Drop Test Analysis of Shadow Mask and Frame Assembly of CRT using Finite Element Method

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Abstract: *Cathode Ray Tube (CRT) subjected to different kinds of mechanical loads during transportation on irregular roads. Shadow mask, which is very much fragile and prone to distortion due to shock loads. It is a delicate component as structural integrity point of view and very thin dimensional structure. Its contour surface defined by the polynomial equation. The variation of this contour surface shape can cause damage to performance of CRT. The one of the shock load it is going to be subject is due to drop of assembly on the ground surface. The objective of this paper is to simulate the drop test phenomena of shadow mask, frame assembly, and predict the non-linear behavior where the shadow mask undergoes plastic strain and improving the structure design against the dropping load. It has found that its in-plane properties behavior is different from out-of-plane behavior. Moreover, a non-linear transient analysis performed using finite element code for different versions of shadow mask design.*

Introduction

Predicting the failure of the shadow mask's contour surface is one of the main aspects of designing of shadow mask of CRT. It is the guiding element for the beam projection over phosphor coat surface on the panel. The contour surface of shadow mask is well-defined polynomial equated surface designed to for forming beam spot. This shadow mask contains apertures or through holes, each one defined with prescribed shape and defined position. The shadow mask plays important role while manufacturing of the phosphor-screen and during electron beam's path registration over color selection. It is well supported by frame and spot-welded with shadow mask periphery, which adds stiffness to the shadow mask. This supporting frame is attaching to the suspension pins in panel. The mask and frame assembly needs to inserted into panel several times during tube manufacturing in between the applications of black matrix layer and the three principal phosphor patterns for red, green and blue. It is the critical component for CRT and any damage is the loss of color purity due to the deformation of shadow mask after shock. The main aim of this paper is to find out contour surface design and bead location of shadow mask, which improves stiffness of the structure against the shock loads.

Approach to Drop Test:

In this paper, the drop test performed by simulating dropping phenomena using finite element method. For this analysis, LS-DYNA 970 explicit non-linear code used and for modeling purpose Unigraphics CAD modeling used. The shadow mask and frame structure are welded with spot welds at different surrounding periphery locations of assembly. The spot welds material considered as rigid body elements.

Spot-weld locations are shown in this figure 2, Discrete finite elements of shadow mask and frame created from Hyper Mesh preprocessing software

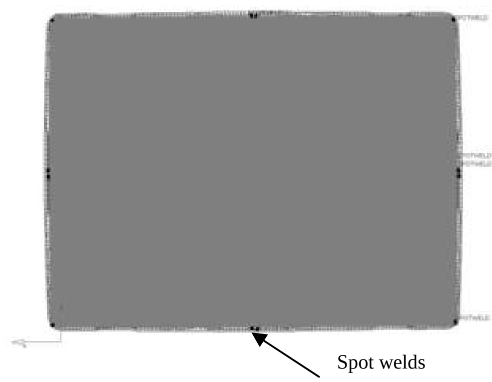

Figure 2.

Two dimensional shell elements used to define the models of mask and frame. In addition, for spot-welds rigid one-dimensional elements defined. Since it is very difficult to model all apertures in shadow mask and occupies huge memory in CPU of computer, so equivalent material properties Young's modulus, Yield stress and Poission's ratio of shadow mask calculated from Finite element method. For this static analysis performed taking one unit cell model using shell element as described in paper Baik, Oh [1] and Chen [2].

The effective shadow mask properties obtained as follows with LS-DYNA static analysis method.

Two versions of 21" CRT shadow mask designs taken for this analysis. Both having different radius of curvature of contour surfaces with beads on their surfaces. The bead location on the mask plays important role for stiffening purpose. Contact algorithm defined between surfaces of mask and frame. It is necessary to make rigid ground surface where the assembly dropped. Version 1 having large diagonal radius and version 2 having small diagonal radius of curvature as shown in fig. 3, X>Y

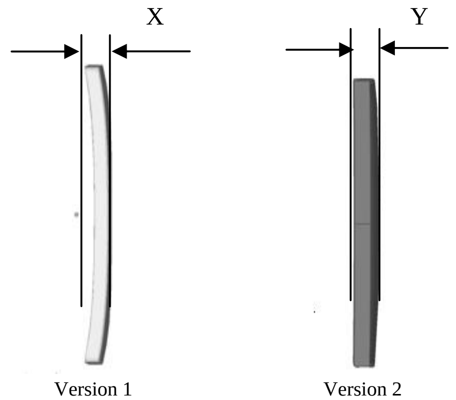

Figure. 3

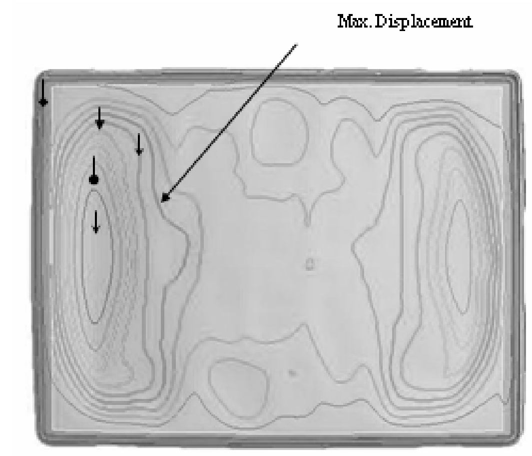

Figure.4

Fringe results of shadow mask of version 1, at 65mm height drop.

