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REDUCTION OF MICROPHONIC PHENOMENON IN CATHODE RAY TUBE BY FINITE ELEMENT ANALYSIS AND DESIGN OF EXPERIMENT

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1. INTRODUCTION

TVs or computer monitors with speakers often have a phenomenon called microphonic which shows fringe-like dark pattern on their screens. The major source of this phenomenon is the vibration of the shadow mask inside of the Cathode Ray Tube(CRT) which is caused by the sound generated from the speakers[1].

Today's most of the multi-media computers use speakers and the level of this phenomenon has become an important factor in terms of the quality of CRT. Furthermore, most of the monitor designers want to make their monitors with speakers attached. Due to microphonic phenomenon, however, it has been failed to make such monitors except when the speakers were attached to the monitors with very good vibration isolation, which increased the cost and difficulties of manufacture and caused design modification depending on the shape of the monitor cabinets.

Instead of using such a method, reducing microphonic phenomenon by modifying the structure of the shadow mask frame in Cathode Ray Tube (CRT) has been examined in this study. A 15" and a 17" CRT model for computer monitors were selected for research.

2. ANALYSIS AND RESULTS

In order to find the relationship between the microphonic phenomenon of the CRT and the shadow mask vibration, frequencies of the screen vibration of the CRT were measured and modal testing was carried out. It was found that microphonic phenomenon was quite large up to 500Hz. As shown in Figure 1, frequency response function of the shadow mask agreed quite well with the frequencies of the screen vibration of the CRT.

A three degree-of-freedom model was built to analyze the effects of the glass, spring and shadow mask frame on the vibration of the shadow mask. Through the analysis of this simplified model, the following three ways for improvement was

obtained:
1) reduction of the friction between the glass connector pin and the spring (shown in Figure 2)
2) reduction of the stiffness of the spring
3) increase of the stiffness of the shadow mask frame

Friction between the glass connector pin and the spring can be affected by the two factors : material type of the connector pin and the spring and the force between these two components. In this study, only the effect of the force was examined. The only control factor of this force was the initial height of the spring as shown in Figure 2. Since friction is proportional to the force applied, initial height was reduced to reduce the force. The optimum height was obtained by trial and error and some reduction of the microphonic phenomenon was observed.

In order to reduce the stiffness of the spring and increase the stiffness of the shadow mask frame, a finite element model for the vibration analysis of the CRT shown in Figure 3 was constructed and analysis was carried out[2]. Reduction of the thickness of the spring brought its stiffness reduction easily, but it was not adopted for production because it also reduced impact strength of the CRT and increased the doming effect which made the screen quality worse.

Increasing the stiffness of the shadow mask frame can be easily obtained by increasing its thickness. But it also increases the cost of CRT and instead, its shape was changed for the 15" CRT model. As shown in Figure 4, large strain energy was observed at every corner and so a bead has been added at the four corners of the frame. Also the bead size in the middle of the frame was optimized. The shape of the frame before and after modification is shown in Figure 5. Finite element analysis showed reduction of the vibration transmissibility by 80% as shown in Figure 6.

A prototype for 15" CRT model with the spring of reduced initial height and the modified frame was built and tested. As expected, it was observed that the microphonic phenomenon was reduced greatly as shown in Figure 7.

In order to find the optimum shape of the shadow mask frame, a method for design of experiment was applied to improve the 17" CRT model. Shape parameters such as depth and length of the bead were chosen as the control variables and L18 matrix was used. Evaluation was done based on the natural frequencies up to 500Hz. The results of analysis are shown in Figure 8. Figure 8 a) shows the sensitivity of each control variable and b) shows the natural frequency change when the best combination of the control variables was applied.

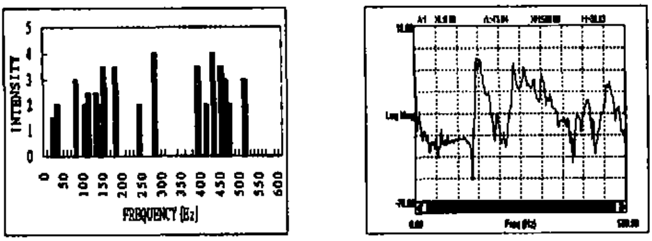
CONCLUSION

Based on the experiments and computer simulation of the CRT vibration, it was achieved to reduce microphonic phenomenon of CRTs for computer monitors significantly. This study showed that it was possible to apply finite element analysis for vibration to reducing microphonic phenomenon which would become more important in the design of computer monitors in the future. It will be also possible to build a complete mechanical design system for CRTs based on computer simulation when impact and doming effect can also be simulated. This will provide optimum design of CRTs, which will improve quality of products and reduce development time and cost due to experimental trial and errors.

