Impact Factor: 9.9 ISSN-L: 2544-980X

EXPERIMENTAL DETERMINATION OF NUMERICAL APERTURE OF OPTICAL FIBERS

Madaminov Muhriddin Ro'ziboy o'g'li
Assistant teacher of Ferghana state technical university

Abstract: This in the material straight away physicist and optical properties, file work principles and main parameters mathematicians through to describe about components statement done Optical to fibers of light fall and his numerous through aperture (NA). expression. Numerical of the aperture theoretical and practical formulas are broken appearances the difference to determine methods of light optical fibers inside internal in the circumstances complete internal settings.Fill out to the core light fall and his to the core effect doer factors. Many fashionable and one fashionable of fibers characteristics, NA and modal dispersion dependency. Optical of fibers numerous aperture and complete internal to look principle in fibers light of energy efficient transmission provide A lot fashion and one fashionable straight away physicist parameters check through of them contact in technologies efficient use possible illuminated.

Keywords: Optical fiber, aperture, shell, refractive index, measurement methods, wave, dispersion, critical frequency.

Introduction

A collection of not one, but several light rays falls on the optical fiber forming an entrance cone, and only the rays falling at an angle greater than the critical angle propagate along the core of the optical fiber. The half angle of the cone of maximum incidence of the rays into the fiber core The opening angle is □a , and the entry cone □is called a digital opening (Fig. 1.1). Numerical aperture is denoted by NA (from English Numerical Aperture) and is determined by the refractive indices of the core and shell from the following relationship:

$NA_0 = \sin\theta_a = \sqrt{(n_1^2 - n_2^2)} = n_1\sqrt{2\Delta_n}$	(1.1)
$NA_1 = k\sqrt{(n_1^2 - n_2^2)}$	

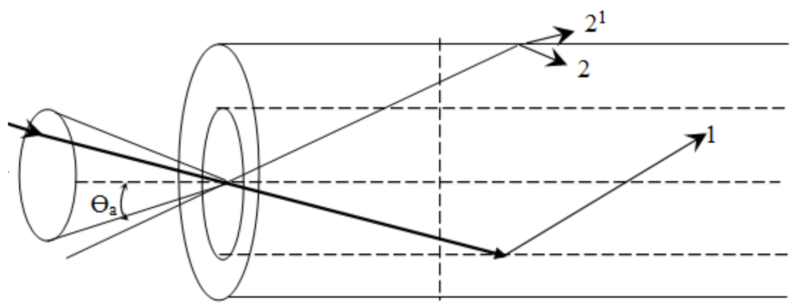

Figure 1. Optical fiber opening corne

Impact Factor: 9.9
ISSN-L: 2544-980X

(1.1) in the literature meeting possible was, numerous aperture of calculation two formula given They are numerous to the aperture near values gives The first formula is theoretical, the second while practical calculations for is used. Here measure methods depends with k= 0,98 or k=0.94 (to EIA-455-29 or EIA-455-44 standards suitable respectively). Breaking indicators relative difference Δ n to the following equal to:

$$\Delta_n = \frac{n_1^2 - n_2^2}{2n_1} \approx \frac{n_1 - n_2}{n_1}.$$

$\theta \leq \theta_a$, that is, within the aperture angle (corresponds to ray 1 in Fig. 1), are transmitted along the optical fiber core with complete internal rotation. $\theta > \theta_a$ aperture corner from within big corner under fell rays broken, from the core goes to the shell . These rays propagate through the shell and gradually fade out or exit the shell (rays 2 and 2^1 in Figure 1.1, respectively).

Rays corresponding to the circle of the aperture are called directional (ray 1), and rays outside the aperture are called radiating (ray 2 and 2^1) rays. Rays propagating through the shell outside the aperture are called shell-transmitted rays.

Typical values of the parameters of the most common optical fibers are presented in Table 1.

NA is an important property of an optical fiber and indicates how light enters and propagates through the fiber.

OT with a large NA value receives light well, optical fibers with a small NA value can enter only a narrowly focused set of light.

A high bandwidth OS has a small NA value. In this way, they have few modes, small dispersion and wide operating bandwidth.