Total no. of elements = 18469
Total no. of nodes = 18963
Total no. of welds = 12

Young's Modulus of Shadow mask in plane is ten times stronger than and out-of-plane. It is found with finite element analysis and compared with practical test. In addition, it is observed from different simulations, the bead location on shadow mask determines its strength. The assembly of shadow mask and frame dropped on rigid surface at different heights and the vertical displacements of mask contour measured. The dropping phenomena of mask and frame assembly started just before ground touching about 2 to 3mm. and Instantaneous velocity applied as initial condition of momentum to whole body. The whole simulation runs for about 100 to 200 m-sec.

Results and Comparison of an Example

Since this paper worked on two versions of shadow mask according to variation of contour surface Fringe results of Version.1 shadow mask are shown in figure 4. The contour surface vertical displacement when it got impact and comes to rest position and when 65mm height dropped, in shown in graphically in the figure 5. Different arrow mark locations shown respectively from figure 4 to figure 5.Similarly for version 2 shadow mask fringe results has shown in figure 6 and figure 7 when dropped from height 65mm height drop. Contour surface displacement for one-quarter area of mask where plasticity zone reached at 65 mm drop for version1.

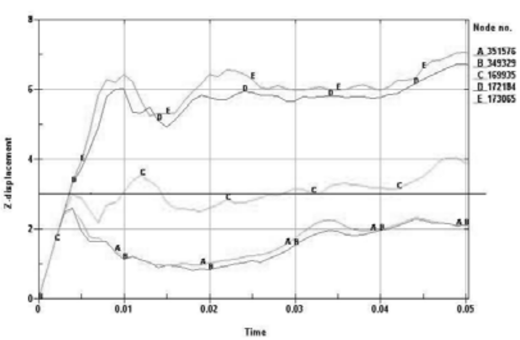

Figure 5.

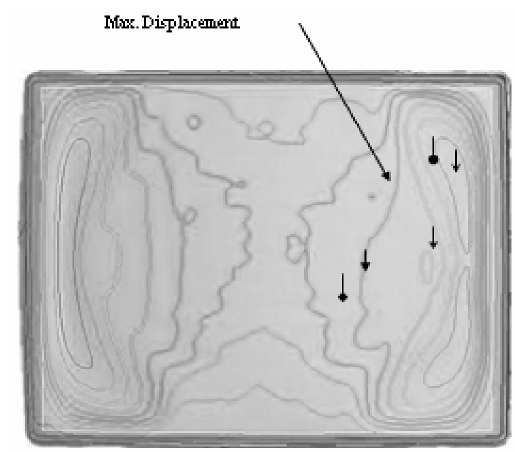

Figure 6.

Fringe results of shadow mask version 2, at 35 mm height drop of version1

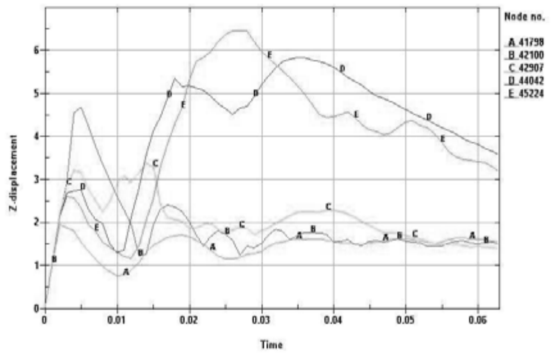

Figure 7.

Contour surface displacement for one-quarter area of mask where plasticity zone reached at 35 mm drop version2.

Conclusions:

1. It concluded that the lower contour diagonal radius of version1 shadow mask is more stable against the shock load relatively higher diagonal radius of contour surface of version2 shadow mask.
2. The in-plane behavior and out-of-plane behavior of shadow mask contour surface are different, as its Young's modulus in plane is ten times higher than out of plane Young's modulus.

References

1. Seung Baik, Kyu Oh, *Journal of Mat.* Processing Technology 58(1996)139-144 Analysis of the deformation of a perforated sheet under uniaxial tension

2. Fuh-Chen and Yi-Che Lee, *ASME Vol*.124 Oct 2004, Plastic Deformation of a perforated sheet with nonuniform circular holes along thickness direction.

3. LSTC LS_DYNA 970 Users Manual