광선추적법을 사용한 가로등 반사판의 최적설계에 관한 연구

논 문
58P-3-18

Study of Optimized Reflector Design for Road Light Using Ray-Tracing Method

최 대 섭† · 한 정 민* · 심 용 식** · 정 찬 웅*** · 오 선§
(Dae-Seub Choi · Jeong-Min Han · Yong-Sik Shim · Chan-Oong Jeong · Seon Oh)

Abstract - In this study, it was studied about the improved road light design for drivers and pedestrians using forward or reverse ray-tracing method. Many of conventional road lights are not suitable for drivers and pedestrians because it has some serious problems such as glare effect or randomicity of illuminated areas. It was oriented from customary design method which was pointed at simple target such as luminance or electrical power. But it was not truth any more that the high luminance or electrical power consumption mean more bright and good road light. We studied ray-tracing method for road light reflector design to get the several goals. It means that good road light has easy for drivers and pedestrians eyes and illuminating objects on the road clearly. So, we set the design targets such as uniformity on the road area per one road light, shading angles and continuous luminance uniformity on the long distance road. We designed ideal road light conditions using ray-tracing method. We set the height of drivers and pedestrians eyes and calculated design guideline to make above design targets. Then we designed road light reflector using reverse ray-tracing method. And we achieved same luminance on the road almost half power consumption because we reduced loss of light. We achieved ideal design guide as 75 degrees of shading angles and 0.5 of luminance uniformity on the road area. It is superior than conventional road light ability such as 0.35 of luminance uniformity of 400 watts power consumption lamp. Finally, we suggested reflector design for 250 watts power consumption CDM Iight source.

Key Words : Road Light, Ray-Tracing Method, Shading Angles, Luminance Uniformity

1. Introduction

Recently, it is very important that energy saving application in the public facilities. Most of public electrical power consumption is light for drivers or pedestrians on the road during night time. Many of conventional road light has been powered up because more convenient road condition for drivers and pedestrians. It is really important that drivers recognize objects on the road during night time because it prevents traffic accident. But vehicle's head lamp is not sufficient for generating required luminance. So that, many of countries set the standard guide in road light luminance. Therefore, it is not always true that more bright light cause safer road condition. It is more important that well-tuned road light for drivers and pedestrians must be installed actual road circumstance. It means proper energy consumption and easy for human eyes. Many of road light is tuned high power consumption because it came from serious misunderstood such as brighter road light mean safer road condition. Besides, brighter road light focused on the developing high power consumption lamp and required circuit system. But it is more important that optimized lamp reflector design bring to low power consumption and proper luminance condition on the road.

We investigated optimized lamp reflector design using ray-tracing method.[1] It shows that optimized lamp reflector cause definite energy saving effects such as 250W CDM lamp is capable to 400W sodium lamp application. We designed half-bowl shaped reflector and improved it. It is investigated that the curves of luminance at 180 degrees view and realistic luminance simulation on the road. And we presented optimized reflector design based on the half-bowl shape.

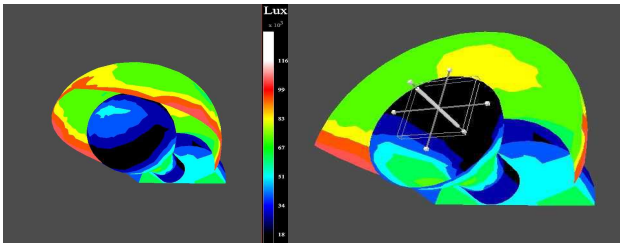
At last, we calculated road condition and uniformity of road. It shows that using optimized reflector, road brightness uniformity is improved.[2~4] We set the several road light, and then investigated continuous road brightness uniformity condition.[5~8]

* 정 회 원 : 서일대학 전기공학과 교수 · 공박
** 정 회 원 : 태영 E&C 기계전기팀 부장
*** 정 회 원 : 서울시청 도로관리담당관 기전관리팀장 재직
§ 정 회 원 : 서일대학 자동차과 교수 공박
† 교신저자 정회원 : 서일대학 전기전자공학과 교수 · 공박
E-mail : choids@seoil.ac.kr
접수일자 : 2009년 5월 25일
최종완료 : 2009년 6월 22일

2. Experimental and Result

Using ray-tracing method, we designed conventional half-bowl shaped lamp reflector and calculated brightness characteristics on the road. Figure 1 shows traditional design such as bowl shaped basic reflector of road light. Figure 1 shows the role of reflection on the reflector

parts, and Figure 2 shows that the brightness on the right bottom of designed road light. And Figure shows horizontal brightness curve on the illuminated road. It is clearly recognized from figure 3, luminance of central point is 17 Lux and brightness averages counted 6.7 Lux. Based on the Figure 1, it is most serious defect such as edge part of opening side. It is displayed red colour and it means this edge part has many reflection light from CDM lamp.



