Evaluation of Optical Components in the Backlight Unit of LCD-TVs

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Abstract

The influence of optical components constituting the backlight of TV on the luminance property of backlight was analyzed. The variation of luminance when the light emitted from light source passes each optical part was evaluated.

1. Introduction

As the LCD-TV market grows, the industry related to backlight apparatus also grows up. In the backlight apparatus industry, optical sheets take an important share. Therefore, the improvement of optical property of optical sheets becomes an important issue. In addition, the endeavors to reduce the number of lamps are continuously made as a kind of measure to save the cost of backlight. Institutes, government organizations, and several companies are conducting studies on the standardization of optical sheets and the property of electric discharge depending upon the number of lamps.

In this study, the influence of each optical sheet constituting backlight apparatus on the luminance property of backlight was quantified. This can be utilized as the guide of direction to develop optical sheets. Also, through the analysis of optical property of backlight depending upon the number of lamps, the direction for cost saving is suggested.

2. Characteristic of Backlight Unit

Fig. 1 is the cross section view of backlight apparatus for LCD-TV and shows the arrangement and interval of lamps and sheets constituting backlight. The lamps used in this backlight are external electrode fluorescent lamps and are arranged between reflection sheet and diffusion plate. The light was dispersed with use of diffusion plate and diffusion sheet to improve the luminance uniformity. The luminance vertical to backlight surface is usually elevated when passes prison sheet and 3M's BEF sheets are most popularly used. Reflective polarization sheet polarizes the light emitted from backlight to the direction of #1 polarization plate of liquid crystal part so that the light passes the #1 polarization plate with almost no loss to improve the luminance of display. In this case also, 3M's DBEF-D is the most commonly used sheet.

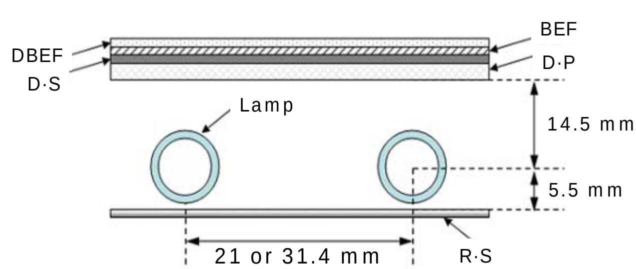


Fig. 1. Backlight unit formation

The constitution of backlight apparatus for 32-inch LCD-TV should be reviewed. First of all, effective area is 0.70×0.40 m^2. One piece of diffusion plate (DP) was used over the lamp, one piece of diffusion sheet (DS), and one prism sheet (BEF) and one piece of reflective polarization film (DBEF-D, DBEF) were placed over DP.

In this study, 18 or 12-EEFL's were used. Although 18 EEFL's are commercially used now, 12-EEFL's were also used in this study to review the optical property.

Table 1 shows the specifications of EEFL's used as backlight.

Table 1. Lamp specification

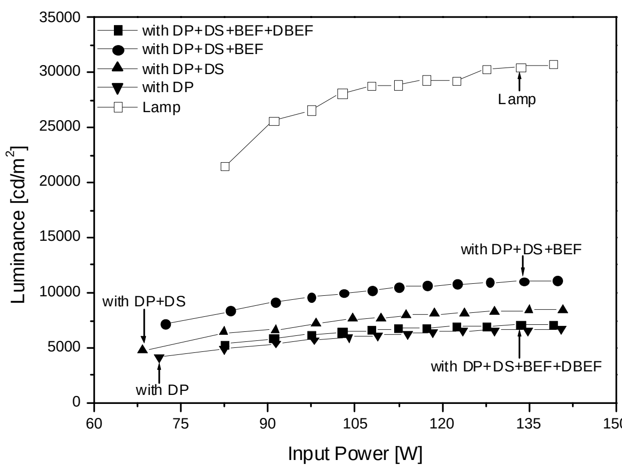
	unit	Value
Lamp Length	mm	738
Electrode Length	mm	23
Diameter	mm	4
Thickness	mm	0.5
Pressure	torr	60

