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Study the Calibration of Bending Losses and Critical Radius of Curvature for Different Light Sources in Single-Mode Fibers

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Abstract: the bending losses rise greatly of the longer wavelengths, inspite of the dependence of the wavelength is extremely strongly on the oscillatory because of the overlap with the reflected lightin the coating boundary or cladding as well as from the outer of the coating surface. The growing of bending losses at longer frequently of the wavelengths defines as the suitable range of the wavelength for the single-mode fiber. An experimental investigation was made of the bending losses and the calibration losses in a single-mode fiber using two types of different light sources that were the pure red laser diode with range of 635 nm as wavelength and the infrared light-emitting diode operate between 940-950 nm. The measurements were carried out at the Communication and Postal Service, Al-Hillah-Babylon-Iraq. the bending losses, the calibration losses and the curvature critical radius were considered in this study. the results were contrasted with the theoretical data in order to investigate out that the both finding were very close.

Keywords: Bending losses, cladding, critical radius, single-mode fibre, laser diode

INTRODUCTION

The technology of optical fiber that present the single-mode fiber as an optical fiber. This produce to transmit the single wave or the mode of light essentially a carrier as well as utilize for the long distance of the signal transmission (Zendehnam *et al*., 2010). Whereas, the multi mode fiber applies in the short distances. The cable of fiber optic consist of four parts Core, Cladding, Coating (buffer) and Jacket, as shown in Fig. 1. The suitable wavelength light is usually between 850 nm and 1610 nm (Nakajima *et al*., 2010). The core of the fiber was manufactured from high purity silica glass, whereas, the cladding that around the core is made from the glass with a lower index of refraction than the core, in order to ensure that the total internal reflection (Matsui *et al*., 2011; Zahra'a, 2014).

As ingle-mode fiber customarily consist of an arrow core of 8-9 μm in diameter that yields only a single mode of light to propagate (Martins *et al*., 2009; Zahra'a, 2014). The narrowness diameter of the core leads to a lower number of internal reflections and minimizes optical dispersion, producing in faster signal propagation and lower optical dispersion loss. This allows wide signal b and width s (Zheng *et al*., 2014; Al Timimi *et al*., 2012). Bending losses is considered a commonly faced the problem in fiber optics that illustrate further propagation losses when the yare bent. That losses are raised very fast when the radius of certain critical bend is got (Watekar *et al*., 2009).

As is well-known in the core, the macro-bending can significantly increase the losses in fibers through the optical signal transmission because of leaving the light in to cladding. That commands to the defect in the mechanism of transmission (Saitoh *et al*., 2009; Ulrich *et al*., 1980). Generally, the selosses can be very significant when the critical radius value is reached. This critical radius is considerably larger than 10 cm of the single-mode fibers through the large mode are as in comparison with the small mode areas fibers (Nakajima *et al*., 2010; Nakajima *et al*., 2011).

In the optical fiber, the wave front should be perpendicular to the direction of propagation, when it is bends in the fiber. the signal transmitted in cladding is slower than in core. This may leads to losing in the signal transmitted energy into the optical fiber (Wu *et al*., 2011). therefore, the speed of light must be raise in the cladding to avoid that as that shown in Fig. 2. The light is lost from the core to the cladding when the wave incident angle in the core-cladding interface don't reach to the total internal reflection critical angle (θc) (Ulrich *et al*., 1980; Makouei *et al*., 2007), as shown in Fig. 3.

The radiation attenuation coefficient (α_r) described the losses, where (α_r) given by the Eq. 1:

$$\alpha_r = C_1 e^{-C_2 R} \quad (1)$$

where, R is a radius of curvature, C_1 and C_2 are constant (RCS) means the curvature critical radius of the single-mode fiber can be determined by:

$$R_{CS} = 20\lambda \Big/ (n_1 - n_2)^{3/2} \left(2.748 - 0.996\, 6\frac{\lambda}{\lambda c}\right)^{-3} \quad (2)$$

where, λ_c is the cut-off wavelength for the single mode fiber.

A critical curvature of the radius is instantly proportional to the applied wavelength etc. Smaller wavelength guides to a smaller radius of curvature (Saitoh *et al*., 2010).

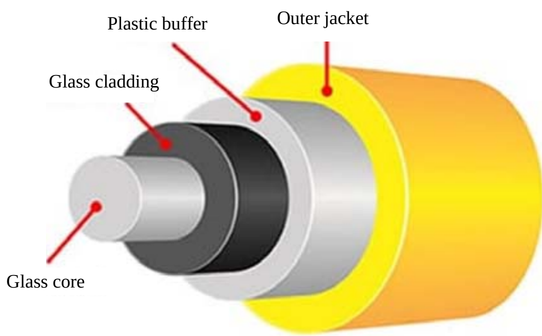

Fig. 1: Structure of a fiber optic cable

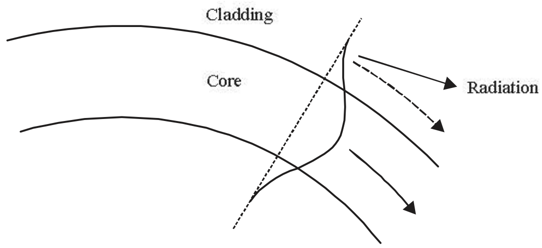

Fig. 2: Bending effect on transmission of radiation within the optical fibre

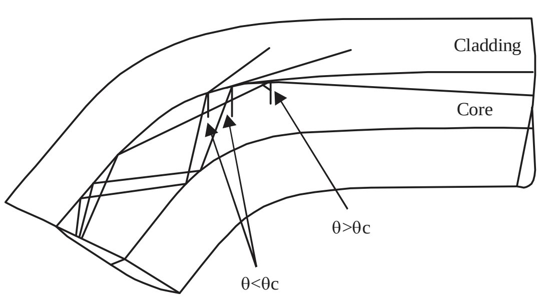

Fig. 3: Macro-bending schematic in an optical fibre

MATERIALS AND METHOD

The main specifications of used single-mode fiber were: λc was 1260 nm and the chromatic dispersion for the wavelength 1285 nm was 3 ps/(nm.km) while, for the wavelength 1322 nm was 22 ps/(nm.km).

