Analysis of a Mask Vibration Considering the Damping Wire in the Flatron

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Abstract

The vibration of a mask degrades the color purity in CRT. In order to reduce the vibration, a damping wire is put into contact with the mask in the Flatron. We analyzed the vibration of the mask considering the damping wire using FEM. The natural frequencies and mode shapes of the mask are calculated by modal analysis. And those are compared with the measured results to confirm our finite element model. The modal analysis of the wire is also performed to investigate resonance with the mask. Finally, the transient dynamic analysis of the mask contacting with the wire is performed. The vibration of the mask is measured to confirm our analysis, and the results are in good agreement with the analysis.

Introduction

The recent trend of development in CRT is mainly focused on perfect flatness of the screen. Because the Perfectly Flat CRT(PF-CRT) has some advantages such as reducing the glare of the screen, the image distortion and etc. LG Electronics developed the PF-CRT that was named Flatron. Unlike other conventional CRT, Flatron has its own structure that is composed of rail, a flat mask and a flat panel. The conventional CRT is shown in Fig.1 (a) and the Flatron is shown in Fig.1 (b).

In general, the mask is vibrated due to the impact imposed on the outer surface of the CRT and the sound from the built-in speaker. The vibration of the mask cause the landing shift of the electron beams, it deteriorates the color purity of the CRT. In conventional CRT, it is not considered serious problem, because the vibration of the mask can be isolated by a spring. However in case of the Flatron, a damping wire is put into contact with the mask instead of the spring. The wire absorbs the kinetic energy of the mask by collision with the mask in the Flatron.

In this study, we analyzed the vibration of the mask considering the damping wire using FEM. Experiment was performed to confirm our analysis. Particularly in this experiment, we measured the displacement of the mask in a vacuum using laser sensor to exclude the air damping effect.

Finite Element Analysis

The mask has numerous holes which electron beams pass through, but it is almost impossible to model holes in FEM. Therefore, we generated finite element meshes without holes. In order to get the same behavior with holes in the analysis, we used effective material properties instead of original material properties. To reduce the analysis time, 1/4 modeling was done.

The natural frequencies and mode shapes are calculated by modal analysis. The governing equation is as follows

$$[M]\{\ddot{u}\}+[C]\{\dot{u}\}+[K]\{u\}=\{F\} \qquad (1)$$

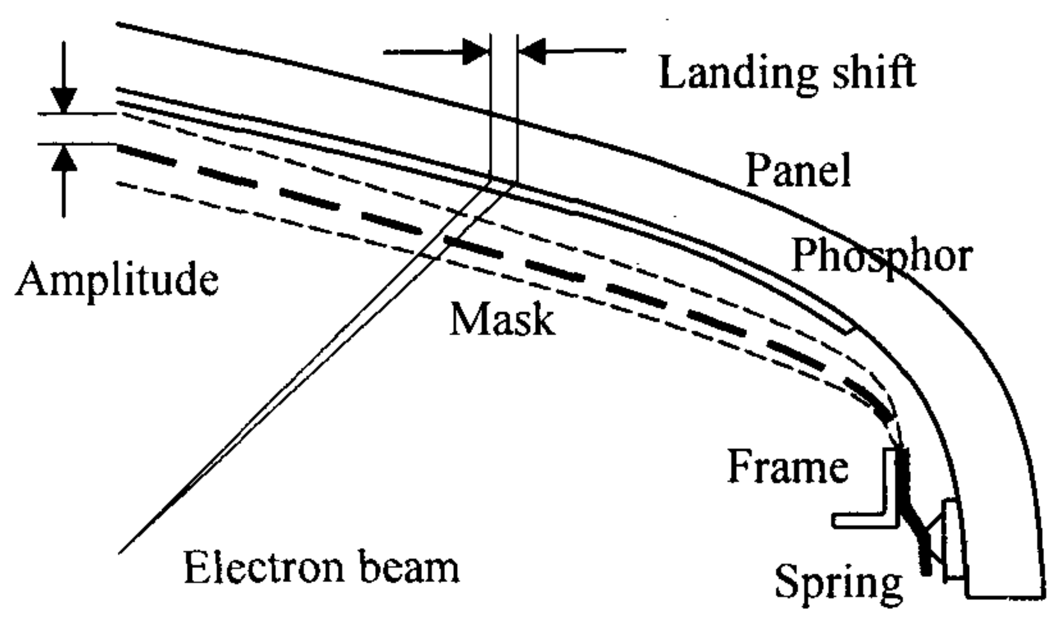
Let's assume free vibration and ignore damping term

