Optical Simulation of Direct-type Backlight Unit for Medical Application

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In this study, it was investigated about optical simulation in direct-type backlight design. Direct-type backlight has been used high-brightness backlight such as medical LCD application. The key parameter in designing direct-type backlight was consists of three geometrical dimension such as the distance of two lamps, the gap of lamp and reflection plate and the number of lamps. It has many of variations in optical design and it causes the different properties in backlight system. It shows the best values of above parameters; 26 mm of the distance of two lamps, 4.5 mm of the gap of lamp and reflection plate and 16 lamps. And we produced the specimen as above condition, and acquired good result in backlight such as the value of the brightness is 6423 nit in center of emission area and less than 5 % in brightness uniformity. It shows the effective ways of designing backlight system using optical simulation method for medical LCD application.

Keywords : TFT-LCD, Direct type backlight, Optical simulation, High brightness, Medical LCD application

1. INTRODUCTION

Recently, the demands of LCD (Liquid Crystal Display) for medical application increase rapidly. The high brightness backlight is very important technical essential for medical application such as MRI, CT and electrically processed Roentgen images. Because LCD is oriented organic shutter theory, it is not emissive device, high brightness LCD application means more high brightness Back light technology. In addition, medical application has several particular characteristics. It must have high uniformities property in visual displayed area. And it has high brightness because it is required high contrast ration to decode particular illness spot in still or moving image. Most of medical use LCD application has high resolution. So that, transmission ration of LCD panel is very low. It means that it is required more bright backlight unit. Conventional medical use LCD has 3 times high resolution as full color LCD because it is used monochromic display image. By not using 3 colors, it has high resolution naturally. Most of medical use LCD application needs more bright backlight unit than LCD's luminance because LCD has extremely low transmission ration[1,2]. And high quality medical display means high contrast ratio, wide viewing angle, especially gray scale conversion-free properties, it is more low transmission ration than note PC or monitor application. Conventionally, Backlight for medical LCD application has a direct type shape. It consists of arrays of CCFL(Cold Cathode Fluorescent Lamp), bottom reflection plate and upper diffusing plate. If we use many CCFL, it is very easy for design[3]. But using many lamps, it is impossible for achievement low power consumption. On the other hands, if we use small number of CCFLs, it is impossible for making good visual uniformity and high brightness. Most of medical application backlight has optimized number of actual ability[4,5]. But, knowing optimized CCFL's numbers means not optimized optical design. We have to solve another problem, such as more thin thickness and more good visual uniformity. It depend on several optical parameter, such as length of lamps, height of lamp to reflection plate and to diffusing plate. Most of LCD production companies, tested actual samples, it costs very high and takes much times. So we propose optical simulation using reverse ray tracing method. We uses SPEOS(OPTIS co., ltd, French) and very exactly results of comparison simulation data and actual specimens data. We achieved design data about optical parameters[6-10]. We investigated about relationship of lamp numbers and diffusing plate height, angles of inner walls and shapes of reflection plate. At result, we calculated 6423 nits backlight unit condition under 16 lamps usage, 2 mm thickness diffusing plate, one diffusing sheets condition for 32 inch medical LCD application.

2. SIMULATION

Before simulation, we set simulation condition. And we targeted the goal of simulation such as numbers of lamp versus heights of lamp, numbers of lamp versus heights of diffusing plate, heights of lamp versus heights of diffusing plate and brightness dependent of shape of reflection plate or inner wall angle. First, we set the simulation condition. Table 1 shows characteristics of material, and Fig. 1 and Table 2 show optical simulation parameters.

Table 1. Simulation condition.

Number of rays	10,000,000 rays	
Reflection plate	RF188	Total reflection ratio : 95.19 % Gaussian Reflection : 4.5 % Lambertian Reflection : 95.5 %
Diffusing plate	Kuraray	Transmission ratio : 70 %
Flux of lamp	Matsushita	350 lumens

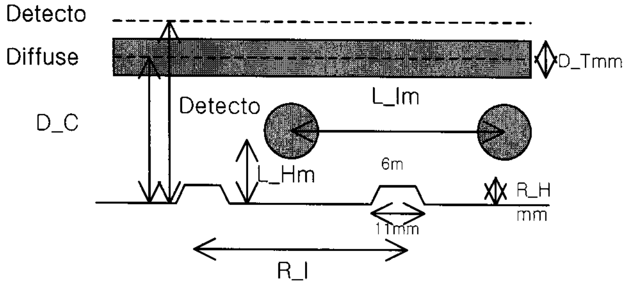

Fig. 1. Optical simulation parameters.