After setup, a single-mode fiber, 4 m, is the connection between the transmitter and the receiver, where the data transmission, which are numbers, characters and text message, are achieved for two different light sources. The first light source was infrared light-emitting diode operate between 940-950 nm model (COM-09349) which had high-density irradiation and greatest operation wavelength. The viewing angle 20° and high reliability.

Pure red laser-diode was the second source, it is Model (RLD63NZC5) that work in the average wavelength 635 nm with 5 mw output power, whereas, the process voltage and current are 2.2 V and 33 mA, respectively. The measurements of the bending losses of curvature radius for both sources collected applying a power meter model, corning OM-610.

RESULTS AND DISCUSSION

The practical calibration of bending losses measurements of radius of curvature for infrared light-emitting diode equals to -42.67 db and for pure red laser diode was -33.01 db.

The data of bending losses characterized applying the single mode optical fiber for infrared light-emitting diode operate between 940-950 nm showing in Table 1 and Fig. 4, where decreasing the radius of curvature leads to reduction in the output power, but with in certain of the curvature value, where the critical radius is 0.25 mm and the output power is cut off, whereas, applying the formulation (2) resulted a the theoretical critical radius equal 0.23 mm.

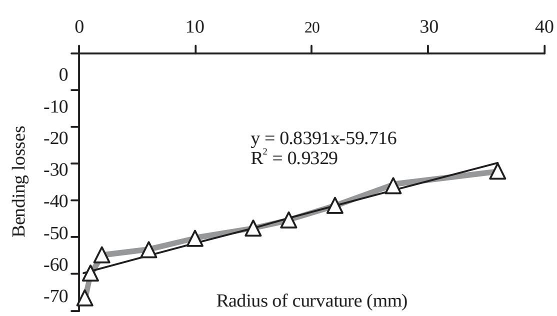

Fig. 4: Bending losses for infrared light-emitting diode operate between 940-950 nm source in single mode optical fibre

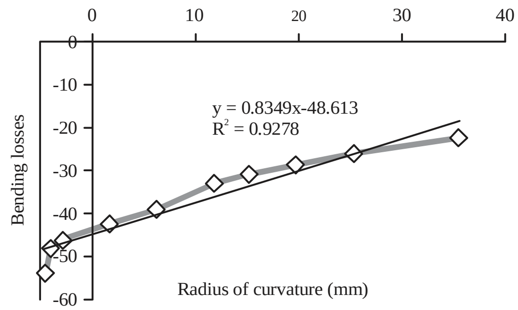

Fig. 5: Bending losses for pure red laser diode (635 nm) source in single mode optical fiber

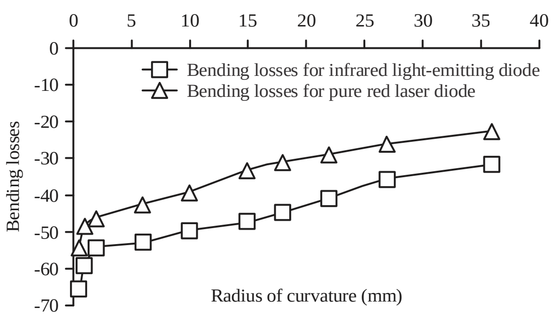

Fig. 6: Comparison of bending losses for pure red laser diode (635 nm) source and infrared light-emitting diode source in single mode optical fibre

Table 1: Bending losses for infrared light-emitting diode operate between 940-950 nm source in single mode optical fibre

Radius of curvature (mm)	Bending losses
0.5	-65.67
1	-59.16
2	-54.43
6	-52.75
10	-49.78
15	-47.15
18	-44.75
22	-40.85
27	-35.67
36	-31.58

Table 2: Bending losses for pure red laser diode (635 nm) source in single mode optical fiber

Radius of curvature (mm)	Bending losses
0.5	-54.02
1	-48.22
2	-46.18
6	-42.47
10	-39.05
15	-33.15
18	-30.89
22	-28.74
27	-26.14
36	-22.47

The bending losses for pure red laser diode (635 nm) was characterized through the single mode optical fiber was shown in Table 2 and Fig. 5, where, 0.21 and 0.12 mm are the practical and theoretical curvature critical radius, respectively.

According to results from both sources, the results exhibited the high value of the curvature critical radius if increasing presented in the wavelength that matched the behaviour by Eq. 2. Figure 6 demonstrates the differences in the results between both sources. Where the measured results exhibited very close during the comparison between it. Meanwhile, this small different in the results related to the several factors such as, the properties of the optical fiber, which is linked to the loss of the calibration between the fiber and light sources (Zheng *et al*., 2014; Saitoh *et al*., 2009; Kashiwagi *et al*., 2012).

CONCLUSION

In this study, the infrared range was achieved when the wavelength was increased and the curvature critical radius of was high. That match the investigation of Eq. 2. When the critical radius was 0.25 mm, the source was cut and the entire signal from infrared Light-Emitting Diode operate between 940 and 950 nm, also when the entire signal from pure red laser diode was 635 nm the n the source was cut when the critical radius was 0.21 mm.

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