wjert, 2016, Vol. 2, Issue 5, 109-117. Research Article ISSN 2454-695X

World Journal of Engineering Research and Technology
WJERT
www.wjert.org
SJIF Impact Factor: 3.419

TO STUDY FOR THE DIFFERENT PHENOMENONS AND BEHAVIORS IN OPTICAL FIBER.

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Article Received on 21/06/2016 **Article Revised on 11/07/2016** **Article Accepted on 02/08/2016**

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INTRODUCTION

Communication has always dreamt of higher information bandwidth for wires and coaxial lines with frequency available for transmission extends from 10^8 to 10^9 Hz. But modulated light transmission frequency about 10^{10} Hz range, thus here increase in several orders of magnitude in potential bandwidth is possible.

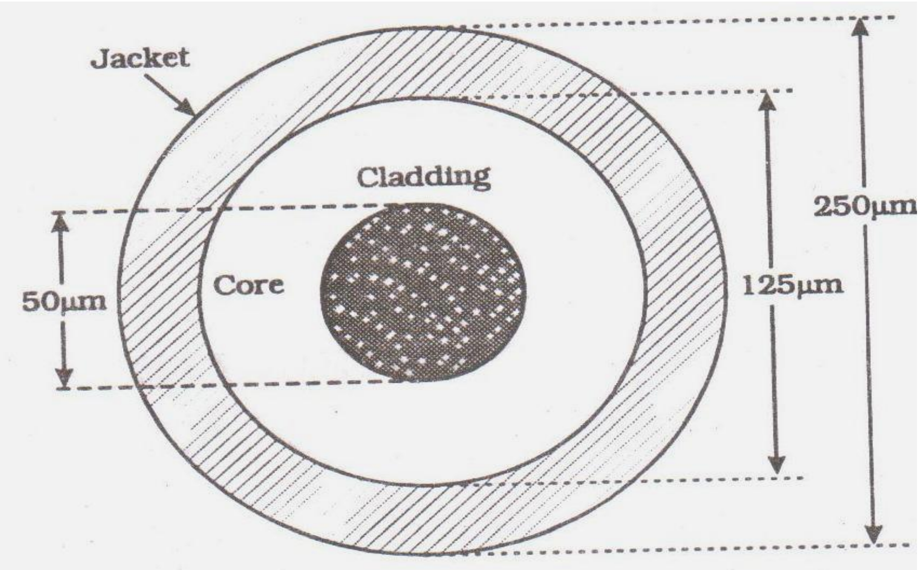
The main drawback these communication systems using the light signal is unguided and it is transmitted through atmosphere where it is subject to attenuation and distortion. Therefore, a better light wave communication system would certainly need a light guide to help preserve the signal and increase the relability and distance of transmission.

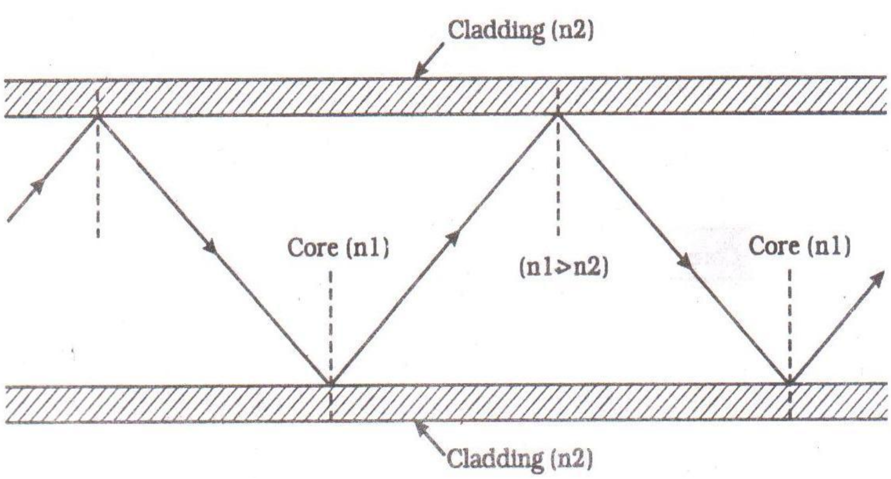
However, it was not until like a practical wave guide unnvisaged. This guide was a solid cylinder capable of guiding a wide range of electromagnetic waves including the upper limits of visible light. Another light guide developed during that consist of a hollow tube with a highly reflective metal coating with its inner surface. Thus, light injected into one end of either guide bounced back and forth along the length to exit at the other end. These devices had high signal loss and hence, were not much practical use. With some success therein by 1950's these glass fiber bundles were used as light conducts readers, for this time the core with its high refractive index and surrounded by that had a lower refractive index.