1-table

OS type (quartz bottle)	Core diameter , µm	NO	Fiber to the core maximum drop off angle, grad.	Δ_n
Many fashionable OS	50-200	0.25 - 0.5	20-30	0.005 – 0.02
One fashionable OS	5-12	0.12 - 0.25	5 - 8	0.002 – 0.01

NO big to value have optical in fibers possible has been light directions , that is fashions number abundance as a result between fashions dispersion high will be

It should be noted that only an electromagnetic wave (l<d) with a wavelength smaller than the diameter of the light guide can travel along the light guide.

However, transparent glass acts as the core-shell dividing boundary in the light guide, so optical rays at such a dividing boundary have the property of entering and returning from the shell of the light guide without returning completely. In order for the transmitted energy not to penetrate into the shell and for the entire transmitted energy to move completely along the propagation medium, the condition of full internal rotation must be fulfilled, the application of such a condition for a two-layer light conductor is shown in Fig. 2 .

Impact Factor: 9.9
ISSN-L: 2544-980X

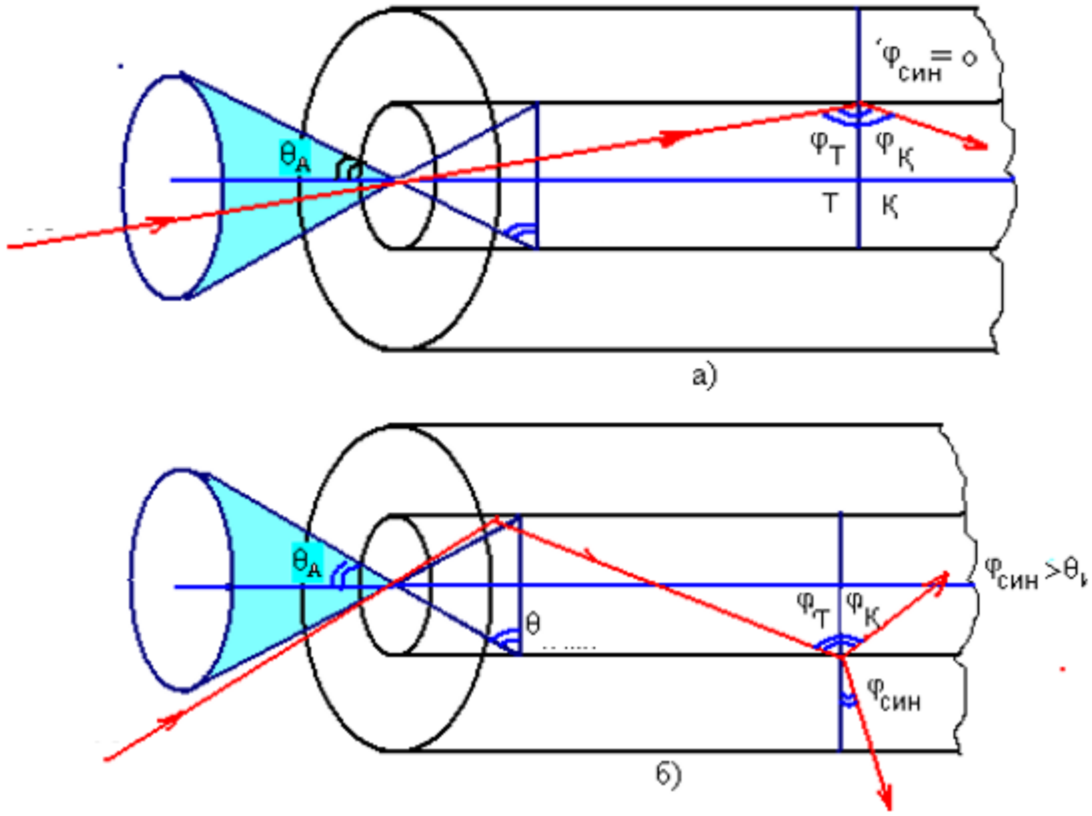

Fig. 2. The principle of operation of the light-conducting fiber: a) in the range of the beam aperture angle; b) the beam is outside the aperture angle