References

[1] K.Sung, and et. al., "A study on the TV Microphonic Phenomenon," Journal of Korean Society of Noise and Vibration Engineering, Vol. 5, No.1, pp. 123-132, 1995.

[2] I-DEAS System Dynamics Users' Guide, SDRC, 1993.



a) Microphonic Phenomenon b) Transmissibilty of Shadow Mask

Figure 1. Microphonic Phenomenon and Shadow Mask Vibration Transmissibility

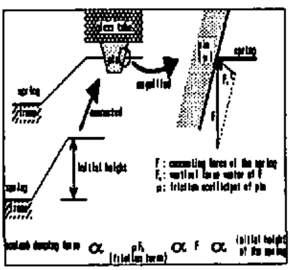


Figure 2. Friction and Spring Height

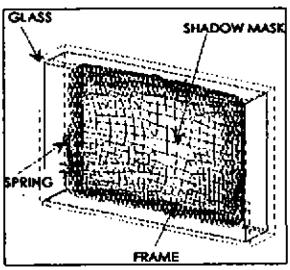


Figure 3. Finite Element Model

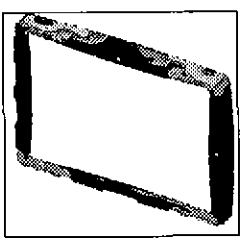
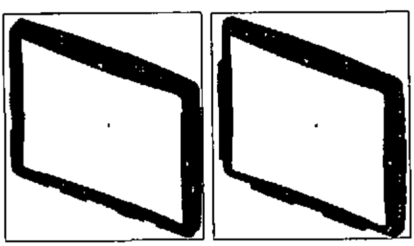
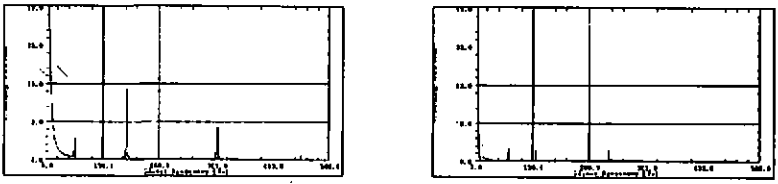


Figure 4. Strain Energy Distribution in Shadow Mask Frame



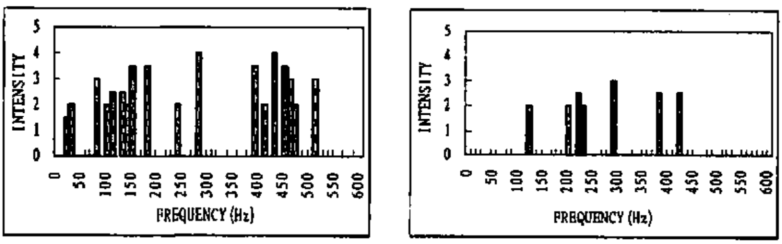
a) Before Modification b) After Modification

Figure 5. Shape of the Frame



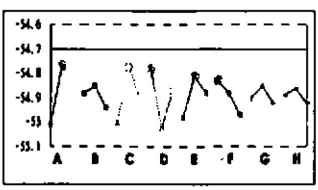
a) Before Improvement b) After Improvement

Figure 6. Change in Vibration Transmissibility of Shadow Mask Frame



a) Before Improvement b) After Improvement

Figure 7. Reduction of Microphonic Phenomenon



Natural Freq.	1st	2nd	3th	4th	5th	6th
Original	57.3	238	241	280	385	427
Improved	65.0	160	302	390	468	589

a) Sensitivity Analysis b) Natural Frequency Change

Figure 8. Modification of a 17" CRT Shadow Mask Frame Based Using Design of Experiment