39. Non Uniform Increment of Surface Luminance of Fluorescent Lamp due to Reflected Light from Reflector

Shin SAKAMOTO*, Ryuichi KAIDA* and Koichi IKEDA*
Nobumitsu KATSUMATA**, Yoshimi ENDO**, Shuichi SONE**

(*T o k y o R i k a D a i g a k u)

(**T E C C O R P O R A T I O N)

Introduction

Recently, a number of optical simulation system for luminaire design have been reported. However, exact optical simulation method, which contains analysis for the non-uniform distribution of a fluorescent lamp luminance due to reflected light from the reflector, has not been reported, though it takes significant difference in the efficiency and the luminous intensity distribution.

The algorithm, which is able to calculate the non-uniform distribution of a fluorescent lamp luminance, has already developed in our laboratory. Nevertheless, sufficient precision might have not been obtained in the case that the interreflection between reflector surface and source surface is remarkable. Because the tube surface has been treated approximately as uniform diffuse source.

In this paper, reflection characteristics of a fluorescent tube surface, which is composed of specular reflection, diffuse reflection, and diffuse transmission, has been experimented. A result of this experiment, the new routine which is able to calculate specular reflection, diffuse reflection, and diffuse transmission is added to the simulation program.

The luminance distribution of a fluorescent tube surface has been measured, and is compared with the simulated value using improved program.

Reflection characteristics of fluorescent tube surface

Fig.1 shows the illustration of experimental system to measure the reflection characteristics of a fluorescent tube surface. The light source is a He-Ne laser (633 nm, random polarization). In this experiment, specular and diffuse reflectance are obtained and represented as a function of the angle of incidence. However it is difficult to measure the diffuse transmission, so it is estimated by evaluating the difference between the simulated value and the measured value. Fig.2 shows the reflection components of a fluorescent

tube surface. Fig.3 shows the relation between the angle of incidence and both specular reflectance and diffuse reflectance.

Fig.1 Illustration of experimental system to measure the reflection characteristics of a fluorescent tube surface

Fig.2 Reflection components of a fluorescent tube surface

Fig.3 The relation between the angle of incidence and specular reflectance, diffuse reflectance, and diffuse transmittance

Non-uniform distribution of a fluorescent lamp luminance

Fig.4-A shows the illustration of the experimental system to measure the distribution of surface luminance of a fluorescent lamp. The pinhole is made through the reflector plate. The diameter of the pinhole is 1 mm, which is considered too small to effect on the reflection characteristics of the reflector. The cylindrical light guide, whose inside is painted black, is installed through the hole so as to cut the stray light which is not required. Fig.4-B shows the illustration of a light detector. The light through the cylindrical light guide is measured by low-level light detector installed at the end of the light guide. The luminaire used in this experiment is

one of typical luminaires reflector composed of white painted planes.

In this experiment, the light intensity is measured at 7 points by 30 degree separation.

The temperature difference of 3 °C between upper side and lower side of the tube surface is recognized in this experiment. However, it is difficult to grasp the non-uniform distribution of fluorescent lamp luminance occurred by the difference of the temperature quantitatively. Because temperature distribution depends on the shape of luminaire and the position along the direction of the tube axis. Then, the effect of temperature is not considered in this experiment.

Fig. 4-A Illustration of experimental system to measure the distribution of lamp luminance.

Fig. 4-B Illustration of light detector

For the light transmitted into a fluorescent tube, it is assumed that multiple reflection is occurred inside the tube and the intensity is integrated totally like integrating sphere. For the estimation of diffuse transmittance, mean squared error between the simulated values and the measured values is evaluated. The relation between the mean squared error and diffuse transmittance is shown in Fig. 5. As a result, it is estimated that the optimum proportion of the diffuse transmission is about 65% of all transmission.

Fig. 6 shows comparison between the simulated values and measured ones.

Then the improved program, which is able to calculate the specular reflection, the diffuse reflection, and the diffuse transmission, is newly developed. The luminous intensity distributions obtained by the former program, the improved program that of measured are showed in Fig. 7.

Fig. 5 The relation between the mean squared error and the diffuse transmittance.

Fig. 6 Comparison of distribution of fluorescent lamp luminance obtained by the improved program in which diffuse transmittance is 65 % and measured one.

Fig. 7 Luminous intensity distributions obtained by the former program, the improved program and that of measured.

Result

According to the measurement of the reflection characteristics of a fluorescent tube surface, the relations between the angle of incidence and the reflectance of three components, i.e. specular reflection, diffuse reflection, and diffuse transmission, are obtained. Then taking them into consideration as a function of the angle of incidence, the new program, which is able to analyze non-uniform distribution of the fluorescent lamp luminance, is developed.

As a result of the measurement of the luminance distribution of a fluorescent lamp surface, the non-uniform distribution of the fluorescent lamp luminance is obtained quantitatively. And the effect of improved program is estimated by comparing the simulated distribution of the fluorescent lamp luminance and that of measured one. Then it is found that the simulated distribution is well in accord with the measured one with small error.

The calculated result of the luminous intensity distribution by using improved program is also shown by Fig. 7. From this figure, the simulated luminous intensity distribution is become more conformable with the measured one, and also efficiency of the luminaire is increased about 10%, and is well agree with the measured value.

From now on, precise estimation of the luminous intensity distribution can be obtained by using this program.