The Design of Glass for Vixlim

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Abstract

Nowadays, CRTs are threatened by the flat panel displays (FPD). The screen quality of the CRT is one of best among the displays, however, the depth of CRTs becomes one of the most important design factor to maintain the dominated portion in the display market. When designing slim CRTs, the structure of the glass is important design factor because of the weight and safety. The stress in the glass is increased according to the shortening the total length of tube. The residual stress of the seal is also a major factor should be considered due to the large seal edge thickness. The glass design concept for Vixlim is introduced in this paper.

1. Introduction

CRTs have played a major role in displays for a long time. However, many kinds of FPD appeared a few years ago and they are threatening the CRTs nowadays. Although CRTs have strong merits of good performances and low cost, they have some defects compared with FPD such as depth, weight and power consumption. The set design with CRTs is bulkier than the flat panel displays. CRTs companies have made efforts to overcome the defects of CRTs, however, they didn't have the good results yet. Now we are developing 32" Vixlim of which deflection angle is 125 °. The wide deflection angle makes it possible to design the set thin enough to compete with FPD.

There are many problems when designing the wide deflection angle CRT. In those difficulties, the glass implosion is one of the most important factor. The stress in the glass is increased according to the shortening the total length of tube. The simplest method to decrease the stress is to make the tubes heavier than normal one. However, the designer associated in the new concept CRT can not avoid the cost problem and costumer's needs.

One of the difficult problems to design the glass of Vixlim is to decide the seal edge thickness (SET). If the implosion problem is considered only, the SET should be increased much more than normal CRT. However, the SET can not be increased so much due to the effective screen size, outside size of the panel, etc. Therefore, we have to consider the variable thickness of seal edge to reduce the SET. The residual stress on the interface of panel and funnel occurred in sealing process is also an important factor for mass product.

The implosion characteristic for normal tubes is mainly dependent on stress of panel, however, the importance of funnel is as much as the panel in Vixlim. The stress concentrations on funnel can be reduced by applying the optimal curvature. This study introduces the designing concept of the glass of Vilxlim.

2. Design concept

2.1 Variable SET

The first step to design the glass is to decide the SET. The SET of the glass strongly depends on the total length including panel and funnel. Although the SET would be controlled by the shape of funnel and the ratio of panel and funnel, the amount can be reduced is not so large. Therefore it can not be avoidable to make the SET large enough to stand against the vacuum stress. Figure 2.1 shows the vacuum stress of the glass. The tensile stress mainly concentrates to the seal and funnel body. The largest stress arises in the funnel body and the seal stress is little bit smaller than the funnel body. However, the most dangerous position at which crack can initiate is the seal, because some voids and small notches exist in the frit seals made in the process of sealing. The stress of the seal on short axis is large, however, the stress of the seal on long axis is relatively small. The compressive stress arises on the corner of seal. The seal of short axis needs large thickness, but small thickness is enough for long axis and corner seal. The SET of normal deflection angle CRT is not so large that there is no problem to use same thickness on entire periphery of the seal. If the SET on entire periphery is the same in large deflection CRT, the weight of the glass should be too heavy. The variable SET is used to reduce the total weight of the glass in Vixlim.

