A Small Proposal for the Panel Inner Curvature for Flat-Surface Color Tubes

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Abstract:
Regarding doming of AK mask, many investigations have been made so far.
The mechanical design looks almost at the limit.
Curvature design of the mask is a key point.
The subject is discussed from the panel curvature point of view and a new panel curvature function that is advantageous for mask design is proposed

1. Introduction

For color picture tubes, 'cost' is the strongest point over other display devices.
In order to make use of the merit, how to reduce 'doming' with AK iron mask is the most important point in the design.
For the purpose, it is required for a mask to be given a large curvature of suitable distribution.
The mask curvature is practically a function of the panel curvature and the slot pitch. Therefore, when a panel is designed, its relationship or combination with slot pitch should be taken into account.
In connection with this view, the paper discusses a very beginning step of designing the panel inner curvature.

2. Parameters That Dominate Mask Curvature

Imagine a process of designing an inner curvature of a panel for a flat-surface color tubes.

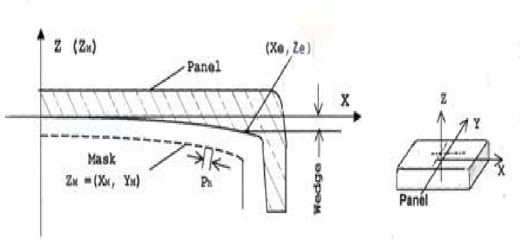

Fig. 1 Definition of Variables

First, thickness of the glass at the center and the periphery (Corner, X-end, and Y-end) is decided (Fig.1). At that time, distribution of optical transmittance of the glass is considered.
The thickness increment from the center to periphery is usually called 'wedge'.
Next, the profile of the panel on Y=0 cross section is to be decided.
The paper focuses the discussion on this process.
(Note): Therefore, the discussion is limited on Y = 0 cross-section (and X>0 region) hereafter.
The cross section of the panel is usually expressed with a polynomial as

$$\{Z(X, 0) =\}\ Z(X) = A_2X^2 + A_4X^4 + A_6X^6 \quad (1)$$

Use of this function is natural, because the panel is symmetric with respect to X = 0 plane.
The profile is decided by appropriate selection of the coefficients that satisfies the given wedge condition.
Importance of this process has been well understood, because the panel curvature directly affects to the mask curvature that dominates the doming. (See section 4).
(Note) The local curvature of the panel on Y = 0 cross section is approximated with $|\partial^2 Z/\partial X^2|$ throughout the paper.
On the other hand, the horizontal pitch of the mask slot arrays (slot pitch) is another important parameter that dominates the mask curvature.
This means that the panel design should be so made that the total effect of the panel curvature and the slot pitch realizes the optimum mask curvature over its entire span.
Regarding the slot pitch (P_h), its second derivative relates closely to the curvature of the mask. Usually Ph function has a monotonous second derivative [1] [2].

In short, the local curvature of the mask at X_M (= denoted by κ_X) can be expressed very roughly as

$$\kappa_X = K(\partial^2 P_h / \partial X_M^2) + L\,|\partial^2 Z/ \partial X^2| \quad (2)$$

K and L are constants given at every X (or X_M).
In a very rough discussion, the above two terms can be almost comparable in magnitude.
Therefore, decision of the ratio with which, from the screen center to X-end, κ_X is borne by the above two terms should be one of the points to be discussed.
The panel profile (1) should be decided considering the situation.

3. An Inspection of the Panel Inside Surface

Note: The coordinates of X-end of the panel are expressed with (X_e, Z_e). See Fig.1.
Roughly speaking, in the zone close to the screen center, the mask curvature κ_X is not so important because of the smaller deflection angle. That is, there is little problem in deciding the magnitude and the ratio of the first (pitch) term and the second (panel) term in expression (2).
In the mid-zone (roughly $X_e/4 < X < 3X_e/4$) both the terms should exercise their power maximally for making the mask curvature large.
However in this area, the smaller X is, the more important the second term is, because it (the second term) does not influence the resolution and coarseness of the screen mosaic at the major zone of the screen.

(In the zone near X-end, it is easy to give a considerable curvature near to enough as a natural result of the effort in the above mid-zone.)

Therefore, the panel profile Z preferably be so designed that curvature $\left| \partial^2 Z / \partial X^2 \right|$ takes as large a value as possible at a certain X in the mid-zone. The point of emphasis should be on smaller X of the mid-zone.

Now, going back to expression (1), Fig. 2 shows typical graphs of $\left| \partial^2 Z / \partial X^2 \right|$ that are calculated from expression (1).

Note: The inverse of the curvature is shown in Fig. 2

Graph 1, 2, and 3 corresponds to the case in which expression (1) consists of just a single term of X^2, X^4, and X^6 respectively. Of course, it is possible to consider combination of these terms.

