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Bend loss in large core multimode optical fiber beam delivery system

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Abstract: We are going to analyze the effect of bend loss in large core multimode optical fiber beam delivery system by varying the core diameter of the fiber, its bend radius and the wavelength of the laser used. By analyzing the bend loss after varying the various parameters for different fibers, the fiber which contributes minimal bend loss is taken for the beam delivery system application.

Key words: Beam Delivery system, Bend radius, Bend loss, Multimode Optical Fiber.

I. INTRODUCTION

The efficiency of an optical fiber is mainly reduced due to its losses. The various losses in optical fiber are absorption loss, scattering loss, dispersion loss and bending loss. Here, we are going to study the effect of bend loss on a fiber, especially in fiber optic beam delivery system application. The optical fiber can either be a single mode fiber or a multimode fiber. This fiber optic beam delivery system is made up of a large core multimode fiber. A multimode fiber is used for short distance purposes; these fibers have high capacity and reliability [1]. The main difference between a single mode fiber and a multimode fiber is that, the multimode fiber has a larger core diameter and also the value of its numerical aperture is large. Hence, the light gathering capacity of the fiber is high. In a multimode fiber the bandwidth distance product is much lower than that of a single mode fiber as the former supports more than one propagation mode. A beam delivery system is used to capture light from one point and delivery it to another point. A beam delivery system is also used to scan the work piece in inaccessible areas or hazardous locations. It is also used to distribute power from a single laser source to a number of work stations [2]. While carrying out these applications most of the time the fiber is bent to reach the its destination point and thus resulting in bend loss. Bend loss is a phenomenon which occurs when the optical fiber is bent above the critical bend radius. The bend radius varies for different optical fiber. Reasons for these bend loss are poor cable design, microscopic fiber deformation and tight bends.

Bend loss depends on bend radius, fiber parameters such as numerical aperture, core radius and the launching conditions of the input beam.The bend loss can be of two types. They are: macro bend loss and micro bend loss. Macro bend loss occurs when the critical angle is exceeded at high order mode and the light is refracted out of the core into the cladding region[3].The macro bend loss can be seen with the naked eye and these bends can be rectified up to a certain extent. Micro bend loss is just opposite to the macro bend. Micro bend loss occurs when the pressure is applied on the surface of the fiber and due to the distortion of core cladding interface. The micro bend loss is too small to be seen with the naked eye.

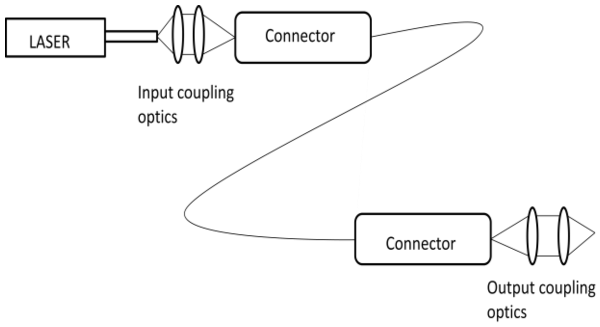

Fig.1. Fiber optic beam delivery system.

Fig.1 shows that the standard beam delivery system, which contains laser source, input and output coupling optics, connectors and the transmission medium optical fiber.

II. DESIGN OF THE FIBER

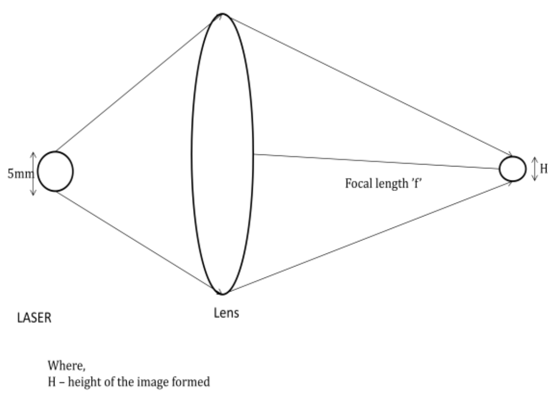

Fig. 2 .

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From Fig.2 , we can calculate the core diameter of the fiber and numerical aperture of the fiber. From this we can choose the fiber, which is more suitable for beam delivery system with less bend loss.

Height (H) = $\frac{5\lambda}{\pi} * \frac{f}{D}$

H=175µm.

To calculate the numerical aperture (NA) we have considered a Cassegrain Telescope, with diameter (D) = 317.5mm and focal length (f) = 1239.77mm. By using these parameters we find the half acceptance angle (θ), from the value of θ the numerical aperture (NA) is found.

The Laser light of 5mm in diameter is made to fall on the lens, as diffraction occurs, the laser light is focused on the screen and the height of the beam falling on the screen is calculated using the above Height formula. Therefore, the value of H is found to be 175µm. Hence, the core diameter of the fiber should be approximately equal to 175µm, so that the loss of light is avoided.

Considering the value of NA and core diameter a suitable fiber is selected. In this case we consider an All Silica Fiber whose NA=0.12 and core diameter=200µm. The value of refractive indices are: refractive index of core (n_1) =1.557 and refractive index of cladding (n_2) =1.552.