Table 2. Major parameters of optical simulation.

Items	Major parameter	Minor parameter
Heights of Diffusing plate	D-H	
Heights of Diffusing plate center		D-C
Thickness of diffusing plate		D-T
Distance of reflection plate shapes	R-I (Distance)	R-S (Shape)
Distance of lamps		L-I
Heights of lamp from reflection plate		L-H

3. RESULTS AND DISCUSSION

Figure 2 and Table 3 show the results of relationship number of lamps and heights of lamp. It shows that 4.5 mm heights is the best luminance condition in 16 lamps operating. Conventionally, it depends on the quaternary number because it is more convenient for design inverter. So, 16 lamps condition is best suitable result for backlight unit[11]. And 16 or 18 lamps have the best luminance result in 4.5 mm heights. Under the 16 lamps and 4.5 heights condition, 6597.29 nits was simulated.

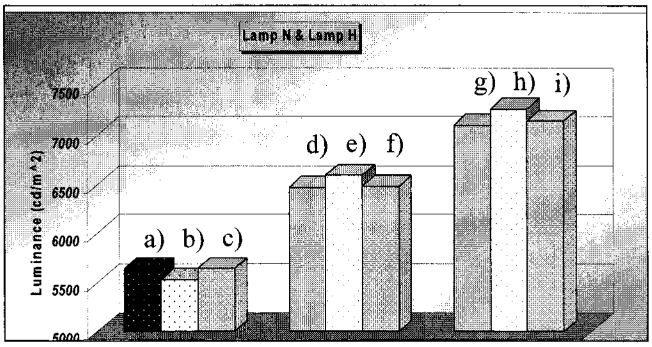

Fig. 2. Simulation results of numbers of lamps and heights of lamp.

Table 3. Simulation results of numbers of lamps and heights of lamp.

Heights of Lamp	14 Lamps	16 Lamps	18 Lamps
3.5 mm	a) 5643.14	d) 6474.62	g) 7103.90
4.5 mm	b) 5534.28	e) 6597.29	h) 7269.74
5.5 mm	c) 5645.41	f) 6485.97	i) 7144.80

In Fig. 3 and Table 4 show the results of number of lamps and heights of diffusing plate. In 16 lamps condition, 22~24 mm is the best luminance and visual uniformity. And it is not good visual uniformity under the 18 mm condition.

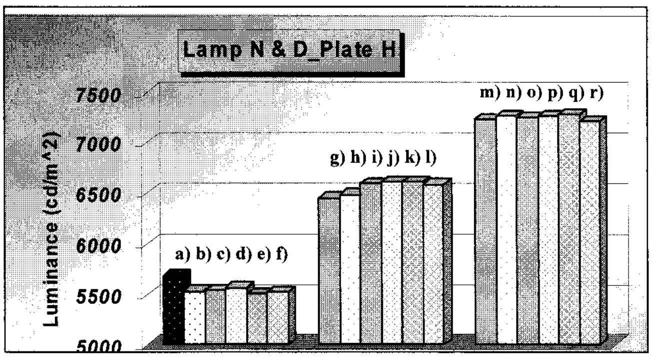

Fig. 3. Simulation results of numbers of lamps and heights of diffusing plate.

Table 4. Simulation results of numbers of lamps and heights of diffusing plate.

Heights of Diffuser plate	14 Lamps	16 Lamps	18 Lamps
18 mm	a) 5679.49	g) 6451.90	m) 7237.94
20 mm	b) 5527.26	h) 6458.97	n) 7269.74
22 mm	c) 5534.09	i) 6597.20	o) 7251.57
24 mm	d) 5561.35	j) 6606.38	p) 7260.66
26 mm	e) 5509.10	k) 6615.47	q) 7276.56
28 mm	f) 5522.73	l) 6585.93	r) 7215.22

In Fig. 4 and Table 5 show the heights of lamp and heights of diffusing plate. In Table 5 gray area means not suitable condition because it generates lamp luminance line defect. It has not enough distance between lamp array and diffusing plate.

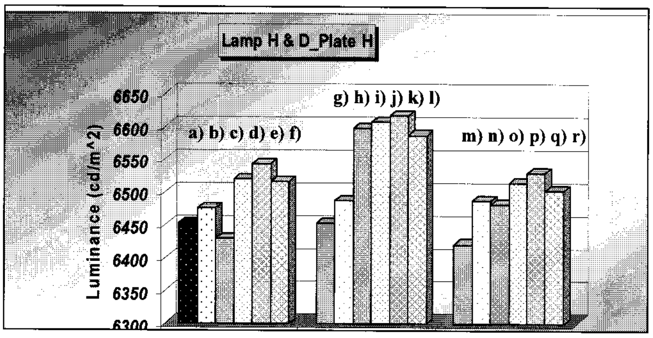

Fig. 4. Simulation results of heights of lamp and heights of diffusing plate.

