THERMALLY INDUCED STRESSES IN PLASMA DISPLAY PANEL (PDP) MODULE

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PDP내에서의 열응력

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Predictive modeling schemes have been developed to characterize the heat transfer and thermo-mechanical behavior for the plasma display panel (PDP) in operation. The inverse approach was adopted to predict the accurate temperature distribution and deformation in PDP. The predictive models were validated with the measurements from real panel. The developed models could be utilized to predict and/or improve the product quality of PDP.

1. INTRODUCTION

The plasma display panel (PDP) operates on the principle of light emission by a gas discharge. The light output is the result of the direct conversion of input power into visual light. During the gas discharge, a considerable portion of input power is lost in form of heat generation. The thermo-mechanical behavior due to the power loss in PDP needs to be understood to improve the product quality and to obtain the guidelines on new product design. The computational model helps understand and gain insight into the basic trends of physical characteristics, without costly experimental tests. In this work, the thermal and structural modeling schemes have been developed to characterize the heat transfer and thermo-mechanical behavior of PDP in operation. The inverse approach was adopted to predict the accurate temperature distribution and deformation. The predictive models were validated with the measurements from real panel.

2. MATHEMATICAL MODEL AND CALCULATIONS

The governing equations for the heat and fluid flow and the structural behavior in PDP are considered. The general form of equation for the air flow and heat transfer is as follows:

$$\frac{\partial}{\partial t}(\rho\phi) + div(\rho\mathbf{u}\phi) - div(\Gamma grad\phi) = S_\phi$$

where ϕ represents $u, v, w, k, \varepsilon, h$. S_ϕ is volumetric source for ϕ The governing equation for the structural behavior is derived by forming a balance between the external and internal forces using the principle of virtual work. For reasonably small strains, the stress-strain relationship is linear and may be expressed as:

$$\sigma = D(\varepsilon - \varepsilon_0) + \sigma_0$$

Here, D is the elasticity matrix containing material properties, σ_0 and ε_0 are the initial stresses and strains, respectively. We solved the governing equations, using commercial software, CFD-ACE(U) by CFDRC,[1] to carry out the analysis of heat transfer and thermo-mechanical behavior.

3. RESULTS

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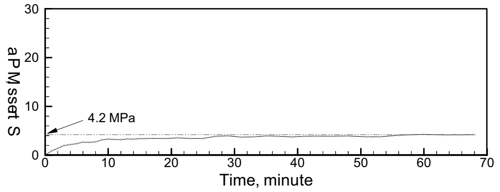


Fig. 1 Principal stress from the measured data of strains.

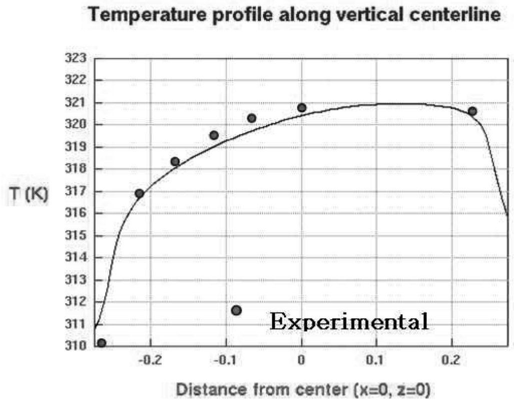
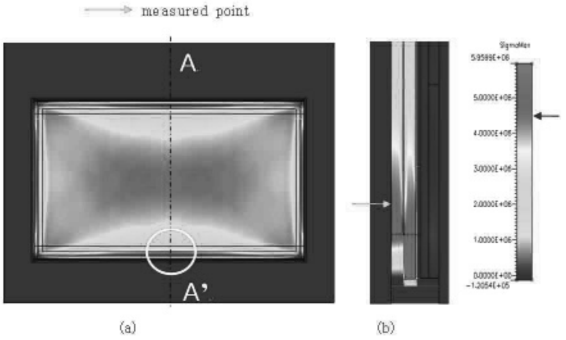


Fig. 2 Temperature profile along the vertical centerline.

The temperature distribution depends on the display pattern of visual screen. The study of the thermo-mechanical behavior was performed for full display pattern. Fig. 1 shows the principal stress variation with time at a lower-center point on the surface of the front glass. The stress was estimated from the strain data measured by strain gauge. As can be seen in Fig. 1, the measured stress converges a constant value of 4.2 MPa. The comparison of the predictive temperature with the measurement is given in Fig. 2. Temperature profile was plotted along the vertical centerline on the front glass surface. Fig. 2 shows that the modeling prediction has good agreement with experiments for real panel.



(a) (b)

Fig. 3 Principal stress distribution (a) for front glass surface (b) for cross-sectional area through line AA'

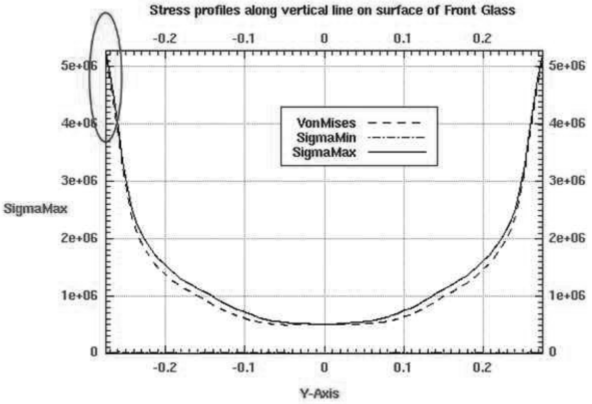


Fig. 4 Principal stress profile along vertical centerline

Fig. 3(a) shows principal stress distribution on the front surface of PDP. As can be observed in Fig. 3(a), tensile stress occurs over the front glass surface. Especially, high value of principal stress takes place on the mid-edge of all sides. Lower level of stress appears on the most part of the surface. Fig. 3(b) represents stress distribution over the lower zone of the cross-sectional area through the vertical centerline (line AA' in Fig. 3(a)). Maximum stress exists at the lower edge of rear glass. Fig. 4 shows the predicted stress profiles along the vertical centerline (refer to Fig. 3) on the front glass surface. Higher stress takes place at both lower and upper edges. As shown in Fig. 4, the stress sharply decreases with distance from the edges to central zone. From this tendency, it is presumable that PDP failure is likely to happen near the edges. When compared with experiments, model prediction at experimental location has fallen within 5% accuracy.

4. SUMMARY

Model predictions showed good agreement with the experimental data. Therefore, the developed models could be utilized to predict and/or improve the product quality of PDP.

REFERENCES

[1] 2002, *CFD-ACE(U) Modules, Ver.2002.*