To compare the bend loss for different fiber we chosen two different types of fiber at the wavelength of 633 nm, which is given in the Table 1.

Fiber type	Core Diameter (µm)	Cladding Diameter(µm)	Core Refractive Index (n_1)	Cladding Refractive Index (n_2)	Numerical Aperture(NA)
All-Silica Fiber	200± 4	220±4	1.457	1.452	0.12
	200± 4	220±4	1.457	1.440	0.22
HSC Fiber(Hard Clad Fiber)	200± 5	230±5	1.457	1.410	0.37

Table.1

III. BEND LOSS DERIVATION

The power loss formula for a mode of propagation constant β [4],

$$\alpha = 2 * \frac{\gamma^2(0)}{\beta} * e^{(-2*\int_a^{r_0} \gamma(r)d\,)} \quad (1)$$

Where,

$$\gamma^2(r) = \frac{\beta^2 R^2}{(r+R)^2} - n_c{}^2 k^2 \quad (2)$$

$$r_0 = \frac{R\beta}{n_c k} - R \quad (3)$$

To solve the equation (1), rewrite the equation (2) in the form of,

$$\gamma^2(r) = \gamma^2(0) - \frac{2\beta^2 r}{R} \quad (5)$$

As an additional approximation we replace β by $n_c k$. We then insert equation (5) into equation (1) and solve the integral .

Then the power loss attenuation result will be[5],

$$\alpha = 2n_1 k(\theta_c{}^2 - \theta^2)\exp\left[-\frac{2}{3} n_1 kR\left(\theta_c{}^2 - \theta^2 - \frac{2a}{R}\right)\right]^{\frac{3}{2}} \quad (5)$$

Where K is propagation constant($\frac{2\pi}{\lambda}$) ,θ_c is critical angle($\sin^{-1}\frac{n_2}{n_1}$) of the fiber, n_1= refractive index of the core,n_2= refractive index of the cladding, a= fiber core radius, R=radius of the bend measured to the fiber axis.

IV. RESULT

BEND RADIUS EFFECT:

The effect of Bend radius on bend loss is presented in fig 3 and Fig 4.

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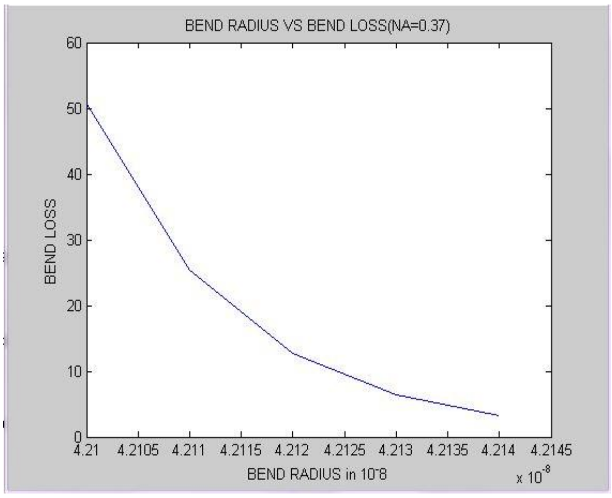

Fig.3.Theoretical bending loss as a funtion of band radius.HCS fiber with NA=0.37.

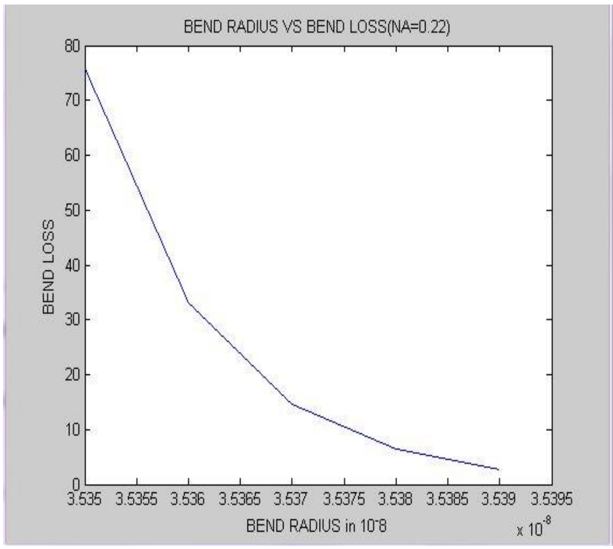

Fig.4.Theoretical bending loss as a funtion of bend radius.All-Silica fiber with NA=0.22.

WAVELENGTH EFFECT:

The effect of Wavelength of the transmitted light on bend loss is presented in fig 5.