According to the laws of geometrical optics, a general wave incident at the core—shell boundary is at an angle φ T —, while the returning wave is at an angle —φ Q and is refracted at the core—shell boundary the wave is at an angle φ sin . We know that when passing from a medium with a high density to a medium with a low density, i.e. in the case n 1 > n 2, the incident wave at a certain angle returns completely and passes into another medium does not, which means that there is no refracted light. At the boundary of the environment, the total energy φT —in the angle of incidence, return, φT= θ is called the angle of internal internal return. The total internal return angle is defined as:

$$\sin\theta_{ички} = n_2 / n_1 = \sqrt{\mu_2\varepsilon_2 / \mu_1\varepsilon_1} \quad (1.2)$$

where: m 1 and e 1 — magnetic and dielectric absorption of the light-conducting core;

m 2 and e 2 — magnetic and dielectric absorption of the light-conducting shell;

n1 — refractive index of the light-conducting core;

n2 — the refractive index of the light-conducting shell.

If φT ≥ θ will be the internal state, then the energy falling into the core of the light guide will completely return and move along the light guide in a zigzag pattern. The greater the angle of incidence of the wave, i.e. φT> θ is the internal state, its value is between 0 0 and 90 0 , then the propagation conditions are good, and the propagating wave quickly travels to the receiving side. reaches In this case, all the energy is collected in the core of the light conductor and does not move around the surrounding medium at all.

Impact Factor: 9.9 ISSN-L: 2544-980X

If the beam is smaller than the angle of total internal return, and in the internal case φ T < θ, then the energy penetrates the shell of the light guide and spreads along the surrounding medium, and the surrounding medium as a whole does not move through the medium, because a refracted beam is formed (Fig. 2 b—). In fully internal return mode, it provides a condition for the light beam to enter the optical part of the fiber. As shown in Fig. 2, if the light guide is under the full internal return angle, then it transmits the light beam in the range of θ internal - internal angle. Such gap angle θ A describes the aperture of the light-conducting fiber. Aperture refers to the angle between the optical axis and the angle that forms a cone of light, which falls on the incoming side of the light-conducting fiber, and in this case the condition of full internal return is fulfilled.

In a fiber optic communication line, the concept of numerical aperture is used and it is defined by the following expression:

$$NA = n_0 \sin\theta_{ички} = \sqrt{n_1^2 - n_2^2} \quad (1.3)$$

where: n 0 — refractive index of air;

n 1 is the refractive index of the beam core;

n 2 — refractive index of the light guide shell.

the refractive index of air n 0 =1, the numerical aperture is determined as follows:

$$NA = n_0 \sin\theta_A = \sqrt{n_1^2 - n_2^2} \quad (1.4)$$

2 — as can be seen from the figure, there is a correlation between the total internal return angle — θ internal and the aperture incidence angle — θ A of the beam. Therefore, the larger the full internal angle θ internal , the smaller the aperture angle θ A of the light-conducting fiber.

In an optical fiber communication line, as much as possible, the beam falling on the core—shell boundary of the optical fiber — the angle φ TUSh should be larger than the full internal rotation angle θ and the internal angle θ should be within 90º, and the rays will be divided into the beam o The angle of the light incident on the incoming surface of the conductor must be within the range of the aperture angle θ_A θ A (φ≤).

As discussed earlier, between the wavelength λ and the core diameter d of the light guide, there is a value of cos θ =l/d, where θ is the incident wave incident on the core-shell dividing boundary is the corner. If $\cos\theta = \sqrt{1-\sin^2\theta}$ we take into account the expression and apply the condition of complete inner return sin θ =n 1 /n 2 , then $\cos\theta = \sqrt{1-(n_2/n_1)^2}$ it is obtained. If we equate the right-hand side of the given expression, then

$\lambda_0 / d = \sqrt{1-(n_2/n_1)^2}$ is formed.

Then the critical wavelength of the light guide is determined by the following expression:

$$\lambda_0 = d\sqrt{1-\left(\frac{n_2}{n_1}\right)^2} = \frac{d}{n_1}\sqrt{n_1^2 - n_2^2} \quad (1.5)$$

and the critical frequency is defined as follows:

$$f_0 = \frac{V_1}{\lambda_0} = \frac{V_1}{d} \cdot \frac{1}{\sqrt{1-(\frac{n_2}{n_1})^2}} = \frac{c}{d} \cdot \frac{1}{\sqrt{n_1^2 - n_2^2}} \quad (1.6)$$