(a) Mainmapping Design (b) Cutting Images of Design

Fig. 1 Conventional lamp reflector design

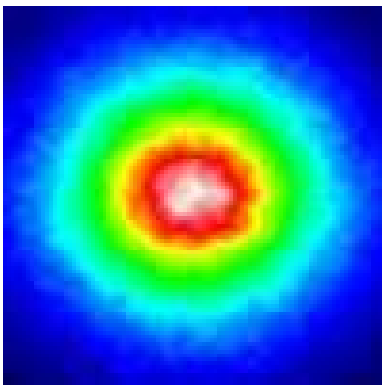


Fig. 2 Brightness characteristics on the road surface

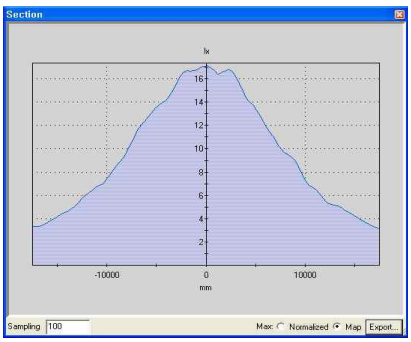
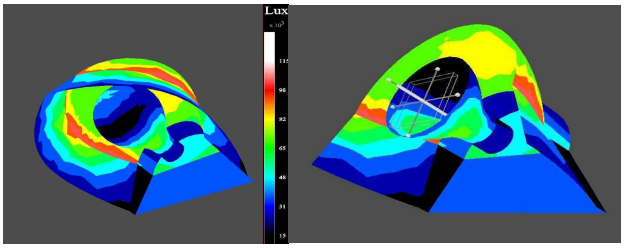


Fig. 3 Brightness curve on the road surface

And then we improved above design in the edge parts. It is changed con-shaped edge shape and it is good role to send light to the road surface. Figure 4 shows improved design. And Figure 5 and Figure 6 show improved brightness characteristics on the road surface. As optimized design using ray-tracing method, it is dramatically rise up at 40 Lux of central luminance and 8.7 Lux of average brightness. It shows that the improvement of lamp reflector is major elements at road light design.



(a) Mainmapping Design (b) Cutting Images of Design

Fig. 4 Optimized lamp reflector design

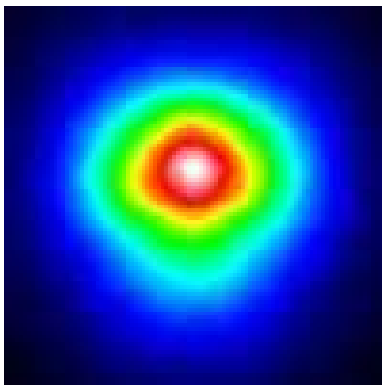
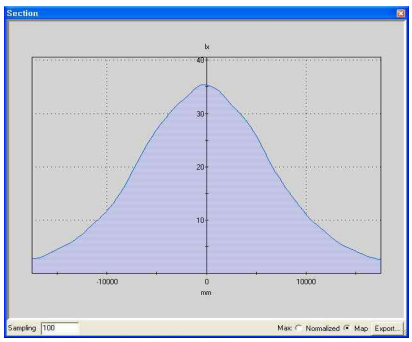
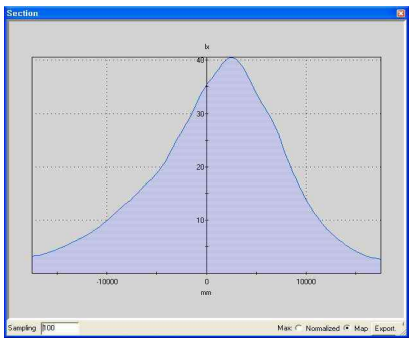


Fig. 5 Brightness characteristics on the road surface using optimized reflector



(a) Brightness curve at horizontal direction



(b) Brightness curve at perpendicular direction

Fig. 6 Brightness curves on the road surface

At last, we investigated actual installation simulation. Figure 7 shows brightness characteristics on the road surface. Road light was set the height of 12 meter and 2 meter of distance of pole to light. And road surface set the 35meter * 35 meter. And Figure 8 shows brightness uniformity of road surface at several road lamp installed 35meter intervals. We investigated road light improvement design using ray-tracing method. First, we presented improved lamp reflector shape design in the edge shape of reflector and it cause significant improvement result such as 40 Lux of central brightness in traditional half-bowl shape reflector. And it was good result of improvement average brightness and at the same time. At last, we presented simulation result at actual road condition and reviewed uniformity of several road light installed condition.

