The stress positioning control method for slim CRTs glass design using FEM

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ABSTRACT

One of the important roles of glass is safety guarantee in CRTs. It is working under high vacuum and has to be maintained continuously for the atmosphere pressure, humidity, and excitation etc,.

This paper propose to CRTs glass design method via the stress positioning control for slim CRTs using FEM to ensure the national safety standard and newly demanded safety standard by CRTs set makers.

1. INTRODUCTION

CRTs have to be made more slim and cheaper to survive in the display device area. Accordingly, slim CRTs developments are becoming the essential element. One of the importance in the slim CRTs developments is a security possibility of reliability for consumer.

CRTs have to maintain a vacuum using glass and glass having the characteristic of brittle material and the strong durability from elastic load. But, it is easily broken by crack under the plastic and impact load with broken pieces.

When the damage occurring, There is a possibility the consumer being injured. So, the safety of the consumer is the first in the CRTs glass design. Otherwise, glass has benefit from price, the characteristic of electrics, and mass production in the manufacture. From this reason, when developing the new model, it certainly must pass an international standard. In slim CRTs cases, the depth is decreased about 30% less than normal and the design of CRTs glass is base on the level of stress.

That is, slim CRTs are more difficult to satisfy allowable stress. In addition to, when the fire occurr, buyers are demanding that CRTs must be able to secure a safety.

This paper will propose the method of slim glass design to secure all of the safety guideline via stress positioning and direction control using finite element modeling.

2. DESIGN

Glass is a brittle material and strong under compressive load. But, it is weak under tensile load. In normal CRT case, glass has broken by the perpendicular direction of tensile stress such as Fig. 2. The tensile stress is very small enough to disregard such as Fig. 8. But, the tensile stress increases with effect of depth on the funnel of slim CRTs. The solution of this problem, stress will have to be distributed by the changing method of glass design via stress positioning and direction control. The method for a stress position and direction control is using a glass design factors. A design factor of slim CRTs glass is able to divide as panel and funnel.

A design of panel is typecast as a size and the change of design is excessively restricted.

According to this reason, this paper exclude panel from the design method of slim CRTs glass.

Consequently, the stress positioning and the direction control are constrained by factors of the funnel design.

Dividing a funnel into design factor, which are composed with SET, FBC, and FBT such as Fig. 1. And the design of yoke excluded because it is DY design factor.

This paper will propose the method of slim glass design via stress positioning and direction control using the change of funnel design.

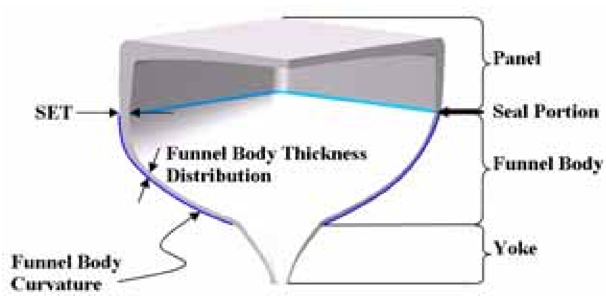

Fig. 1. The Schematic design of slim glass.

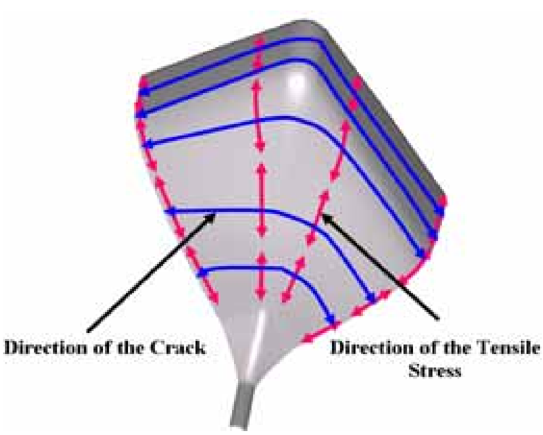

Fig. 2. Direction of the Stress & Crack

The SET is thickness of the seal portion. Panel and funnel are joined by frit glass at this position such as Fig. 1. A stress is occurred by the Equation. 1 on the glass and increase at the seal portion by a vacuum. Because the strength of frit glass is lower than panel and funnel.