3. Results

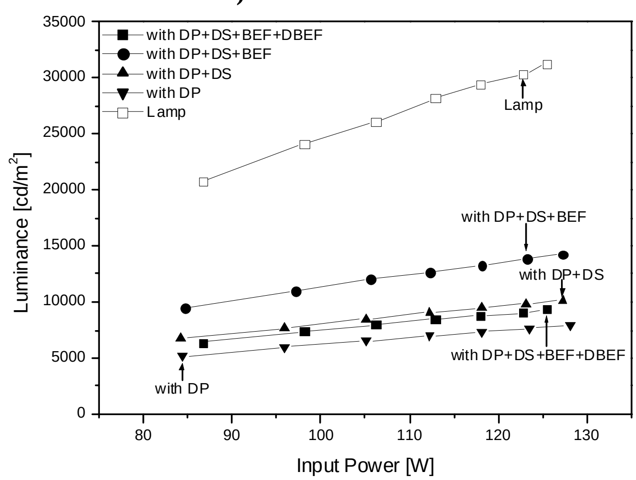
Fig. 2 shows the luminance of lamps and the measured luminance when passing DP, DS, BEF, and DBEF. Also, the luminance was measured with changing input voltage in the range of 65~145W and it was found that the luminance of backlight was linearly increased depending upon the input voltage. Also, Fig. 2-a) shows the case that 12-EEFL's were used and Fig. 2-b) shows the case that 18-EEFL's were used; both cases showed similar trends.

As shown in Fig. 2, the input voltage to produce approximately 7,000 cd/m^2 may be obtained with use of the luminance value passed DBEF-D starting from backlight. Approximately 110 W was required when 12 lamps were used and approximately 90 W was required when 18 lamps were used. In such cases, eth luminance values were approximately 30,000 cd/m^2 and 23,000 cd/m^2, respectively.

When 12 lamps were used, the interval between lamps is increased and the problem in luminance uniformity may be expected. However, in this study, it was found that no significant problem was produced in appearance although only 12 lamps were used. It seemed that, as many sheets such as DP, DS, BEF, and DBEF were used, sufficient uniformity could be obtained. Recently, many studies have been conducted to reduce the number of sheets for cost down purpose and, according to the result of this study, significant reduction in the number of lamp might also satisfy the purpose of cost down. However, if the number of lamps is reduced, the luminance of each lamp should be elevated and there may be the lifetime problem with lamps. Nevertheless, if the method to improve the illumination efficiency of lamps is found out, reduction of the number of lamps may be further effective cost-down method compared to reduction of the number of sheets. The reason is that, in terms of whole BLU system, reduction of the number of sheets results in higher loss of light.