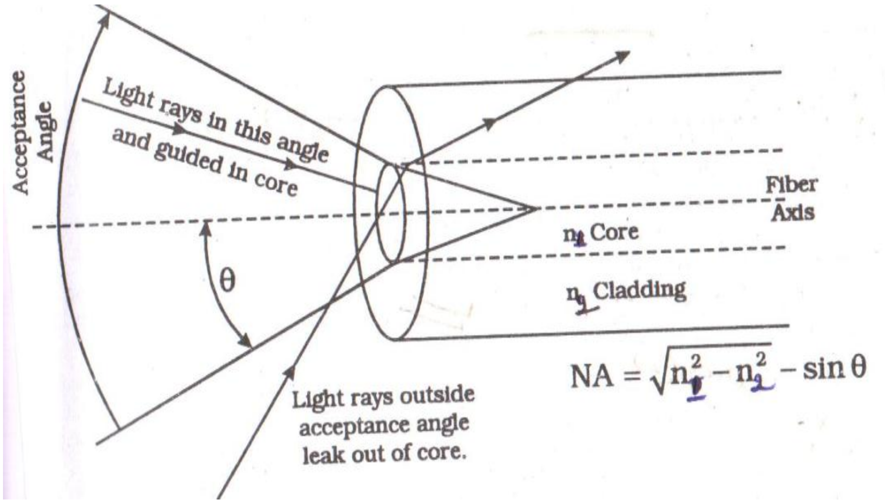
THEORY

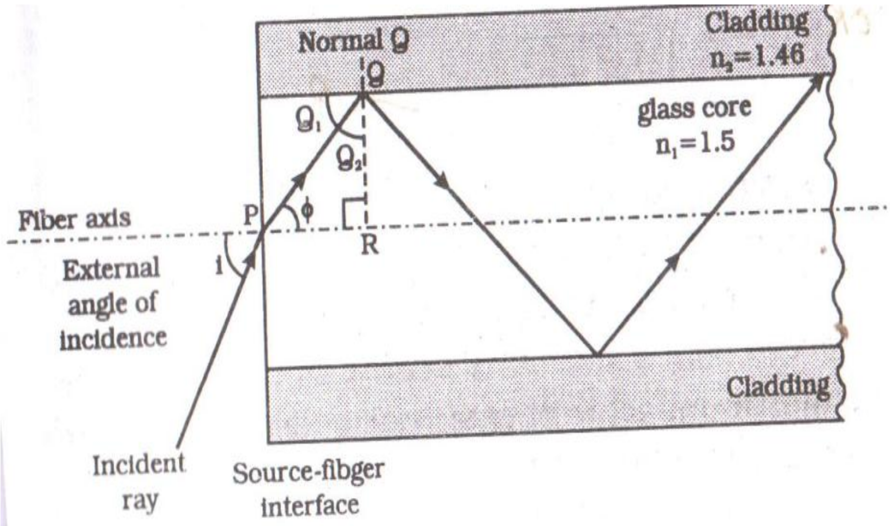
The communication fiber has a core surrounded with a cladding where the refractive index of cladding is to be smaller than core. The thickness of cladding is normally one or two wave lengths of the light to be guided, considering these fibers as dielectric waveguides one could visualize having transmitting only one mode. The multimode fiber has diameter of the order of 50 um it is difficult to have small diameter and also there are certain difficulties in handling them such as splicing, joining and bending etc. In the case of step index fiber a large number of modes can propagate and since different modes have different group velocities, therefore smaller the loss of information capacity however is being compensated by certain advantages. Then calculated values of numerical aperture is normally based on the refractive indices .Then only an actual measurement of the acceptance angle will provide a true indication of numerical aperture. In spite of these uncertainties associated with the quantity it is still common practice to specify the NA of the fiber as one of its basic parameters and it is same ratio of n_1/n_2, NA increases as core refractive index also increases.