$$\textit{Stress}\ (\sigma) = \frac{\mathrm{P}(\textit{pressure})}{\mathrm{A}(\textit{area})} \quad [\textit{MPa}] \quad (1)$$

According to this reason, the SET has close relationship with a tensile stress and the stress level. A stress can be able to decrease by the change of it. But, it is only related to reduce the absolute stress and not engaged in the positioning and direction of a stress.

Therefore, in this paper exclude the SET from the variable of glass design to control of the stress.

If the outside surface area of glass is the same, the total stress is same also because it will be occurred by the law of conversation of energy. But, the shape of glass can be able to make vary shape considerably by the aim of design. Therefore, the change of stress and direction control make possible.

A funnel design is based on the FBC, R1, R2, and R3 that 3D modeling has designed from them such as like Fig. 3. It is easy to see that the shape of funnel is depended on FBC.

That is, R1, R2, and R3 are dependent on FBC. From this result, FBC is the main factor for the stress control.

At the Fig. 3, FBC is composed of several curvatures such as the major, minor, and diagonal axes.

It can make different surface entirely of the funnel by different curvature height among the major, minor, and diagonal axes.

The direction and distribution of a stress are depended on the shape of funnel.

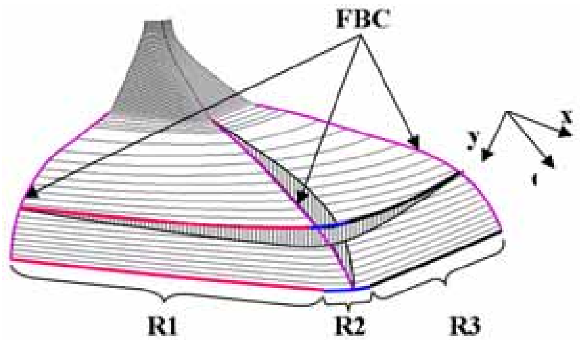

Fig. 3. Design Method of the Funnel

In normal CRTs cases, the distribution of funnel body thickness is thinner proportionally from seal portion to yoke. In slim CRTs case, the stress of funnel body has increased and driven to the major and minor axes. Refer to the Fig. 4, stress of funnel body is divided with tensile and compression.

Glass is strong in compression but weak in tensile stress. From this a physical phenomenon, the distribution of funnel body thickness is applied to vary from seal portion to yoke on the diagonal axis using Fig. 5.