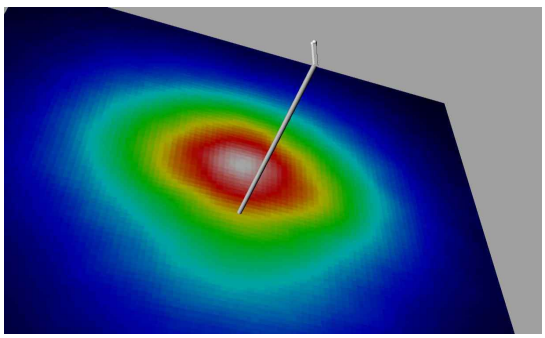


Fig. 7 Brightness characteristics of road surface

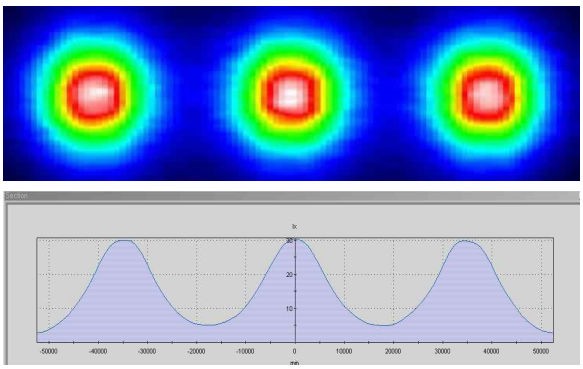


Fig. 8 Brightness uniformity at 3 lamps installed 35 meter intervals

3. Conclusion

As a result, Using optical simulation such as ray-tracing method, it is very significant method of road light reflector design. And it means that low energy consumption is able to design high efficiency reflector design. And we achieved same luminance on the road almost half power consumption because we reduced loss of light. We achieved ideal design guide as 75 degrees of shading angles and 0.5 of luminance uniformity on the road area. It is superior than conventional road light ability such as 0.35 of luminance uniformity of 400 watts power consumption lamp. Finally, we suggested reflector design for 250 watts power consumption CDM light source. So that, optimized road light design is necessary elements of energy saving and improvement road circumstance at the night time.

Acknowledgement

The present research has been conducted by the Research Grant of Seoil university in 2008.

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저 자 소 개

최 대 섭 (崔 大 燮)

1950년 12월 23일생. 1977년 숭실대 전기공학과 졸업. 1981년 연세대 대학원 전기공학과 졸업(공학석사). 1996년 일본 북해도 대학원 전기공학과 졸업(공학박사). 현재 서일대학 전기공학과 교수.

Tel : 02-490-7413

Fax : 02-490-7412

E-mail : choids@seoil.ac.kr

한 정 민 (韓 禎 敏)

1973년 3월 19일생. 1997년 숭실대 전기공학과 졸업. 1999년 숭실대 대학원 전기공학과 졸업(공학석사). 2007년 연세대 대학원 전기전자공학과 졸업(공학박사). 현재 서일대학 전기공학과 교수.

Tel : 02-490-7255
Fax : 02-490-7412
E-mail : hanjm@seoil.ac.kr

심 용 식 (沈 龍 植)

1962년 6월 26일생. 2004년 서울산업대 전기공학과 졸업. 2006년 고려대 공학대학원 전기공학과 졸업(공학석사). 2009년 현재 홍익대 대학원 전기공학과 박사과정. (주)태영건설 전기부장.

Tel : 02-2090-2493
Fax : 02-2090-2238
E-mail : young@taeyoung.com

정 찬 웅 (鄭 燦 雄)

1958년 1월 6일생. 1988년 8월 한양대 산업대학원 졸업 (공학석사), 2007년 서울산업대학교 철도전문대학원 수료 (공학박사), 1983-현재 서울시청 도로관리담당관 기전관리팀장 재직

자격 : 전기철도기술사
전화 : 02-3707-8164
FAX : 02-3707-8160
E-mail : chan56@seoul.go.kr

오 선 (吳 善)

1959년 8월 19일생. 단국대학교 대학원 기계공학과(공학석사) 단국대학교 대학원 기계공학과(공학박사) 현재 서일대학교 자동차과 교수

Tel : 010-9107-6673
Fax : 02-490-7422
E-mail : ohseon@seoil.ac.kr