Figure.









In order to understand the propagation of light through an optical fiber, consider a light ray entering the core, And it travelling through the core until it reaches the core cladding boundary at anther end as long as the light ray intersects the core – cladding boundary at small angles. The ray will be reflected back in to the core to travel through anther process of reflection is repeated i.e., total internal reflection. When the angle of incidance(i) is greater than the critical angle (θ_c), the angle of intersection is too large so reflection back in to the core does not take place and the light ray is enter the core with an angle called the acceptance angle(θ_c) of the fiber.

The most commonly having the wavelength 155nm in single mode and 850nm to 1300nm in multimode. Then core diameter ranges from 8um to 62.5um and cladding diameter about 65 um to 125um and material of buffer coating is hard plastic such as acrylic, nylon and with diameter ranges from 250um to 900um. And it provides mechanical protection and bending flexibility for the fiber. When light enters one end, then it travels from a denser to rarer medium with a finite angle and finally emerges other end of the fiber. The core refractive index[n_1 while the cladding is made up of a material of refractive index[$n_{2]}$ ($n_1 > n_2$). Then Using Snell's laws.

$n_1 \sin i = n_2 \sin r$ — (1)

$n_1 \sin \theta_c = n_2 \sin 90$

$\sin \theta_c = n_2/n_1$ — (2) Where θ_c is critical angle

Therefore, the light propagated within the core, the angle of incidence at core cladding interface should be greater. Therefore, there is maximum value of incidence beyond and it does not propagate rather it termed as the numerical aperture (NA).

From equation (1) & (2),

$$NA = n_1 \sqrt{1 - \sin^2\theta_c}$$

$$= n_1 \sqrt{1 - n_2^2 / n_1^2}$$

$$NA = n_1 \sqrt{\frac{n_1^2 - n_2^2}{n_1^2}} \quad \text{— (3)}$$

Taking n_1^2 outside from the square.

Then $$NA = \sqrt{n_1^2 - n_2^2} \quad \text{— (4)}$$

The significance of NA is that light entering in the cone of semi vertical angle only propagate through the fiber. Thus numerical aperture is considered as a light gathering capacity of an optical fiber.

Advantages

- These are being light in weight and small in size, No possibility of internal noise
- No hazards of short circuits in wire.
- No problems when used in explosive environments.
- Immunity to adverse temperature and moisture conditions.
- Lower cost of cables per unit length compared to that of metal counter part.
- No need for additional equipment to protect against grounding and voltage problems.
- Very nominal shipping, handling and installation costs.

- Lesser problems in space applications such space radiation shielding and line to line data isolations.

Because of these advantages, development of integrated optical technology is hoped to play a bigger part in influencing further electronic systems for communication control and instrumentation.

Calculations

1) $n_1 = 1.40$, $n_2 = 1.35$

Numerical Aperture

$$NA = \sqrt{(n_1)^2 - (n_2)^2}$$

$$= \sqrt{(1.40)^2 - (1.35)^2}$$

$$= \sqrt{1.8225 - 1.7424}$$

$$= \sqrt{0.0801}$$

$$= 0.2830$$

Acceptance Angle (θ_o)

$= Sin^{-1}$ NA

$= Sin^{-1}(0.2830)$

$= 16^0$

Critical Angle(θ_C)

$= Sin^{-1}(n_1/n_2)$

$= Sin^{-1}(0.9777)$

$= 78^0$

2) $n_1 = 1.35$, $n_2 = 1.32$

Numerical Aperture

$$NA = \sqrt{(n_1)^2 - (n_2)^2}$$

$$= \sqrt{(1.35)^2 - (1.32)^2}$$

$$= \sqrt{1.9044 - 1.8225}$$

$$= \sqrt{0.0819}$$

$$= 0.2861$$

Acceptance Angle (θ_o)

$= Sin^{-1}$ NA

$= Sin^{-1}(0.2861)$

$= 17^0$

Critical Angle (θ_C)

