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Studying the Effect of Curvature in the Multimode Optical Fiber and Calculate Critical Radius of Curvature for the Wave Length 850 nm and 1550 nm

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Abstract: A bending effect of the multimode optical fiber on the signal that transferred within it has been studied for tow wavelengths 850 and 1550 nm. The bending losses were measured for each wavelength with different bending curvature radii. In addition, the critical radius of curvature was calculated for both wavelengths, it was 0.34 and 0.26 mm of wavelength 850 and 1550 nm, respectively. The results appeared that the bending loses of 1550 nm was less than of 850 nm.

Key words: Multimode fiber, critical radius of curvature, bend loss, optical fiber, multimode optical, wavelengths

INTRODUCTION

Now a days, optical fiber has been considered as one of the significant and vital communication systems. It is developed too quickly after inventing laser. Thebasic principle of its work depends on total internal reflection of laser at the interface between two mediium with different indices of refraction (Bass and Stryland, 2002) Thefiber optics cable usually consists of bunches of cylindrical dielectric waveguide. The single fiber involve of core and gladding layers to confine signal inside the core (Senior and Jamro, 2009). Because of the lightweight of fiber, low cost, low losses and huge transferred data.The fiber is the favored in communication systems. However, there are many types of losses is occurred inside fiber due to impurity, micro crack, air bubble or micro and macro bending of the fiber.

MATERIALS AND METHODS

Theory: The light intensity will suffer losses when light signal transfers through the optical fiber due to the presence of curvature in the fiber path that is assumed to be straight along the light propagation line. The transmitted light through fiber depends on accepted angle and critical radius of curvature (Amanu, 2016; Murad and AL-Ebrahimy, 2016). When there is a strong curvature that will effect on the mechanism of directing light, therefore, escape of light from the core of the optical fiber to the gladding layer. These loss are represented by the radiation attenuation coefficient which is calculated by Senior and Jamro (2009):

$$r = C_1 \exp(-C_2 R) \quad (1)$$

Where:

C_1 and C_2 = The constants
R = Radius of curvature

The critical Radius of curvature (R_c) represents the minimum curvature radius of fiber in which neglected the loss due to bending. R_c is proportional to the used wavelength and it is calculated by Amanu (2016):

$$R_C = \frac{3n_2\lambda}{4\pi\left(n_1^2-n_2^2\right)^{\frac{3}{2}}} \quad (2)$$

Where:

n_1 = Refractive index of the core
n_2 = Refractive index of the gladding
λ = The wavelength

The Numerical Aperture (NA) is defined as (Amann, 2016):

$$NA = \sqrt[2]{n_1^2-n_2^2} \quad (3)$$

The critical radius of curvature is inversely proportional to the amount of energy losses where the smaller the critical radius of curvature, the greater the loss.

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Cut-off wavelength: Cut-off wavelength (λ_C) is the largest wavelength that travels through the multi-mode optical fiber is defined as (Lecoy, 2013):

$$\lambda_c = \frac{2\pi a n_1}{v_c}(2\Delta)^{\frac{1}{2}} \quad (4)$$

Where:

a = The core radius

v_c = The Velocity of cut off wavelength in core

Δ = The refractive index difference which is calculated by Amanu (2016) and Agrawal (2012)

$$\Delta = \frac{n_1^2 - n_2^2}{2n_1^2} \approx \frac{n_1 - n_2}{n_1} \quad (5)$$

Fiber parameters such as the refractive index difference, core radius and numerical aperture determine the amount of loss in the optical signal, besideshe radius of bending. There are two types of bending micro and macro bending (Sangeetha *et al.*, 2015) micro bend loss occurs when there is distortion of core cladding interface due to the pressure that may be applied on the surface of the fiber.

Experimental: In this study, the experiments have been done of the existing multimode optical fiber with length of 10 m that is installed on transmitter SDH4 (Synchronize Digital Hershey) in the Post and Communication Office of Najaf. Two wavelengths were used 850 and 1550 nm. The optical signal that arrived to other end of fiber is measured by a power meter, then find the loss of energy. At the beginning, the energy losses of signal is measured with absence of any macro bending (straight-line fiber) that represents initial loss. The bending loss of multi curvature radi 1, 1.5, 2, 2.5 and 3 mm is taken many times and then calculated the average of that readings for each radius to obtain more accurate of measurements

RESULTS AND DISCUSSION

The bending loss of multimode fiber is measured with changing the curvature radius from 1-3 mm in step of 0.5 mm for two wavelengths 850 and 1550 nm.The results of wavelength of 850 nm is shown in Table 1 and Fig. 1. The initial loss of signal without bending for 850 nm wavelength was -13.1 dB/m and the critical radius of curvature was 0.34 mm. The loss of optical signal increases rapidly when the curvature radius <2 mm. The cutoff signal occurred at bending radius of 1 mm.

For wavelength 1550 nm, the initial loss of signal was -6.2 dB/m and the critical radius of curvature was 0.34 mm. The loss of optical signal that is transferred via. fiber has been recorded as shown in Table 2 and Fig. 2.

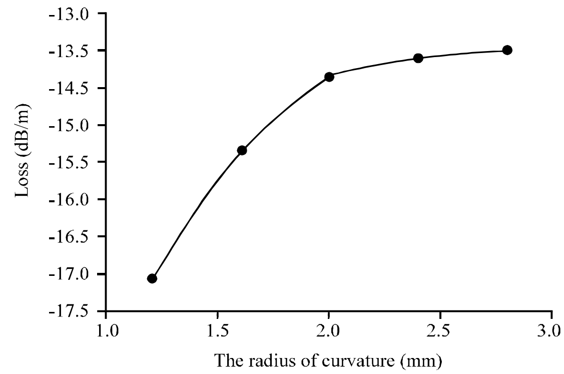

Fig. 1: The curvature loss of wavelength 850 nm

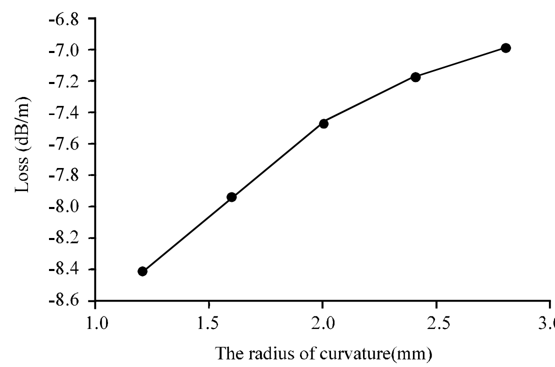

Fig. 2: The curvature loss of wavelength 1550 nm

Table 1: The curvature loss of wavelength 850 nm

R (mm)	Loss (dB/m)
3.0	-13.5
2.5	-13.6
2.0	-13.9
1.5	-15.0
1.0	-17.0

Table 2: The curvature loss of wavelength 1550 nm

R (mm)	Loss (dB/m)
3.0	-7.0
2.5	-7.2
2.0	-7.5
1.5	-8.0
1.0	-8.5

The loss of bending increases exponentially with decreasing the radius of curvature until cut-off signal occurred atbending radius of 1 mm.

CONCLUSION

In this study, there is a significant effect for bending in determining the amount of optical energy transmitted through the multi-mode optical fiber. The increasing of the fiber bending leads to the greater the loss of energy transferred. The wavelength 1550 nm is the best because of less attenuation that is occurred as a result of bending fiber.

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