$$[M]\{\ddot{u}\}+[K]\{u\}=0 \qquad (2)$$

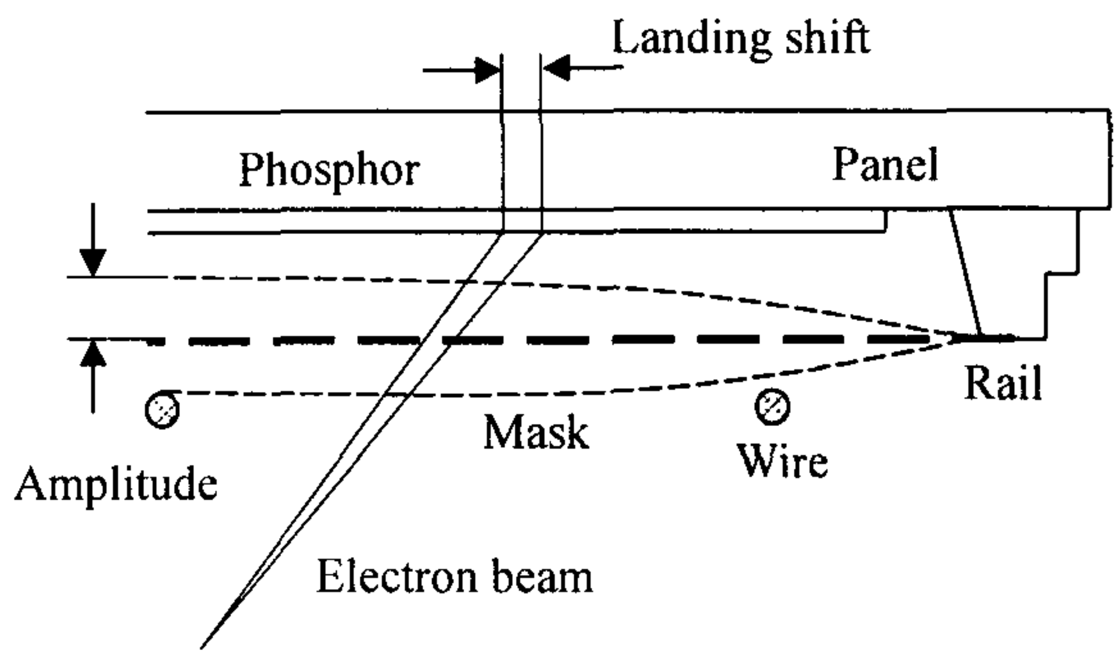
Finally, if the motion is the harmonic motion, natural circular frequency can be obtained by equation below

$$\left|[K]-\omega^2[M]\right|=0 \qquad (3)$$

To analyze the vibration of the mask, we must perform four analysis steps in sequence. The first step is the tension analysis of the mask which is welded on the rail. The second step is the tension analysis of the wire. The third step is the static analysis, which is the imposing force on the mask considered as exciting force. Final step is the transient dynamic analysis including contact between the mask and the wire after eliminating the imposed force. Fig.2 shows the principal stress distribution of the mask at the third step.



(a) Conventional CRT



(b) Flatron

Fig. 1 Schematic figures for landing shift due to the vibration

Experiment

We performed experimental modal analysis to verify our finite element model. In order to save the measuring time, we used Electronic Speckle Pattern Interference (ESPI). Unlike other conventional measuring equipment, it can measure the mode shape of the mask at once.

We constructed a new system shown in Fig.3 that can measure the vibration of the mask in a vacuum through the panel. To measure the displacement of the mask using laser sensor, a sample must be made without phosphor coating. And the sample is excited by the pendulum to give the same amount of force to the panel. Laser sensor checked the vibration of the mask when the pendulum excited the sample. Output signals from the laser sensor go to the Digital Oscilloscope through the Low Pass Filter (LPF). The frequency analysis is also performed from the measured results.