$= Sin^{-1}(n_1/n_2)$

$= Sin^{-1}(0.9777)$

$= 78^0$

3) $n_1 = 1.40$

$n_2 = 1.35$

Numerical Aperture

$$NA = \sqrt{(n_1)^2 - (n_2)^2}$$

$$= \sqrt{(1.40)^2 - (1.35)^2}$$

4) $n_1 = 1.35$

$n_2 = 1.32$

Numerical Aperture

$$NA = \sqrt{(n_1)^2 - (n_2)^2}$$

$$= \sqrt{(1.35)^2 - (1.32)^2}$$

$= \sqrt{1.9600-1.8225}$

$= 0.3708$

Acceptance Angle(θ_o)

$= Sin^{-1}$ NA

$= Sin^{-1}(0.370))$

$= 14^0$

Critical Angle (θ_C)

$= Sin^{-1}(n_1/n_2)$

$= 81^0$

$= \sqrt{0.0576}$

$= 0.2400$

Acceptance Angle(θ_o)

$= Sin^{-1}$ NA

$= Sin^{-1}(0.370))$

$= 22^0$

Critical Angle(θ_C)

$= Sin^{-1}(n_1/n_2)$

$= 75^0$

5) **n_1**= 1.50

n 2= 1.47

n_2 = 1.45

Numerical Aperture

$NA = \sqrt{(n_1)^2 - (n_2)^2}$

$= \sqrt{(1.50)^2-(1.47)^2}$

$= \sqrt{2.25-2.1609}$

$= \sqrt{0.0891}$

$= 0.2984$

Acceptance Angle(θ_o)

$=Sin^{-1}$ NA

$=Sin^{-1}(0.2984)$

$=17^0$

Critical Angle (θ_C)

$= Sin^{-1}(n_1/n_2)$

$=Sin^{-1}(0.9800)$

$=78^0$

6) **n_1**= 1.50

Numerical Aperture

$NA = \sqrt{(n_1)^2 - (n_2)^2}$

$= \sqrt{(1.50)^2-(1.45)^2}$

$= \sqrt{2.25-2.102}$

$= \sqrt{0.1448}$

$= 0.3847$

Acceptance Angle(θ_o)

$=Sin^{-1}$ NA

$=Sin^{-1}(0.3847)$

$=22^0$

Critical Angle (θ_C)

$= Sin^{-1}(n_1/n_2)$

$=Sin^{-1}(0.9666)$

$=75^0$

7) **n_1**= 1.48

n_2 =1.45

8) **n_1**=1.35

n_2 =1.30

Numerical Aperture

NA = $\sqrt{(n_1)^2 - (n_2)^2}$

= $\sqrt{(1.48)^2-(1.45)^2}$

= $\sqrt{2.190-2.102}$

= $\sqrt{0.2966}$

= 0.24

Acceptance Angle (θ_o)

= $\sin^{-1}$ NA

= $\sin^{-1}(0.2966)$

= 17^0

Critical Angle ($\theta_{C]}$

= $\sin^{-1}(n_1/n_2)$

= $\sin^{-1}(0.2966)$

= $77^{\ 0}$

Numerical Aperture

NA = $\sqrt{(n_1)^2 - (n_2)^2}$

= $\sqrt{(1.35)^2-(1.30)^2}$

= $\sqrt{1.8225-1.6900}$

= $\sqrt{0.1325}$

= 0.3640

Acceptance Angle (θ_o)

= $\sin^{-1}$ NA

= $\sin^{-1}(0.3640)$

= 21^0

Critical Angle (θ_C)

= $\sin^{-1}(n_1/n_2)$

= $\sin^{-1}(0.9629)$

= 74^0

9) $\mathbf{n_1}$= 1.45

$\mathbf{n_2}$ =1.41

Numerical Aparture

NA= $\sqrt{(n_1)^2 - (n_2)^2}$

= $\sqrt{(1.45)^2-(1.41)^2}$

= $\sqrt{2.1025-1.9881}$

= $\sqrt{0.1144}$

= 0.3382

Acceptance Angle (θ_o)

= $\sin^{-1}$ NA

= $\sin^{-1}(0.3382)$

= $\sin^{-1}(0.4898)$

= 19^0

10) $\mathbf{n_1}$=1.54

$\mathbf{n_2}$ =1.46

Numerical Aparture

N A = $\sqrt{(n_1)^2 - (n_2)}$

= $\sqrt{(1.54)^2-(1.46)^2}$

= $\sqrt{2.3716-2.1316}$

= $\sqrt{0.2400}$

= 0.4898

Acceptance Angle (θ_o)