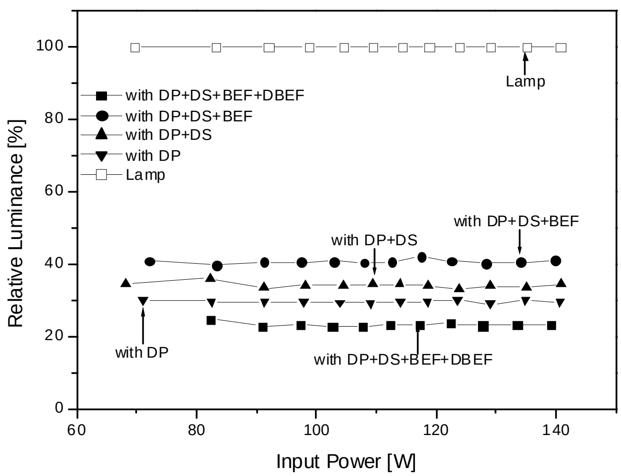
a) 12-EEFLs BLU



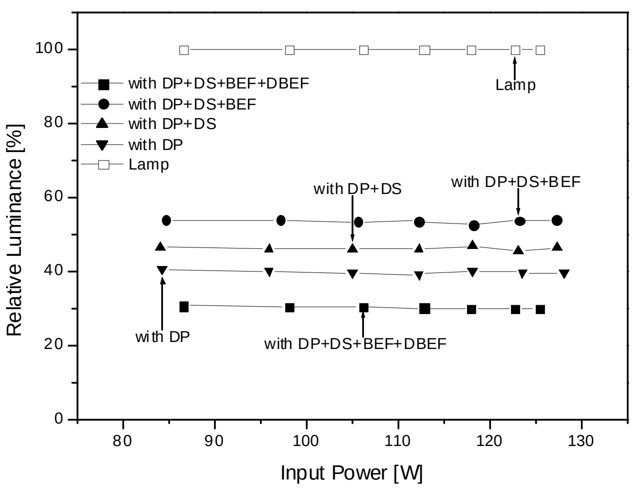
b) 18-EEFLs BLU

Fig. 2. Luminance change on the sheet by input power

Fig. 3 shows the luminance change when the luminance of the lamps is assumed as 100 %. Reviewing this result, it is indicated that the relative luminance change when passing the sheet is not related with input voltage. That is, the optical function of each optical sheet is constant regardless of the intensity of light source. Therefore, although the luminance of individual lamp was elevated, the effect of optical sheets was constant.



a) 12-EEFLs BLU



b) 18-EEFLs BLU

Fig. 3. Relative luminance change on the sheet by input power

In Fig. 4, the relative luminance when passing each optical sheet was compared. In the result, it is indicated that large portion of light emitted from the lamp is lost when passing the diffusion plate. The transmissivity of diffusion plate is usually approximately 55 % but the result was lower as shown in Fig. 4. As shown in Fig. 4, the luminance value of a single lamp was used as the luminance value of lamp part but, in case of BLU, the luminance value of lamp part would be smaller when calculated as the whole average luminance value. Meanwhile, when 18-lamp backlight and 12-lamp backlight were compared, the optical function was higher in case of 18-lamp optical sheet and this result seemed to be cased by the calculation error of the luminance value of lamp part. In conclusion, it could be found the function of each optical sheet was not related with the number of the intensity of light source or the number of lamps. Accordingly, if the luminance of individual lamp is sufficiently elevated when using 12-lamp EEFL, the effect would be similar with that of 18-lamp BLU. However, when 12-lamps were used, there should be no problem in the uniformity in appearance; in the result of this study, there was no problem. Therefore, if the result of study to improve the illumination efficiency of individual lamp is grafted, 12-lamp BLU may be realized and fairly level of cost down effect may be obtained.

Meanwhile, when the light emitted from the lamp passes sheets, whole intensity of radiation is reduced. In this study, the transmissivity of diffusion plate was measured with use of integrating sphere.

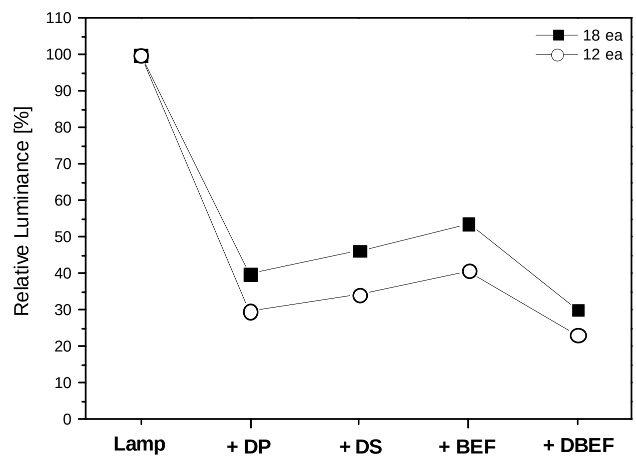


Fig. 4. Relative value of luminance on each sheet

Fig. 5 is the summarized view of the system measuring the transmissivity of optical sheet. In this system, transmissivity was measured by Double Beam (Sample Beam, Reference Beam) method. Where, Sample Beam meant the beam passing the sample and Reference Beam was used to correct the environmental difference between baseline measuring environment and sample measuring environment.