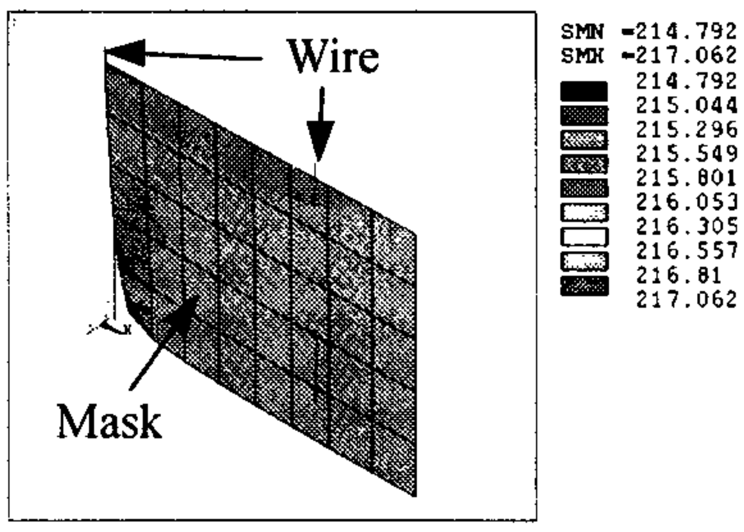


Fig.2 Principal stress distribution of the mask

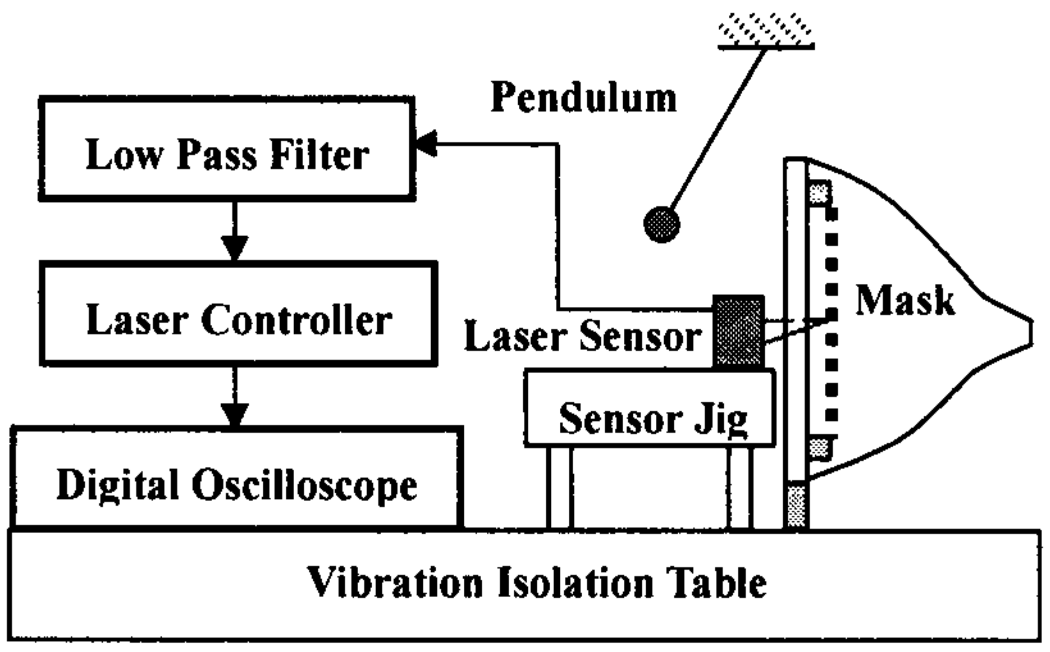


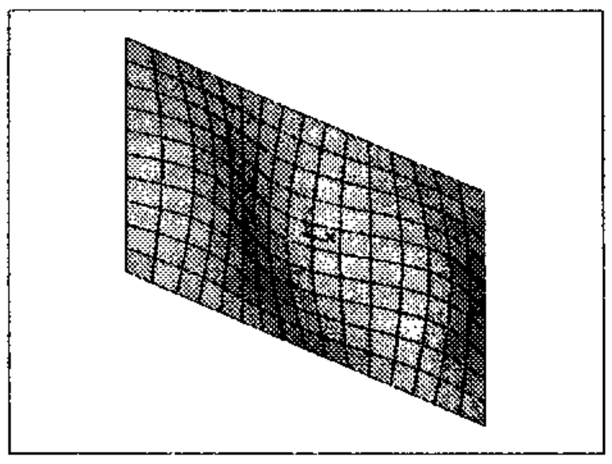
Fig. 3 The measurement system for vibration