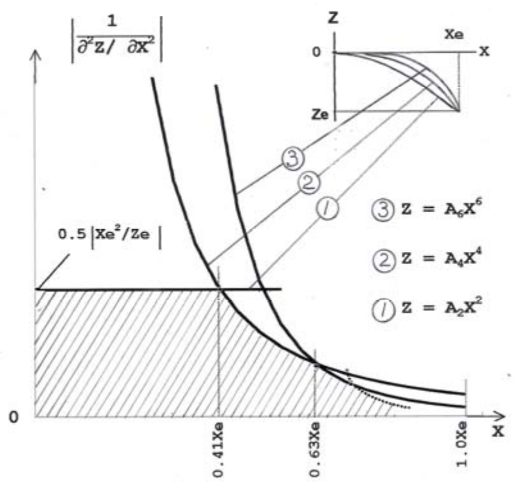

Fig. 2 A Nature of Polynomials of Even Powe of X

As seen, there is a certain freedom of the distribution. However, as far as expression (1) is used, it is impossible to make a curve enters the gray area of Fig.2.

As a result of the natural course, the discussion reaches a thought that the curvature should preferably be so decided that it takes the possible maximum value {possible minimum value in the term of $\left| 1 / (\partial^2 Z / \partial X^2) \right|$} at X where the first convex point is (X = 0.41Xe).

In the light of this consideration, it is analytically found that, among monomial power functions of X,

$$Z = A \left| X \right|^{2.84} \qquad (3)$$

gives the maximum curvature at the first convex point. The graph is shown in Fig.3.

In the graph, an example by expression (1) in which terms of X^2 and X^4 are optimally selected (from the view of the above discussion) is drawn as well.

These two graphs being compared over the zone of $X_e/4 < X < X_e/2$, it is understood that the proposal can increase the curvature $\left| \partial^2 Z / \partial X^2 \right|$ by about 15 to 18%.

This thinking way is proposed as a start point of the panel design (As a matter of fact 2.84 can be replaced with 2.8 or 3.0).

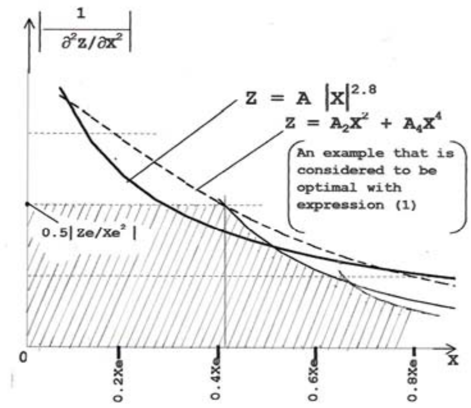

Fig.3 A New Profile

(Note) Since the surface is used for displaying pictures, $\partial^2 Z/\partial X^2$ should be monotonous with respect to X to give natural view of the screen.

4. Substantial Local Curvature of a Shadow Mask Having Slot Apertures

It is known that the local deformation of a mask due to doming is almost inverse proportional to the local curvature of the mask surface [(3)].

That is, referring to Fig. 4, for a given heated area

$$d = \alpha / \kappa \qquad (4)$$

Here, κ is the original curvature at the point in question (local curvature), and α is a constant that includes diameter of the heated area, local rise of the temperature, the thermal expansion coefficients, and the modulus of elasticity.

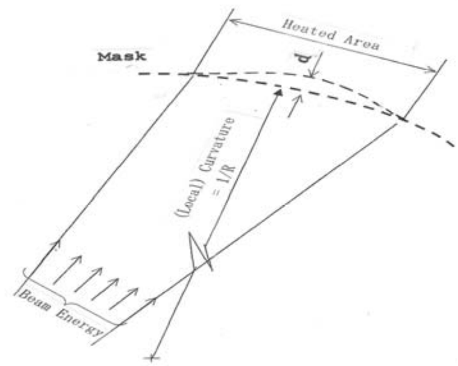

Fig.4 Doming: d

However, this discussion has been done about an isotropic shadow mask surface (a spherical shadow mask having circular holes).

In case of color tubes having slot apertures, it is necessary to examine what local curvature κ means.

Here, it is considered to be possible to introduce a term 'Substantial Curvature' (denoted as κ_s here) with which the doming is expressed as

$$d = \alpha / \kappa_S \quad (5)$$

κ_S is expressed as

$$\kappa_S = C\kappa_X + D\kappa_Y$$
$$\cong C\, |\partial^2 Z_M / \partial X_M^2| + D\, |\partial^2 Z_M / \partial Y_M^2| \quad (6)$$

C and D are the constants that express contribution of each κ_X and κ_Y to κ_S and C + D =1.
Empirically the author thinks that C = 0.3 and D = 0.7 is a good practical pair of values for normal masks.
(Note): The discussions of this section on 'Substantial Curvature' have been made by inference. It is anticipated that someone leads this form theoretically.
Since C is considerably smaller than D, the improvement in doming by the proposal here is not so large.
Further the discussion is limited just on Y = 0 cross-section. There are still so many parameters to be decided after this step.
However, the proposal is considered to be advantageous for shadow masks of AK iron.

5. Conclusion

In the design of panel inside curvature for a flat-surface tube of AK iron mask, it is desirable to consider the relationship with the slot pitch distribution.
After introducing the way of thinking, as an example of Y = 0 cross section of the panel, use of $|X|^N$ curve (Where N is around 2.8) has been proposed.

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References

1 M. Morrell: *IEEE Trans*, Vol.CE-24, No.1, Feb, 1979, pp120-125.

2 *USP* 4,631,441.

3 Y. Takano: *The Journal of the Institute of Television Engineers of Japan* Vol.31, No.6, pp484-490.