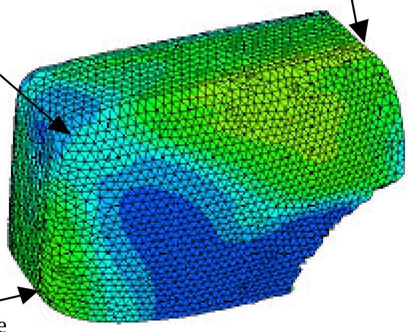

Fig.2.1 Seal stress

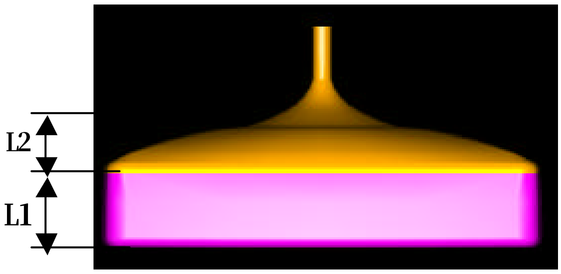

Fig.2.2 Panel and funnel length ratio

2.2 Length ratio of panel and funnel

The best design of the glass is to make it well-balanced between panel and funnel in view of structure. For passing the missile test prescribed in UL, the panel should be strong enough. However, if the panel is too stronger than funnel, it is difficult to control the failure behavior. So, we have to think of the structural balance of panel and funnel when designing the glass. Figure 2.2 shows the length ratio between panel and funnel. The strength of panel is related to the CFT(Center Face Thickness) and wedge ratio. The strength of funnel is mostly related to the length of funnel body. If the funnel length is long enough, the optimum curvature can be applied to reduce the stress of funnel body. The small radius of curvature should be applied to the stress concentrations in the funnel body. So, L2 in figure 2 should be designed long enough. L1 is related to the seal stress, so it is important to find out the best ratio between L1 and L2. The Vixlim glass has a optimal ratio of panel and funnel.

2.3 Residual stress in seal

As mentioned in chapter 2.1, the seal thickness of short axis is very large in comparison with normal angle CRT. Although the large seal thickness is good against the vacuum stress, it could play a bad role in sealing process with frit. It needs high temperature around 500°C in the sealing process because the frit between the panel and funnel should melt for adhesion. When the frit get stiff, mismatch can arise in the frit seal. As a results of this mismatch, residual stress arise in the seal area. Because the tensile residual stress affects the thermal resistance especially in exhaustion process, the mismatch in seal area can affect the productivity in mass product. The crack can be initiated at the high tensile stress area in frit seal. Figure 2.3 shows the stress near the seal. The use of strengthening frit can be one of the best method to decrease the tensile stress in frit seal area.

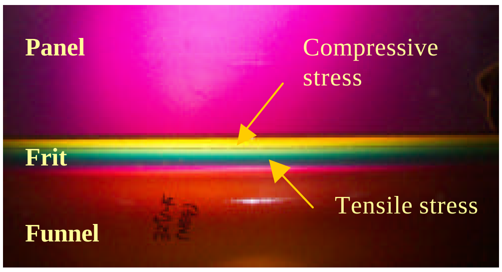

Fig.2.3 Residual stress after sealing process

2.4 Band

As written before, the glass implosion problem is one of the most important factors which should be considered to design the wide deflection angle CRT (Vixlim). The simplest method to decrease the stress is to make the tubes thicker and heavier than normal one. However, the designer associated in these concepts CRT can not avoid the cost problem. The alternative method to decrease the stress of the glass is to control the total length of safety band.

One of the difficult problems to design a band of slim CRT is to decide the total length of band. If the length of band is considered only, it should be decreased as much as possible. However, the band length can not be decreased so much due to the material property of the band and the outer size of the glasses and also manufacturing facilities give another limitation. Therefore, it is fundamental to simulate the banding procedure to optimize length and thickness of band.

One of the best methods to solve the banding procedure is to simulate the actual procedure and boundary conditions. The banding procedure consists of heating and compression by cooling. The main boundary condition is to design a band and glass contact areas when they contact as the band shrinks due to the cooling process.

In this section, procedure of banding simulation is described and the technique to optimize length of band is also presented. After modeling a band glasses, the band is heated to expand its circumference and it is cooled down to compress the panel glass. A vacuum bulb simulation should be done before banding simulations.

Fig. 1 shows typical band stress distribution through banding simulation. It shows concentrated stress around corner arc area of band. By changing a total length of the band or thickness, the stress distribution of band and glasses can be optimized. Its data is given on next graph.

Fig. 2 presents graph that shows tensile stress across the width of the band with different total length of band. Band 1 has shortest total length and band 3 has longest total length. As expected, the tensile stress on the band increases as length of band shortens. The Y axis shows normalized stress level. As the total length reduces, the tensile stress of the band increased. The stress level is normalized by the highest stress value of the band. It is possible to calculate optimum band length because maximum yield stress of the band is known. It is useless to shorten the total length of the band when the stress already reached its maximum yield stress.