Results and Discussion

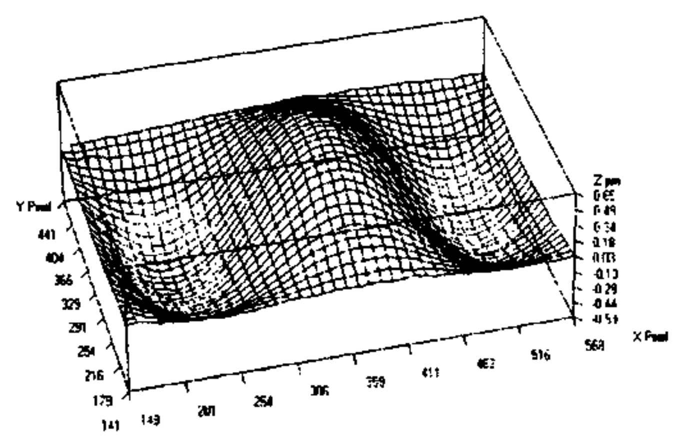
Fig. 4 shows the third mode shape of the mask. Because the horizontal length of the mask is longer than the vertical length, the third mode was occurred horizontally. The analysis results show a good agreement with experimental result.

Fig. 5 shows the analysis results at 128mm apart from the center of the mask. The results show that good damping effect is obtained by the wire. It took much time to analyze the vibration of the mask contacting with the wire. And the displacement of the mask is calculated for only 1.5 seconds.

Fig.6 shows the experimental results during 10 seconds at the same location. And the results are similar to the analysis.



(a) Analysis (fn = 525Hz)

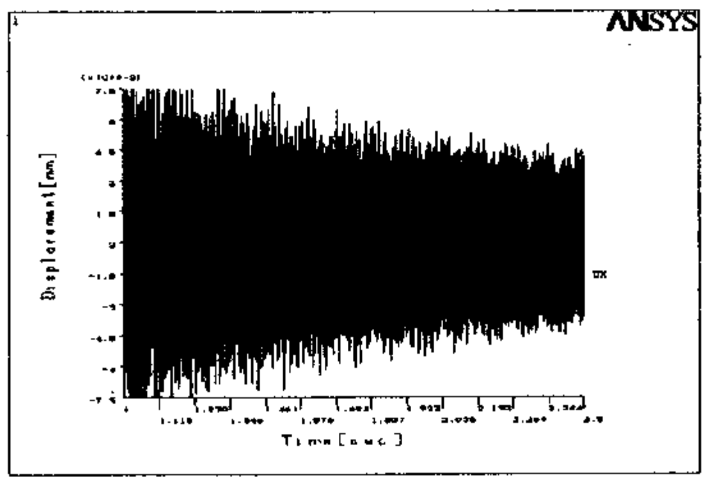


(b) Experiment (fn = 483Hz)

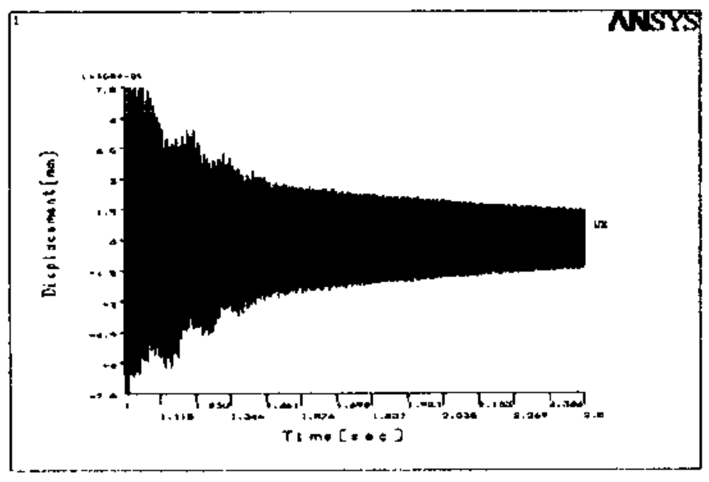
Fig.4 The third mode shape of the mask

Conclusion

We presented the analysis method for the vibration of the mask contacting with the wire, and the measuring method in a vacuum using laser sensor. We compared the analysis results with the measured results to confirm our analysis. In case of the Flatron, the third mode is the most dominant mode of the mask. This results suggested that restriction of the third mode is very effective to reduce the vibration of the mask.