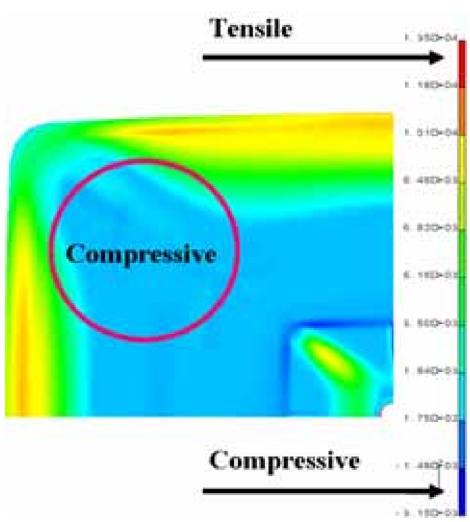

Fig. 4. Tensile & Compressive Stress Position on the Funnel

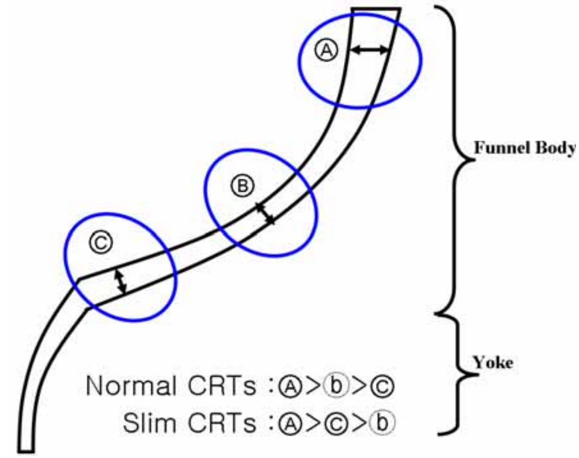

Fig. 5. Slim CRTs Thickness Distribution on the Diagonal

3. SIMULATION

After joining, panel and funnel, a vacuum has maintained in the glass. From this reason, compressive pressure has given on the outside surface of glass perpendicularly. In simulation, the same load of compression gives the 3D model as boundary condition such as Fig. 6.

To reduce solving time, a quarter solid model is applied to making an analysis and give a symmetric constraints.

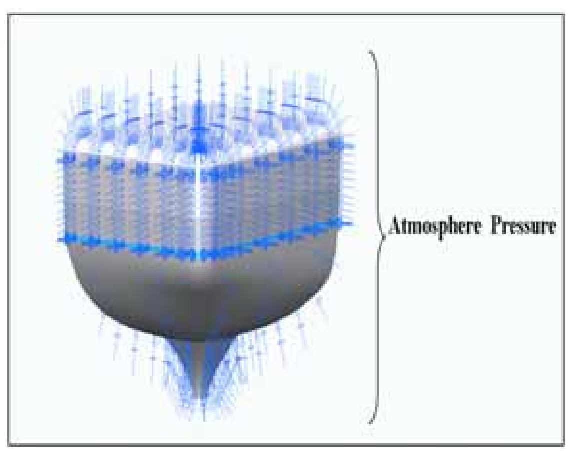

Fig. 6. Atmosphere Pressure on the Glass

The element type is prefer solid to shell in slim CRTs that they have a variable thickness on the funnel body to reduce stress in this paper.

One of solid elements, 8 nodes brick element using mapped mesh have the advantage of the solving time and quality of results.

Material properties apply to the FEM such as follows Table. 1.

Table1. Material Properties.

	E [mN/㎟]	G [mN/㎟]	Poisson's ratio	Density [kgf/㎟]
Panel	7.12E+07	4.43E+07	0.244	2.77E-06
Funnel	7.12E+07	4.43E+07	0.244	3.00E-06

Thermal Coe. [1/℃]	Thermal Conductivity Coe [W/m·K]
1.11E-05	9.70E-01
1.05E-05	9.10E-01

Post processing is carried out linear elastic analysis and monitored the maximum principle stress by compression and extension.

4. Results

In this paper, FBC and FBT were used to the positioning and direction of stress. Regression analysis was carried by the relation of among FBC, FBT and stress. All of the design factor and stress is monitored by the half position on the funnel body height such as Fig. 7.

Regressing equation was calculated on the minor axis same as equation. 2 because the maximum stress appeared on the minor axis such as Fig. 8.

S = 18.4 - 0.026 A - 0.451 B - 0.159 C - 0.0068 D + 0.196 E - 0.0543 F [MPa] ----------------------- 2)

[(A, B, C → Thickness of the major, minor, diagonal),(D, E, F → Curvature height of the major, minor, and diagonal), (S→ Stress on the minor axis)]

The relation of the stress on the minor axis and thickness has proportional. On the major and diagonal, higher curvature has better than lower for stress. In the minor axis case, a lower curvature height has benefit to distribute a stress.

The direction of a stress was changed by the difference of curvature height on the axes. In the diagonal was higher and higher than others, the direction of a stress was change very well such as Fig. 9.

In (B) at the Fig. 9 case, when occurring a crack, the propagation of it is limited partially. According to this reason, the safety can be guarantee.

In this paper offer a markedly different approach to reduce and control stress on the slim CRTs glass and validate that the change of FBC and FBT are able to the stress positioning and direction control..

