Comparison of Optical Characteristics between CCFL and EEFL in Direct-type Backlight Unit

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In this study, It was studied about the luminance characteristics of 17 inch direct-type back light using EEFL(external electrode fluorescent lamp) and CCFL(cold cathode fluorescent lamp). The EEFL has a long life time because the electrode is installed outside of lamp. And it is produced in lower price than conventional CCFL. Moreover, it does not need process of installing internal electrode. However, the EEFL technology has several problems such as difficulty of designing driving inverter and preventing this phenomenon along the skin of lamps. We suggested two types of backlight unit for LCD TV application using the EEFL and the CCFL. We found optimized optical design parameters. We set the optical variation parameters such as lamp height, lamp distance, total thickness, and angles of inner walls. We achieved 7580 nits of center luminance, 82 % of luminance uniformity by using 20 lamps of the EEFL and 7297 nits of center luminance, 78 % of luminance uniformity by using 16 lamps of the CCFL.

Keywords : TFT-LCD, Direct type backlight, Optical simulation, High brightness, CCFL, EEFL

1. INTRODUCTION

Recently, the demands of LCD (liquid crystal display) for TV application increase rapidly. The high brightness backlight is very important technical essential for LCD TV application. Most of direct type backlight unit light source for LCD TV are equipped with CCFL(cold cathode fluorescent lamp)[1,2]. It has been used long time in LCD applications as an optimized light source. The CCFL has several merits as for power consumption, thickness and life time. But it is weak at long time operating in LCD monitor or Note PC[3]. The note PC is not specialized in high performance but the characteristics of mobility[4]. Generally, operating condition for high brightness causes short life time characteristics. The radiations of the CCFL come from consumption of the mercury gas. The CCFL has limitation on the mercury additive so high brightness means short life time. This mercury consumption is bound to exposed electrode in the CCFL. So scientists invented external electrode lamp to achieve long time characteristics. It called EEFL(external electrode fluorescent lamp)[5]. It has long life time because of its mercury consumption-free method. However, the EEFL induces high electrical field around both end sides, not direct current input, it is darker than CCFL. It shows 70~75 % radiation as compared to the CCFL's. But the

EEFL has not internal electrode such as nickel or molybdenum so that it costs lower than the CCFL. So many LCD production company developed direct type back light unit using the EEFL. In this research, we did not mention about critical defects about the EEFL. We tried to optimize backlight design using optical simulation method[6-9]. We set the condition of 20 EEFL use and studied the best opto-dimensional design parameters. It demonstrated 7580 nits of the center luminance and 82 % of visual area luminance uniformity under above condition in 32 inch back light for LCD TV application. And then, we adopted the same method in CCFL use. It showed 7279 nits of the center luminance and 78 % of visual area luminance uniformity. We set the optical parameters in this research and found the best design guide in the CCFL and the EEFL types backlight of LCD TV application using SPEOS(OPTIS co., ltd, French).

2. SIMULATION

Before simulation, we set simulation condition in both cases. Figure 1 and Table 1 show limited condition of simulation. We targeted total height under the 20 mm thickness and calculated 1,000,000 rays by ray tracing method.

Fig. 1. Set the simulation parameters.

Table 1. Set the simulation parameters.

Items	Parameter	Figure Number
Heights of Lamp to reflection plate	H	(a)
Inner wall angle aligned vertical lamp direction	$\Theta 1$	(b)
Inner wall angle aligned horizontal lamp direction	$\Theta 2$	(c)
Total Height	T-H	(d)
Initial distance of lamp to inner wall	L1	(e)
Distance of lamp to lamp	L2	(e)

3. RESULTS AND DISCUSSION

3.1 EEFL type backlight simulation

First, we calculated the EEFL type backlight with above limited optical parameters. Figure 2 shows result of lamp height variation. We increase lamp height, which means closer distance of lamp to diffusing plate. Increasing the lamp height, the luminance is escalated.

Fig. 2. Results of lamp height simulation.

But visual area luminance uniformity goes to worse. We suggested the best lamp height is 6mm as the simulated result.