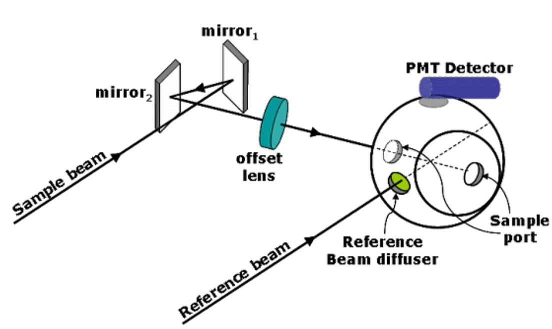


Fig. 5. Measurement of transmisivity and reflexibility of each sheet

Table 2 shows the result of measured transmissivity when the transmissivity and optical sheet were overlapped. Transmissivity was measured with forward arrangement and backward arrangement of the order and direction of sheets. As shown in the result, the largest loss of light was found in diffusion plate and diffusion sheet also showed fairly large portion of light loss. The transmissivity of DBEF-D was expected to be larger than these measurements if polarization is considered. Prism sheet showed fairly high transmissivity in forward direction but showed very low transmissivity to backward direction. The reason was that the quantity of light of total reflection is changed by the incidence angle of light. Therefore, to conduct an accurate test, the surface direction of prism sheet should accurately be set but, in this study, the consideration of this matter was insufficient. Also, if the light passing each sheet is measured with use backlight, the values are larger than the values shown in Table 2. The reason is that the light reflected on the backlight with no passing of each sheet is recycled in the cavity of backlight and passes the sheets again. When the reflexibility was measured with use of this system, approximately 95 % of reflexibility was measured.

Table 2. Transmissivity of each sheet

`	sheet itself		sheets assembly	
	forward	backward	forward	backward
DP	56.7 %	58.1 %	56.7 %	58.1 %
DS	63.7 %	96.5 %	50.7 %	30.2 %
BEF	95.0 %	13.8 %	44.2 %	24.2 %
DBEF	59.0 %	65.5 %	29.3 %	14.3 %

Fig. 6 shows the measurements of luminance and efficiency when the input power of backlight was changed. The case of EEFL 12-lamp BLU and the case of EEFL 18-lamp BLU were compared. To produce approximately 7,000 cd/m^2 of backlight luminance, approximately 90 W of power is needed in case of 18-lamp backlight and the efficiency is approximately 62 lm/W in this case. In case of 12-lamp backlight, approximately 110W of power is needed and the efficiency is 52 lm/W that is lower than 18-lamp case by approximately 10 lm/W. However, as aforesaid, 12-lamp method also shows no uniformity problem in appearance and is sufficient to constitute the backlight. Nevertheless, the efficiency should be improved than current level to be practical and sheet constitution should be simplified for cost down.

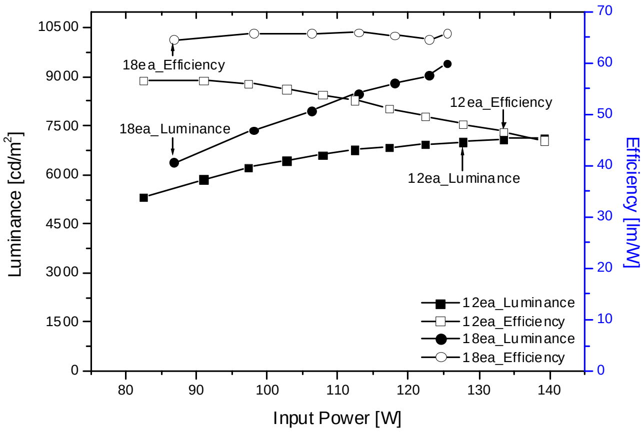


Fig. 6. Luminance and efficiency versus input power

4. Discussion and Summary

In this study, the influence of optical parts and light sources constituting the backlight of TV on the luminance property of backlight was analyzed. That is, the luminance value changing when the light emitted from light source passes each optical part was reviewed. As a result, the functions of each optical sheet were found to be same regardless of the intensity of light source. Also, it was concluded that reduction of the number of lamps from 18 to 12 was possible in terms of luminance uniformity. However, if 12-lamp method is adopted, the luminance of each lamp should be elevated by a large portion resulting in shortening of the lifetime of lamps. Therefore, BLU is mostly developed in the direction to reduce the number of optical sheets rather than reduction of the number of lamps and this trend results in reduced efficiency of light use. However, if the illumination of lamps is improved, reduction of the number of lamp would be further effective cost down method.

5. Acknowledgments

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6. References

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