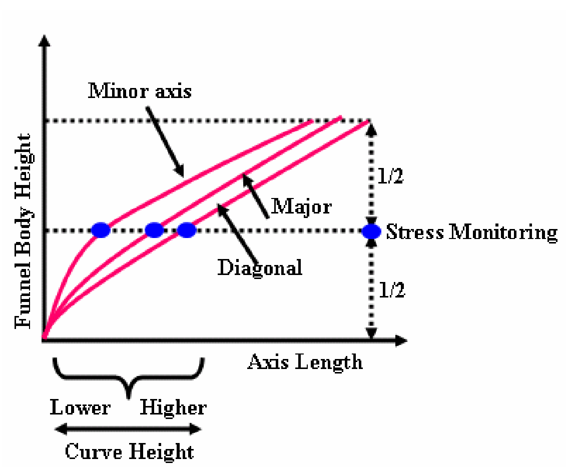

Fig. 7. Change of curvature by the variable height.

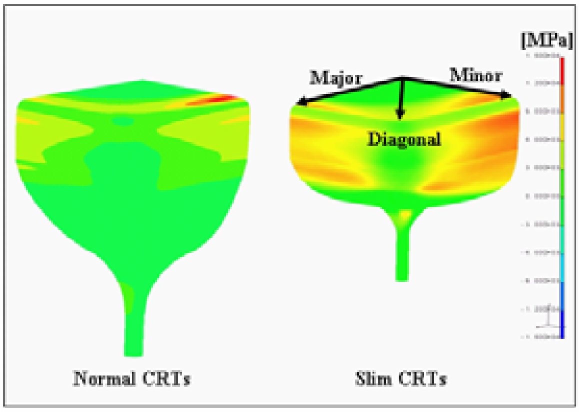

Fig. 8. Tensile & Compressive Stress

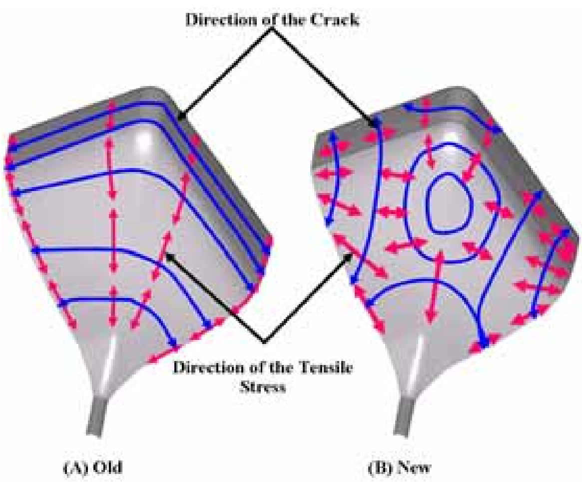

Fig. 9. Direction of the Tensile Stress & Crack

5. References

[1] Asish Ghosh, Chin Young Cha, and Shridhar Vaidyanathan, "Finite Element Stress Analysis and Crack Path prediction of Imploding CRT," European Society of Glass Science and Technology Conference, Ceramic Transaction, Vol.17(1991)
[2] Suresh T. Gulati, "Relative Impact of Manufacturing vs. Service Flaws on Glass Articles," American Ceramic Society, Indiana polis(1994)
[3] T.J.R. Hughes, "The Finite Element Method. Linear static and dynamic finite element analysis. Prentice-Hall, Englewood Cliffs NJ(1987)
[4] O.C. Zienkiewicz, "The Finite Element Method. McGraw-Hill", London(1997)
[5] J.C.W van Vroonhowen, "Dynamic Crack Propagation in Brittle Material: Analyses Based on Fracture an Damage Mechanics," PhD Thesis, Eindhoven University of Technology ,"The Netherlands(1996)
[6] Randy H. Shih, Introduction to Finite Element Analysis using I-DEAS 11,"Schroff Development Corporation(2004)