Use of mathematical software for calculating the pointing angle of laser diode

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Abstract: A practical method was developed by a production engineer and a technician to measure the pointing angle of laser diode using a circular aperture. The method provided qualitative measurement only. A theoretical analysis using a mathematical software such as Mathcad shows that the method can provide quantitative measurement as well.

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A production engineer (BS degree) and a technician (no degree) developed a practical method for measuring the pointing angle of laser diode before the laser diode is coupled with a single mode fiber. First, the total power of the laser diode (assuming A mW) is measured before the laser diode is fixed in the fixture. After the laser diode is fixed in the fixture, a small circular aperture (smaller than the beam waist) is centered at the mechanical axis of the fixture. The power of light passing through the aperture (assuming B mW) is measured as shown in Fig. 1. The pointing angle can be represented by the value of B/A. The larger is the pointing angle, the smaller is B/A. After the aperture is removed, the light is focused into a single mode fiber at the mechanical axis using proper optics. The coupling efficiency is defined as C/A, where C is the measured output power (in mW) from the single mode fiber. The effect of the pointing angle of laser diode on the coupling efficiency is shown in the table of C/A versus B/A.

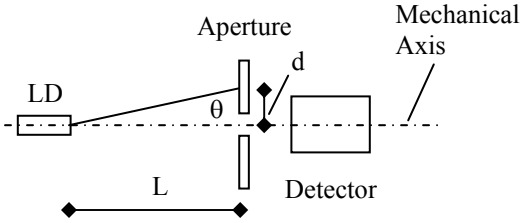

Fig. 1. Measurement setup, θ: pointing angle.

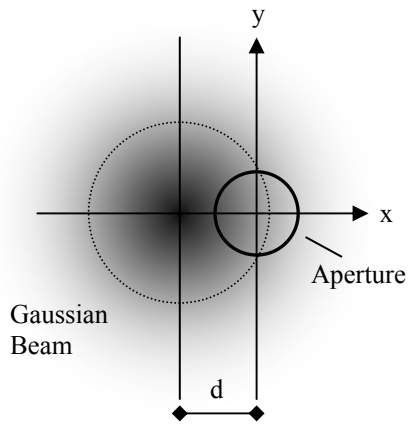

Fig. 2. Positions of laser beam and aperture on aperture plane.

The power of light after passing through the aperture as a function of d (see Figs. 1 and 2) can be calculated, provided that the laser diode beam has been corrected to a circular Gaussian beam [1]. The Gaussian intensity is $I(x,y) = I_0 \exp\{-[2(x+d)^2+2y^2]/\alpha^2\}$, where α is the beam waist, and $I_0 = 2A/\pi\alpha^2$ (remember A is the total power). The power $B = P(d) = 2 \int_{x=-a}^{x=a} \int_{y=0}^{y=b} I(x,y)\, dydx$, where a is the aperture radius, and $b = \sqrt{(a^2-x^2)}$. Although B or P(d) cannot be derived analytically, it can be calculated and plotted using a mathematical software such as Mathcad. Therefore, we can calculate the pointing angle θ from the value B/A.

In conclusion, we have shown how to improve a practical qualitative method developed by an engineer and a technician in a real production facility to an academic quantitative method using a theoretical analysis and a mathematical software such as Mathcad. This will be a good teaching material in the class.

Reference

[1] S. Jutamulia, "Correction of laser diode beam using microlens optics," Optical Memory and Neural Networks, **10**, 113-116 (2001).

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