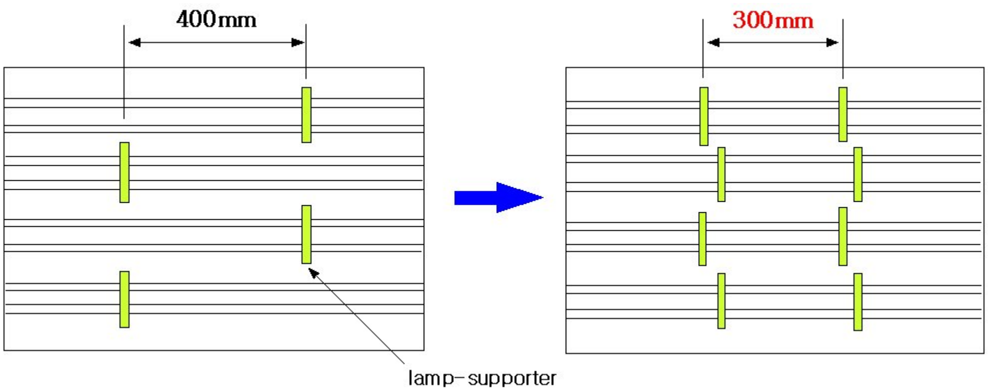

Figure 8. Design improvement of lamp assembly

EXAMINATION AND IMPROVEMENT OF LCD-PANEL BREAKAGE

LCD-Panel that dominate LCD's display performance is keeping structural hardness by Backlight-assembly which is located in lower position of it and It is very important to know LCD-Panel's deformation limit. As stress distribution range of Panel edge is 50 ~ 250Mpa as Figure 9 ~ Figure 10 and Panel's crack was expected because its maximum value passed over Panel's ultimate stress value (70Mpa). The reason of the high stress is that the Panel edges collide with chassis-top's inner side at the impact moment.

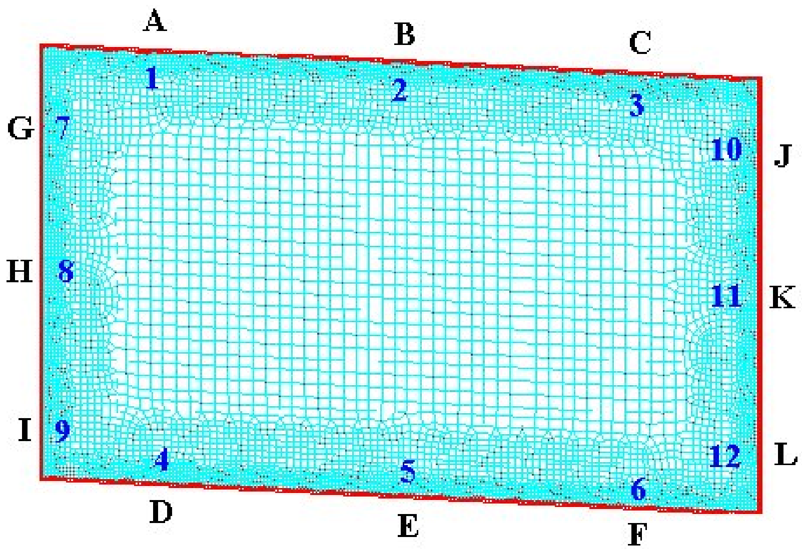

Figure 9. Selected locations in LCD-Panel for stress distribution analysis

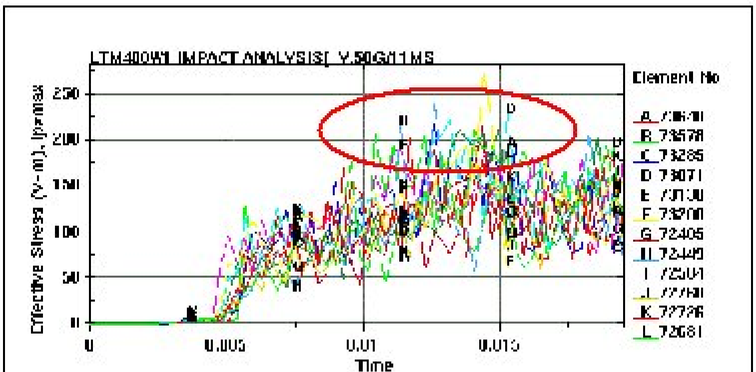

Figure 10. Stress distribution at LCD-Panel edge (A ~ L)

In the meantime, stress at active area adjacent to edge is comparatively stable as presented in Figure 11 (20 ~ 55MPa). Therefore, it is necessary to prevent crack at panel edge by addition of cushions on inner side of chassis-top. According to above, cushions were attached as design modification.

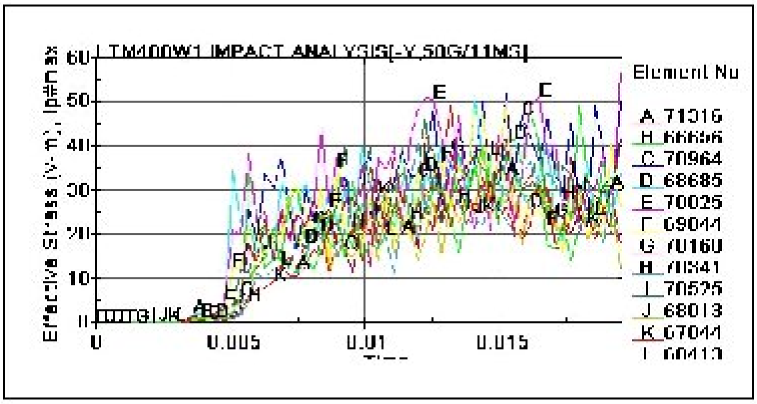

Figure 11. Stress distribution at active area adjacent to edge (1 ~ 12)

OTHER DESIGN EVALUATION AND IMPROVEMENT ITEM SUMMARY

Improvement items of other important parts according to analysis result are explained in Table 1. Further details are omitted for want of space.

Table 1. Design evaluation and improvement of other important parts

Drop direc-tion	Investigation item	Analysis result	Improvement
+Z	Permanent deformation of chassis-top	OK	-
	Frame-mold crack	OK	-
-Y	Crack at LCD panel edge	NG	Add ribs to support panel
	Lamp breakage	NG	Add and rearrange lamp suppoters

After tooling sample was manufactured, formal shock test was performed. In the test, issued matters were O.K and we confirmed that shock reliability was accomplished through impact analysis.

Comparison with existing impact analysis example

In first half of 2000, impact analysis of LCD module for 17" monitor has been executed, but this achieved asking to outside institute because there was no technical resource to do it. (Period : 6 months, Expense : $70,000)
This CAE Process is to make it applicable to short development period of LCD product and we have accomplished remarkable enhancement of CAE execution period within 14 days.

CONCLUSION

We have built mechanical CAE Process for LCD product proceeding simultaneously with product design in order to get impact reliability. That is, we constructed series of process with breaking of existing empirical designing and problem improvement activity and overcome various problems in applying CAE to LCD product development. We applied it in 40" LCD-TV module development to found design problems in early stage and acquired design correction, development period shortening by improving. Also, obtained analysis technique which has been executed by outside research institute and it has been applied to all new product development since first half year of 2002. We can get delivery period reduction, reliability improvement of product through this and accomplish quality competitive power elevation as a result.

Reference

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