Experiment:10

NUMERICAL APERTURE OF AN OPTICAL FIBER

AIM: To determine the acceptance angle and the numerical aperture of the given optical fiber.

APPARATUS: Single strand plastic optical fibers of different core diameter/length, Laser Source, screen

INTRODUCTION: Numerical aperture represents the light gathering capacity of an optical fiber. In optics, the numerical aperture (NA) of an optical system is a dimensionless number that characterizes the range of angles over which the system can accept or emit light. By incorporating index of refraction in its definition, NA has the property that it is constant for a beam as it goes from one material to another, provided there is no refractive power at the interface. The exact definition of the term varies slightly between different areas of optics. Numerical aperture is commonly used in microscopy to describe the acceptance cone of an objective (and hence its light-gathering ability and resolution), and in fiber optics, in which it describes the range of angles within which light that is incident on the fiber will be transmitted along it.

FORMULA:

$$N.A = n_o \sin\theta_A = \sqrt{n_1^2 - n_2^2}$$

Where

N. A is the numerical aperture of the given optical fiber

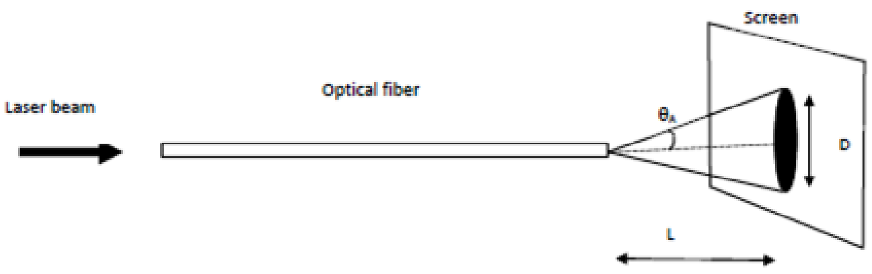
n_o is the refractive index of the medium from which light is entering the fiber

θ_A is the angle of acceptance in degree

n_1 is the refractive index of the core

n_2 is the refractive index of cladding

RAY DIAGRAM :



TABULAR COLUMN:

Trial No	L (mm)	D(mm)	Angle of acceptance $\theta_A = tan^{-1}(\frac{D}{2L})$ (deg)	N.A= n_o sinθ_A $(n_0 = 1\ for\ air)$
1.	2.5			
2.	5			
3.	7.5			
4.	10			

Mean N.A = ………

PROCEDURE:

1. Connect the fiber to the Laser source.

2. Take the other end of the fiber and project the light output on to the screen to obtain a bright circular spot of size say 5mm.

3. Determine the diameter D of the bright spot and the distance L from the fiber end to the screen and measure the diameter of the spot (D) and the distance between the screen & the optical fiber end (L).

4. Calculate the acceptance angle using the formula $\theta_A = \tan^{-1}\left(\frac{D}{2L}\right)$

5. Numerical aperture is given by N.A = n_o sin.θ_A
   Here n_0 is the refractive index of the medium from which light is entering (n_o =1 for air).

6. Now for the same fiber repeat this procedure for at least four other values of distance L and calculate the acceptance angle and numerical aperture in each case. Finally take the average of the four numerical aperture values.

7. Now repeat the above procedure for the remaining fibers.

8. Refer the catalogue and find out refractive index of core and cladding (n_1& n_2) and evaluate numerical aperture using the formula N.A = $\sqrt{n_1^2 - n_2^2}$ and compare it with the experimental value.

RESULT: 1. The acceptance angle of the given optical fiber is ……..
2.The Numerical aperture for the given optical fiber is found to be …………..
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Note: This exercise may be repeated for optical fibers of different diameters. Length of the optical fiber could be 1m. We used single strand plastic optical fiber (POF) of core diameter 1000µm. µcore = 1.49 -1.59, µcladding =1.46. This experiment works better for distances L in the range of 0.2mm to 1cm.

References :

Optical fiber communication by John M Senior, Pearson Publication, page no 429, 911, and 912.