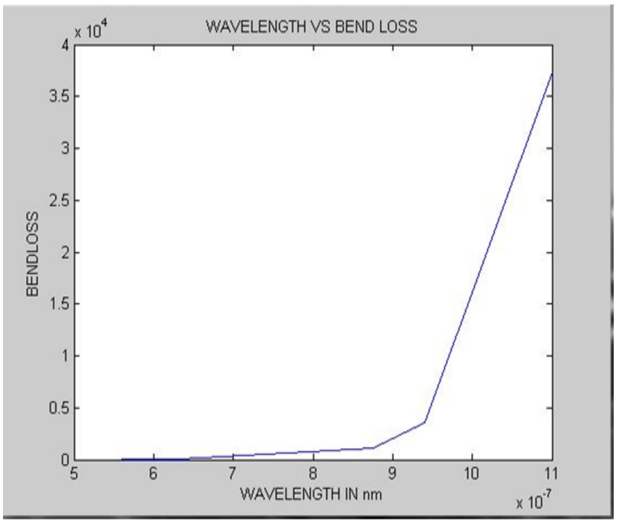

Fig.5.Theoretical bending loss as a funtion of Wavelength. HCS fiber with NA=0.37.

CORE RADIUS EFFECT:

The effect of core diameter on bend loss is presented in Fig.6 and Fig7.

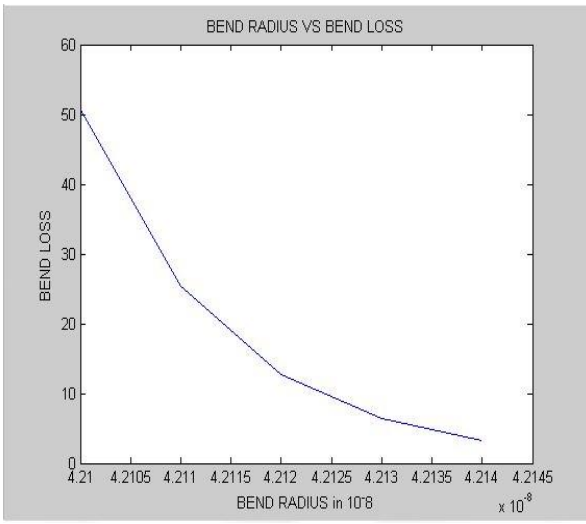

Fig .6.Theoretical bending loss as a funtion of bend radius. HCS fiber with core diameter of 200 µm and NA=0.37.

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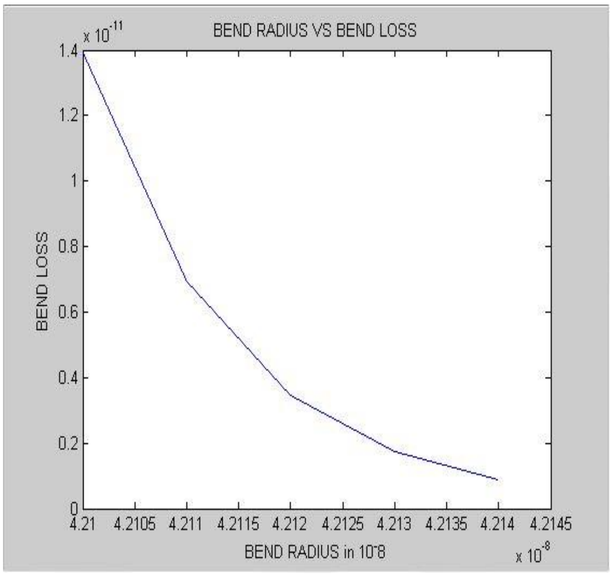

Fig .7.Theoretical bending loss as a funtion of bend radius. HCS fiber with core diameter of 198 µm and NA=0.37.

V. DISCUSSION

Bend loss depends on the parameters of the fiber such as numerical aperture and core radius. And also depends on the bend radius. These fiber parameters must be taken into account when designing an optical fiber beam delivery system. As the core radius of the fiber increases, the bend loss increases, assuming other parameters to be fixed. On the other hand, increasing the numerical aperture will decrease the bend loss. Fig 3. Shows how the bend loss increases by increasing the bend radius. A theoretical curve for bend loss vs fiber bend radius is given in Fig 3 Where the fiber core diameter is 200µm and NA=0.37, We obtain a similar result from Fig 4,where the NA=0.22. A curve for bend loss vs wavelength is given in Fig.5.assuming other parameters to be fixed. It shows that as the wavelength increases, the bend loss also increases and vice versa. The curve for bend loss by varying the core radius of the fiber is given in Fig 6 and Fig 7.From the above study we confirms the importance of using large numerical aperture and small core diameter fibers. So it is better to use small core diameter and large numerical aperture fiber in beam delivery system. So that we can get better performance and high efficiency of the system.

REFERENCES

[1]. http://en.wikipedia.org/wiki/Multi-mode_optical_fiber
[2]. H.P. Weber and W. Hodel, "High Power Light Transmission in Optical Waveguides", Proc.Soc.Photo-Opt.Instrum.Eng.650,102-108(1986).
[3].http://www.altimex.co.uk/guides/application-Microbending-Macrobending.
[4].V. V. Shevchenko, Izv. Vuz. Radiofiz. 15,768 (1971).
[5].D. Gloge, "Bending Loss in Multimode Fibers with Graded and Ungraded Core Index," Appl. Opt. 11, 2506-2513 (1972).