= $\sin^{-1}$ NA

= 29^0

Critical Angle (θ_C)

$= Sin^{-1}(n_1/n_2)$

$= Sin^{-1}(0.9724)$

$= 76^{0}$

Critical Angle (θ_C)

$= Sin^{-1}(n_1/n_2)$

$= Sin^{-1}(0.9480]$

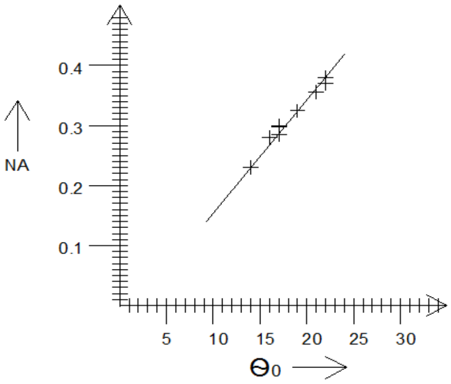
$=71^{0}$

RESULTS

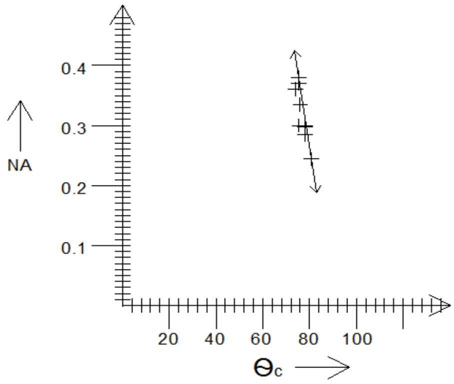
Numerical Aperture (NA)	Acceptance Angle (θ_0)	Critical Angle (θ_c)
0.2830	16^o	78^o
0.2861	17^o	78^o
0.3708	22^o	75^o
0.2400	14^o	81^o
0.2984	17^o	78^o
0.3847	22^o	75^o
0.2966	17^o	77^o
0.3640	21^o	74^o
0.3024	17^o	55^o
0.3382	19^o	76^o

Graph,

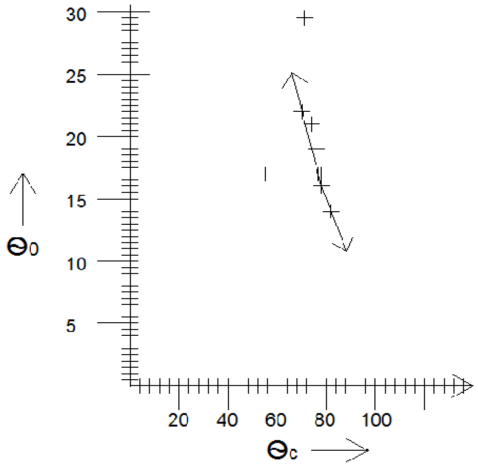
[1] NA versus θ



[2] NA versus θ



[3]



CONCLUSIONS

The information capacity gets increased but in order to the radius of core is reduced and also the difference between the refractive index and radius of core decreases the coupling efficiency gets decreased, where as the increase in difference between core and cladding refractive indices , but waveguide bandwidth decreases.

REFERENCE

1. Kapany, N.S., Fibre optics, principle and applications, academic press. Inc., N.Y., 1967.
2. Barnoski, M.K., Fundamental of optical fibre communication, academic press, Inc., N. Y., 1976; 2nd Ed 1982.
3. Technical staff of CSELT, optical fibre communication, centro studio laboratory Telecomunicazioni. Torino, 1980.
4. Marcuse. D., principle of optical fibre measurements, Academic press, Inc., N.Y.
5. Cherin, A. H., An Introduction to optical fibres, Mc Graw Hill Bookco. N. Y., 1983.
6. Sharma, N., Fibre optics in Telecommunications,Tata Mc Graw Hill Co., New Delhi, 1987; 172-173.
7. Nelson, BP. etal., Design and menufactare of optical fibre with specific dispersion characteristics, electronics letters, 1985; 21(1985): 274-275.
8. Murata, H., Hand book of optical fibres and cables, murcel Dekker Inc, N.Y., 1988.