Table 5. Simulation results of heights of lamps and heights of diffusing plate.

Heights of Diffuser plate	3.5 mm	4.5 mm	5.5 mm
18 mm	a) 6451.90	g) 6451.90	m) 6420.09
20 mm	b) 6474.62	h) 6485.97	n) 6485.97
22 mm	c) 6429.18	i) 6597.29	o) 6481.43
24 mm	d) 6520.05	j) 6606.38	p) 6513.24
26 mm	e) 6542.77	k) 6615.47	q) 6529.14
28 mm	f) 6515.51	l) 6585.93	r) 6501.88

Finally, we investigated the relationship of reflection plate shape and luminance and inner wall angle and luminance. Figure 5 shows the best result was obtained in trapezoid shape cutting condition, it is 6597.29 nits. But it is tiny difference the other shape. As the above results, we suggest that it is more economic and convenient not adopting shape variation.

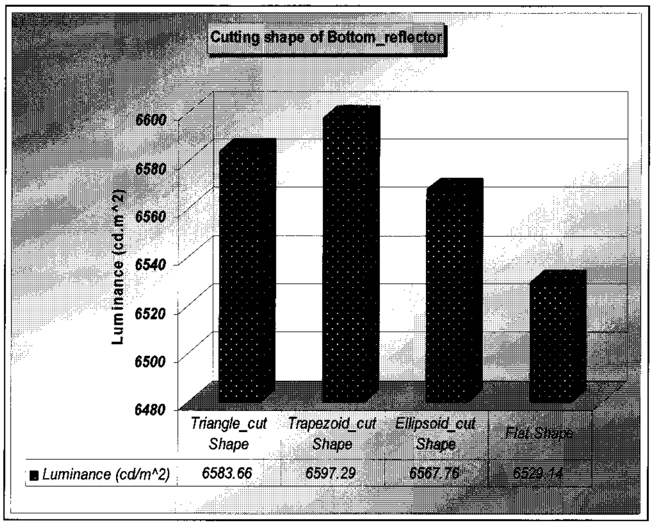

Fig. 5. Simulation results of variation shape of reflection plate.

In Fig. 6, we suggest best inner wall angle in 80 degree condition. It shows 6590.48 nits, 6476.89 nits, 6597.29 and 6467.80 nits at 60, 70, 80 and 90 degrees of inner wall angle. It shows 130 nits difference comparing 80 and 90 degrees.

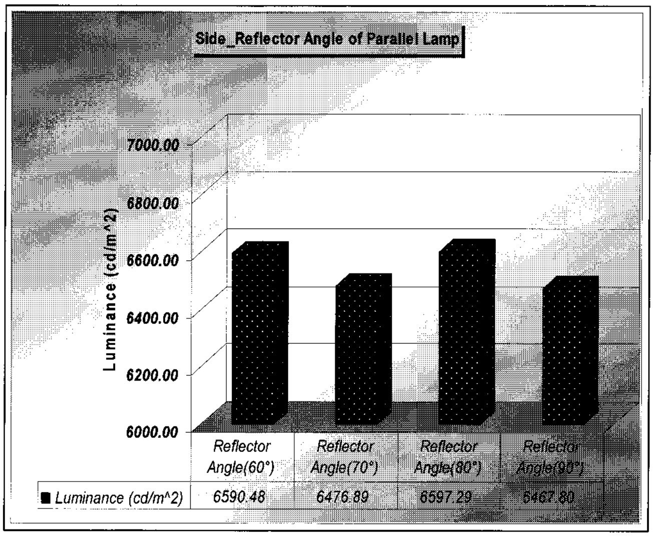

Fig. 6. Simulation results of variation shape of reflection plate.

4. CONCLUSION

We studied dependent of optical parameter in backlight for medical LCD application. We suggested best design condition using reverse ray tracing method. And it shows improvement of visual uniformity and high luminance under 16 lamps, 4.5 mm lamp heights and 17.5 mm difference of lamp heights and diffusing plate height. Finally, we suggested 80 degrees of angle in inner wall angle. But reflection plate shape is not critical parameter in improvement of luminance or visual uniformity. And using simulated data, we calculated 6423 nits backlight unit condition under 16 lamps usage, 2 mm thickness diffusing plate, one diffusing sheets condition for 32 inch medical LCD application.

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