의료용 초고휘도 LCD 소자를 위한 직하형 Backlight의 최적설계

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Optical Design for High Brightness Direct Type Backlight Unit Using Medical LCD Application

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요 약

본 연구에서는 최근 의료용으로 많이 사용되고 있는 고휘도, 고균일도의 직하광원구조를 가지는 백라이트 유닛에 대한 설계 시뮬레이션을 실시하였다. 직하형 백라이트 시스템은 기존의 Edge-Lighr 방식에 비해서 고휘도 및 고균일도를 달성할 수 있어 의료용 판독이 요구되는 고품질의 디스플레이에 사용되고 있으며, 흑백이미지를 바탕으로 진단을 실시하는 경우가 많기 때문에 휘도 및 휘도 균일도에 대한 높은 성능이 요구되는 분야이다. 본 연구에서는 복수 개의 램프를 수평으로 배열한 경우에 각 램프간의 거리 및 반사판과의 거리, 상측 확산판과의 거리에 대한 최적설계를 실시하고, 이 결과를 바탕으로 실물과 유사한 조건에서 시뮬레이션을 실시하였다. 연구 결과, Parameter 에 의존하는 변수를 최적화 할 수 있었으며, 4.5mm 의 램프와 반사판 거리 및 26mm 의 램프간 거리를 바탕으로 16개의 램프를 배치하여, 32인치 크기의 화면에서 6423nit 의 중심휘도를 갖는 고품위의 우수한 광원의 설계가 가능함을 확인할 수 있었다.

Key Words : Medical LCD, High brightness LCD, Direct type LCD, Optical distance, Lamp array ptich

ABSTRACT

In this study, it was investigated about optical simulation in highg brightness and high uniformity direct-type backlight design for medical application. 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; 26mm of the distance of two lamps, 4.5mm 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.

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

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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[6-9]. 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	Total reflection ratio : 95.19% Gaussian Reflection : 4.5% Lambertian Reflection : 95.5%
Diffusing plate	Transmission ratio : 70%
Flux of lamp	350 lumens

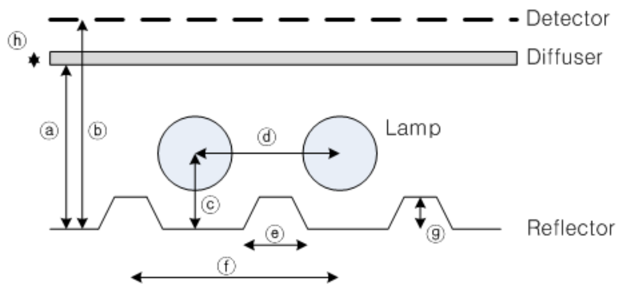

Fig. 1. Optical simulation parameters

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.

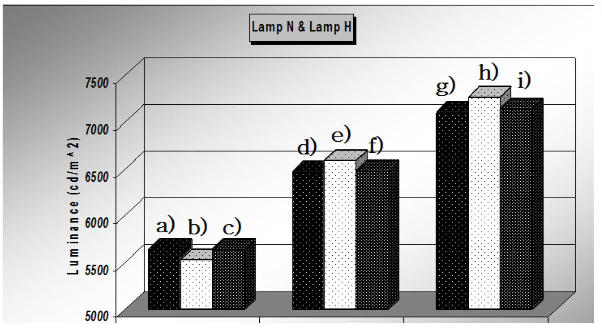

Fig. 2. Simulation results of numbers of lamps and heights of lamp

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.

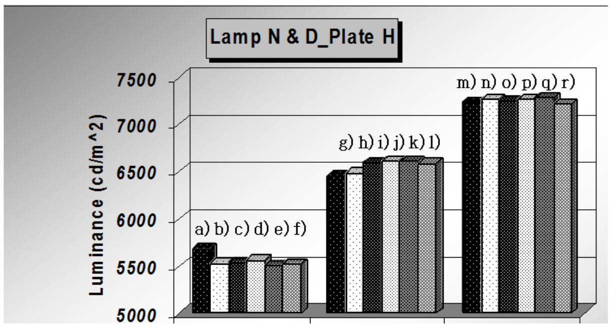

Fig. 3. Simulation results of numbers of lamps and heights of diffusing plate

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.

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.

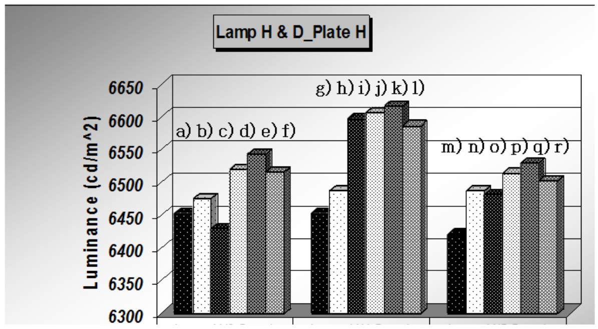

Fig. 4. Simulation results of heights of lamp and heights of diffusing plate.

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

Heights of Diffuser plate	3.5mm	4.5mm	5.5mm
18 mm	a) 6451.90	g) 6451.90	m)420.09
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

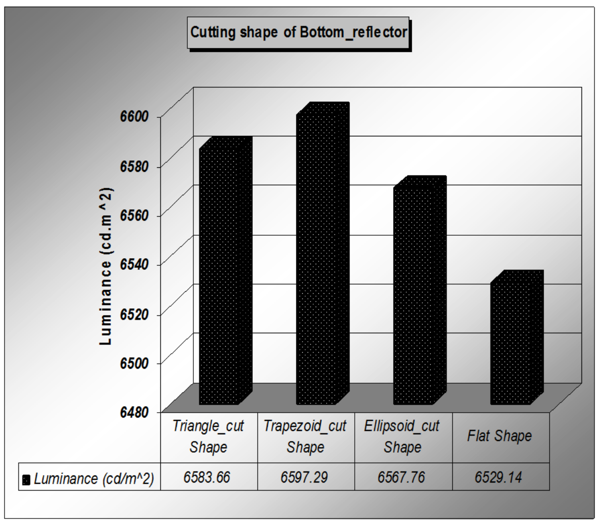

Fig. 5. Simulation results of variation shape of reflection plate

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.

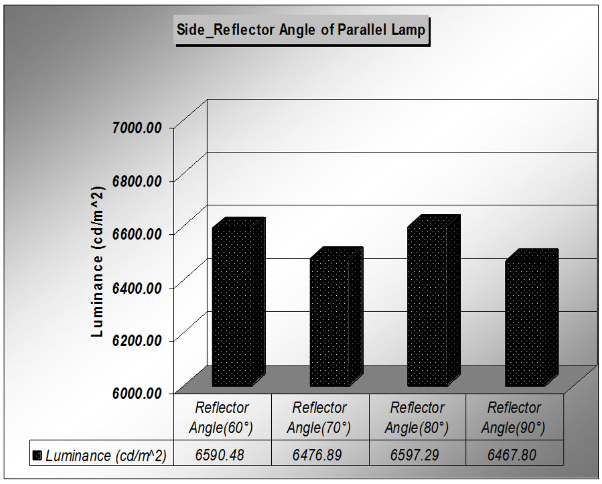

Fig. 6. Simulation results of variation shape of reflection plate

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, 4.5mm lamp heights and 17.5mm 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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