And then, we calculate $\Theta 1$ parameter. The $\Theta 1$ means the inner wall angle aligned to vertical lamp direction. We simulated the $\Theta 1$ variation from 90 degrees to 50 degrees and found the best angle of 70 degrees, which shows the best edge luminance uniformity characteristics.

Fig. 3. Results of $\Theta 1$ simulation. Fig. 4. Results of $\Theta 2$ simulation.

Fig. 5. Results of T-H simulation.

Figure 4 show the results of $\Theta 2$ parameter variation in optical simulation. We investigated the best condition of $\Theta 2$ from 90 degrees to 60 degrees. It shows the optimized condition at 60 degrees of $\Theta 2$ angle.

Fig. 6. Results of L1 and L2 simulation.

Next, we calculated total height parameters. T-H variation starts from 18mm to 21 mm. And we suggested the best condition at 20mm of the T-H parameter. Figure 5 shows simulation results of the T-H parameter.

Finally, we calculated L1 and L2 parameters[10]. Figure 6 shows L1 and L2 simulation data. We selected the best condition at two different views. One focused on center luminance improvement as shown in Fig. 6(b), the other focused on edge uniformity and visual area uniformity improvement as depicted in Fig. 6(d). But the former condition meets uniformity target, we selected Fig. 6(b) condition.

3.2 CCFL type backlight simulation

Second, we calculated the CCFL type backlight. We handled the same format as the EEFL simulation parameters. finally, we compare data each other. Figure 7 shows the simulation results of H parameter variation. We found that it was the best result of simulation in 5.5 mm of H condition.

Fig. 7. Results of lamp height simulation.

Fig. 8. Results of $\Theta 1$ simulation.

And then, we calculate the $\Theta 1$ parameter in the CCFL type backlight. Figure 8 shows the results of $\Theta 1$ parameter variation. It is optimized under the condition of 75 degrees of $\Theta 1$ parameters.

Fig. 9. Results of $\Theta 2$ simulation.

Fig. 10. Results of L1 and L2 simulation.

Figure 9 shows the results of the $\Theta 2$ parameter variation in optical simulation. We investigated the best condition of $\Theta 2$ from 90 degrees to 60 degrees. But we couldn't find ideal value of optimized the $\Theta 2$ parameter. So we divided into more detailed conditions and then found 77 degrees of $\Theta 2$ parameter at last.

Finally, we calculated L1 and L2 parameters. To compare the EEFL type back light, we fix the total height. So we did not need to calculate total height parameter. The best values of the L1 and the L2 indicated 15.95 mm and 24.5 mm. Figure 10 shows the simulation data of the L1 and the L2.

We investigated optimized optical design results for LCD TV backlight via simulation data. Figure 11 shows the EEFL backlight result using 20 lamps. It is adopted with 6 mm of lamp height, 70 degrees of $\Theta 1$, 60 degrees of $\Theta 2$, 20 mm of total heights, 16mm of L1 and 19.33 mm of L2 values. We achieved 7580 nits of center luminance, 82 % visual area luminance uniformity. And then, we design CCFL backlight for LCD TV at the same rule. It was adopted with 5.5 mm of lamp height, 75 degrees of $\Theta 1$, 77 degrees of $\Theta 2$, 20 mm of total height, 24.5 mm of L1 and 24.5 mm of L2 values. As shown in Fig. 12, we achieved 7297 nits of center luminance and 78 % of visual area luminance uniformity.

Fig. 11. Optimized EEFL backlight design result for LCD TV application.

Fig. 12. Optimized CCFL backlight design result for LCD TV application.

4. CONCLUSION

We studied optimized backlight design for 32 inch LCD TV application using the EEFL and the CCFL. We set the simulation parameters of direct type backlight design and found each optimized parameters by using optical simulation software of the SPEOS. We suggested the best design condition using reverse ray tracing method. Using optical simulation is more convenient and economic method than making real specimens. And it shows improvement of visual uniformity and high luminance under the conditions of using 20 EEFL lamps and 16 CCFL lamps.

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