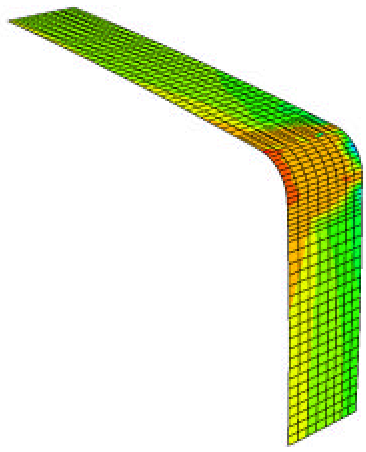

Fig.1 Band Stress Distribution

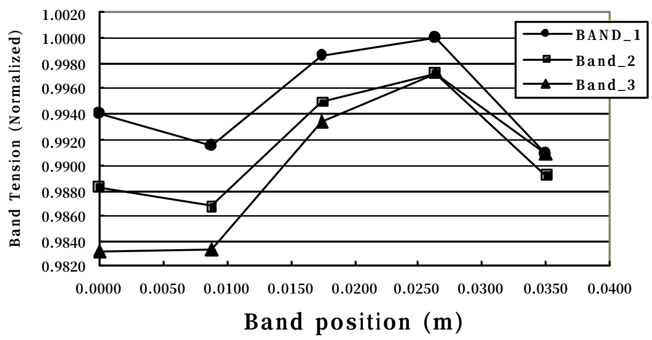

Fig.2 Band Tensile Stress

Fig. 3 shows typical glass stress distribution due to the band compression. It shows concentrated compressive stress on the corner area of panel glass. Band length can be optimized with glass stress distribution to avoid the glass implosion. The change of stress on the funnel body glass is given on next graph as the total length of band changes.

Fig. 4 presents graph that shows maximum principal stress outside of the surface around funnel body with different length of band along the short axis. As expected, the maximum principal stress on the glass decreases as length of band shortens. As the total length reduces, the maximum principal stress of the funnel body decreased. The stress level is normalized by the highest stress value of funnel body. It is possible to optimize the total band length and glass distribution.

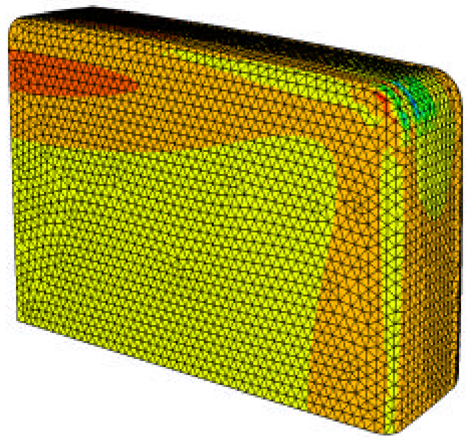

Fig.3 Glass Stress Distribution

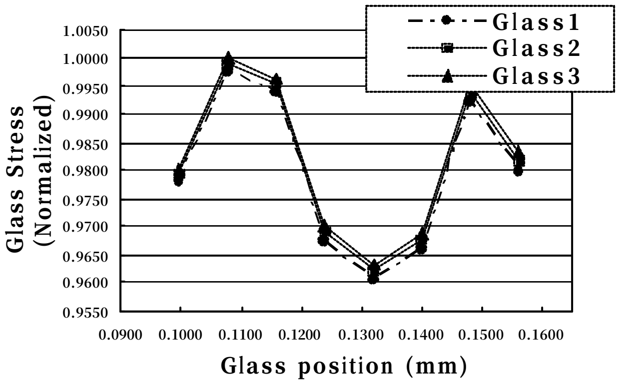

Fig.4 Glass Stress

Above data shows the stress distributions of the glass and the band are important factor to avoid the glass implosion and they can be optimized using total length of band. Therefore, the data shown here will give good guideline to achieve an efficient band design.

3. Conclusion

Although the CRTs have good performance, they have the defects such as depth and weight in compare with FPD. If the set design is shallow, CRTs can compete with flat panel displays and continue to play a main role in display. However, CRTs with wide deflection angle are difficult to make due to the problems such as the glass implosion, the deflection power and the beam spot size etc. Especially, the glass concept is changed in Vixlim, and it could be a new standard to design a glass for now. The obtained results are as follows.

(1) The variable SET is used for Vixlim to reduce the weight and improve strength.
(2) The ratio between panel height and funnel length plays a major role for safety of the glass.
(3) The stress in the seal is increased during the exhaustion process because of residual stress, so the strengthening frit can be a good method to reduce the seal stress.
(4) The effect of the band for Vixlim is very important comparing the normal CRTs.

4. References

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2. Joon-Soo Bae, Sridhar Krishnaswamy, Subinterfacial cracks in bimaterial systems subjected to mechanical and thermal loading, Engineering Fracture Mechanics 68, pp.1081-1094, 2001