Impact Factor: 9.9 ISSN-L: 2544-980X

where: n $_1$ ― the intrinsic refractive index of the light guide;
n $_2$ ― refractive index of the shell of the light guide;
V $_1$ =s/n $_1$ ― the speed of the wave moving along the core of the light conductor;
s― speed of light;
d― core diameter of the beam.
A normalized frequency is widely used in fiber optic technology, which is related to the size of the fiber, the wavelength λ and the refractive indices of the core and shell n 1 and n 2 of the fiber. . The normalized frequency - V is determined by the following formula:

$$V = \frac{2\pi a}{\lambda} \cdot \sqrt{n_1^{\ 2} - n_2^{\ 2}} \quad (1.7)$$

where: α - core diameter of the light conductor; λ - wavelength; n_1 - refractive index of fiber core; n_2 - the refractive index of the fiber sheath.

Conclusion. Optical fibers today's modern contact in technologies big important have is high at speed and low loss with information transmission provides. This analyses fibrous contact lines design and optimization for important scientific the basics present is enough in the article given mathematician expressions and graph images through optical of fibers physicist and geometric features analysis to do opportunity is created. Theirs core and of the shell fracture indicators between dependence through critical wavelength, normalized frequency and another parameters count methods given. Optical fibers light signals transmission for main technology being their work principle and efficiency geometric optics laws is based on. This in the material optical of fibers numerous aperture, full internal return condition, and of light fibers at the core spread features around analysis done.

References

1. Madaminov, M. R. (2023). Experimental study of operating modes of an uninterruptible power supply source using a wind generator as the primary source. International Journal of Advance Scientific Research, 3(10), 125-131
2. A.X.Abdusamatov. (2023). Обнаружение Повреждений В Электрически Обесточенных Линиях Электропередачи. Diversity Research: Journal of Analysis and Trends, 1(6), 62–69. Retrieved from https://academiaone.org/index.php/2/article/view/239
3. D.R.Komilov. (2023). HYBRID INVERTERS FOR GREEN POWER PLANTS. Best Journal of Innovation in Science, Research and Development, 2(12), 39–42. Retrieved from http://www.bjisrd.com/index.php/bjisrd/article/view/1046
4. I. Makhmudov. (2023). EQUIPMENT AND TECHNOLOGIES USED TO IMPLEMENT APPLIED TV TASKS AT THE PRESENT STAGE OF DEVELOPMENT. International Journal of Advance Scientific Research, 3(10), 293–299. https://doi.org/10.37547/ijasr-03-10-45
5. M. M. Tillaboev. BESTJOURNAL OF INNOVATION INSCIENCE, RESEARCH ANDDEVELOPMENTISSN: 2835-3579Volume:02Issue:12|2023. In protected areasdangers elimination methods.
6. Халилов, М. М. (2023). СНИЖЕНИЕ ВЕРОЯТНОСТИ ПОТЕРЬ С ПОМОЩЬЮ КОДИРОВАНИЯ СИГНАЛА В ВОЛОКОННО-ОПТИЧЕСКИХ ЛИНИЯХ СВЯЗИ. European Journal of Interdisciplinary Research and Development, 22, 60-66.
7. M.R.Madaminov. (2023). Classification and operating modes of backup energy supply sources of mobile networks. Best Journal of Innovation in Science, Research and Development, 2(12), 32–38. Retrieved from https://www.bjisrd.com/index.php/bjisrd/article/view/1045

Impact Factor: 9.9 ISSN-L: 2544-980X

8. A.X.Abdusamatov. (2023). MATHEMATICAL MODEL OF THE THROUGHPUT OF AN IP NETWORK SWITCHING NODE WITH A NON-CONSTANT AMOUNT OF SPACE IN THE ROUTER RAM. International Multidisciplinary Journal for Research & Development, 10(10), 186–193. Retrieved from https://www.ijmrd.in/index.php/imjrd/article/view/147
9. D.R. Komilov. (2023). APPLICATION OF ZIGBEE TECHNOLOGY IN IOT. International Journal of Advance Scientific Research, 3(09), 343–349. https://doi.org/10.37547/ijasr-03-09-54
10. Shohbozjon Ergashev. (2023). OPTOELECTRONIC CONVERTERS BASED ON APV ELEMENTS. European Journal of Emerging Technology and Discoveries, 1(6), 1–4. Retrieved from https://europeanscience.org/index.php/1/article/view/265