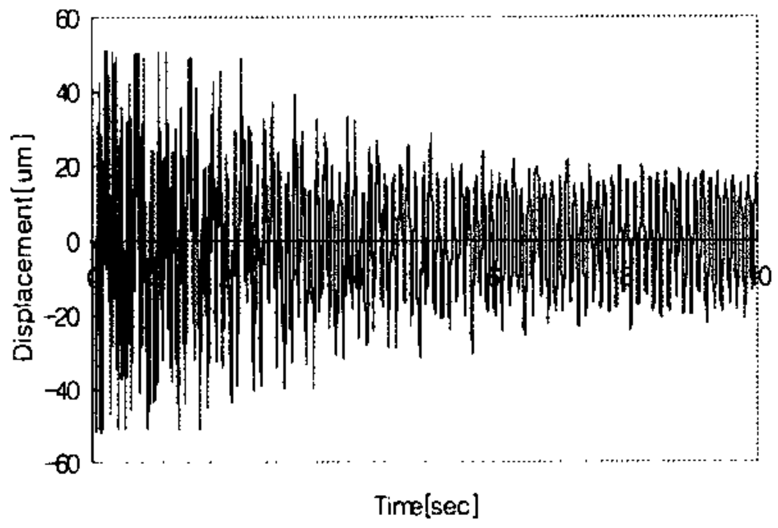


(a) No - wire

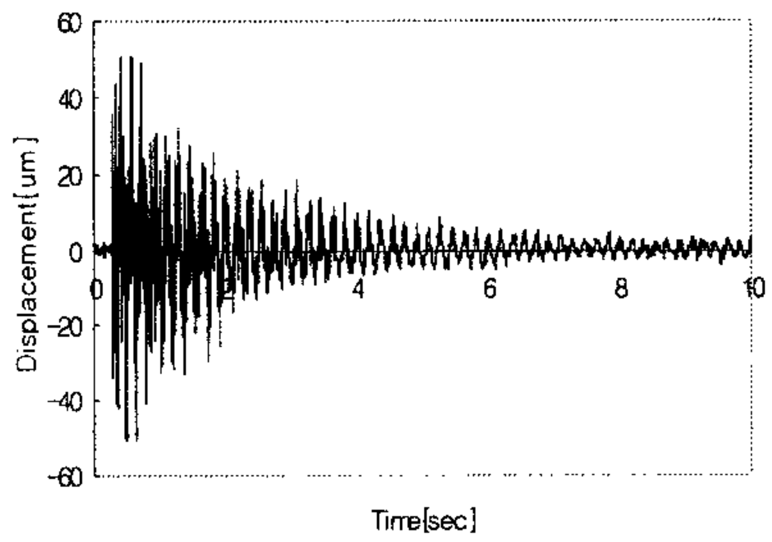


(b) 3 - wire

Fig.5 Analysis result of mask displacement at x = - 128mm



(a) No - wire



(b) 3 - wire

Fig.6 Experimental result of mask displacement at x = - 128mm

Reference

1. H.Taguchi, K.Seto, F.Doi and M.Ren, "Vibration Analysis of Trinitron Aperture Grille," SID 98 Digest, pp.347-351, 1998
2. Koji Saita, " Vibration Analysis of Trinitron Aperture Grille," Euro Display , pp.497-499, 1996
3. H.Nishino, H.Sasai, K.Makino and T.Sugawara, "Aperture-Grille Vibration Suppression in Diamondtron CRT," SID 99 Digest, pp.66-69, 1999
4. Robert F.Steidel, "An Introduction to Mechanical Vibrations," 2nd edition, 1978