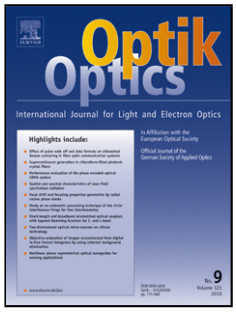

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Numerical Modeling of Tubular Daylighting Devices

Biao Chen,[a] Yeyan Wei,[a] Xiujie Li,[a] Runze Cao, [a] Peng Jin[a*]

[a]Green Lighting System Lab, School of Environment and Energy, Peking University, E building, University Town, Lishui Road, Nanshan District, Shenzhen, China, 518055

*****Peng Jin**,** E-mail: jinpeng@pkusz.edu.cn

Abstract. Tubular daylighting device (TDD) or light pipe is an effective way of energy saving and has been found increasing acceptance for indoor lighting. This article presents a new method to evaluate the TDD's optical performance by the output luminous flux. The method is using position (α,d) and angular distribution of luminous flux (φ,θ,Φ) information to describe the optical properties of the TDD's light collecting cover. With the optical information, the ray tracing simulates the output luminous flux basing on the structural and reflectivity of the light pipe. Our method makes a complete optical description of light ray passing through a top cover, thus enable the subsequent ray tracing of light pipe. As an application, lambertian beam pattern is used as light source which goes through from the cover, and then the results on various length to diameter ratios of light pipes are compared.

Keywords: tubular daylighting device, numerical modeling, output luminous flux, ray tracing.

1 Introduction

Daylighting methods are widely accepted on building lighting for their advantages on energy saving and luminous comfort.[1] The tubular daylighting devices can catch natural daylight and introduce it to inside space. The idea of guiding daylight into the building comes from Chappuis, who use mirrors to reflect daylight into the windows. Modern tubular daylighting devices generally consist of three parts: transparent light cover that collects daylight, light pipe with reflective internal surface and ceiling cover-diffuser.[2]

Experimental studies and mathematical modeling were also conducted for the TDD. Bouchet and Fontoynont (1996)[3] completed computer simulations of a light pipe system; G. Oakley (2000)[4] monitored the light pipes in different areas and compared there performance; Zhang and Muneer (2000–2002)[5,6] introduced a modified form of daylight factor and built a sophisticated model that enables prediction of the luminance admitted by the light pipe system; Jenkins and Muneer (2003)[7] modeled the light levels resulting from a pipe of given dimensions to investigate the effectiveness