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Research Article

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The Test Methods and Reducing Measures of Optical Fiber Loss

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ABSTRACT

In this paper, the conception and measurement method of optical fiber loss are expounded and analyzed, the loss causes of intrinsic and extrinsic in the process of the optical fiber transmission and use are analyzed, reducing measures are put forward too. It provides reference for selection manufacturing process and use of optical fiber.

Keywords: Optical fiber loss, test methods, reducing measures.

INTRODUCTION

Fiber loss directly decided the transmission distance, the stability and reliability of the network [1], it is one of the important indicators of measuring the performance of optical fiber. Optical fiber loss cause in the process of optical fiber transmission and use are many, the cause of intrinsic and extrinsic loss in transmission and use and process is the heaviest. We care more about the causes and reducing measures of optical fiber loss. In this paper the reasons of these two kinds of loss are analyzed and reducing measures are put forward to.

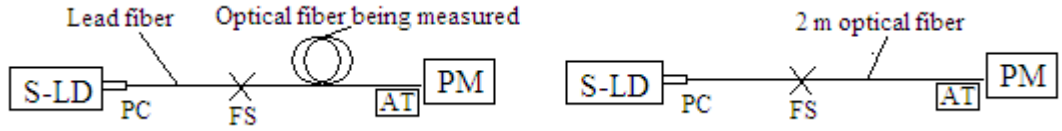
An Overview of Optical Fiber Loss .
Light wave spreads in optical fiber , its intensity becomes weak with the increase of transmission distance**,** this kind of attenuation called optical fiber loss [2]. International Telegraph and Telephone Consultative Committee (CCIT) defined fiber loss as follow:

$$A = 10\log(\frac{P_2}{P1}) = PL_2 - PL_1 \quad (1)$$

Where P1 and P2 is the input power and output power, respectively. According to the produce process, optical fiber loss can be divided into transmission loss and use loss. Fiber transmission and use loss can be divided into the intrinsic and extrinsic loss.

EXPERIMENTAL SECTION

Test Methods of Optical Fiber Loss.
The main measuring method of the fiber loss . Cutting method, the backward scattering method (OTDR), inserted method, welding machine method, four power method [3] and lateral scattering method [4] are the main measuring methods.



(a) before cutting off (b) after cutting off

Fig. 1 diagrammatic sketch of cutting method

The cutting method is a classic method. The diagrammatic sketch of cutting method is show as Fig. 1. In cutting method , guide fiber with PC joint is weld with input end of the optical fiber which will be measured by welding machine，and the other end of the optical fiber being measured connect to the output terminal power meter of stability light source (S - LD) through the alignment apparatus(AT). Adjust the location of the optical output end to accurate alignment photoelectric receiver of power meter and measure power PL_2 (Fig. 1(a)).Cutting off the fiber and remaining 2 m of the optical fiber being measured ,then measure the output power PL_1 of the 2 m optical fiber(Fig. 1(b)). The fiber loss A is calculated by formula (1).

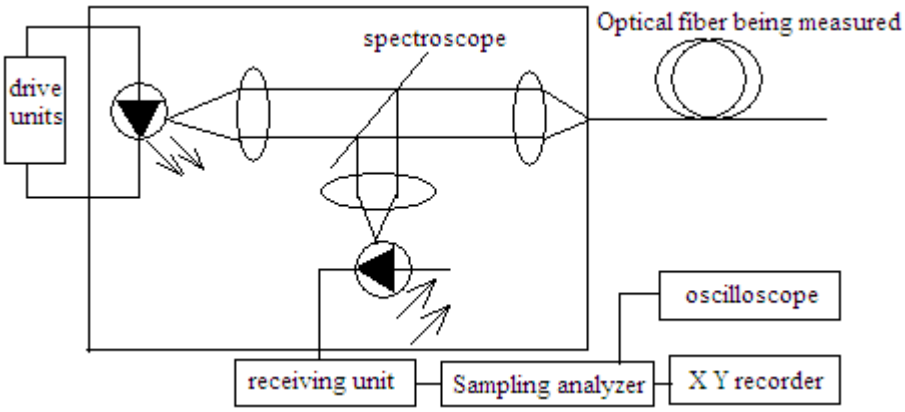


Fig.2 diagrammatic sketch of the backward scattering method (OTDR)

The backward scattering method (OTDR) is show as Fig. 2. The light from laser light sources is divided into incident light and the backward scattering light by spectroscope. Incident light enters into optical fiber being measured, and the backward scattering light is received by light receiving module. The intensity of backward scattered light can be obtained by sampling processing to the backward scattered light, so that we can get the fiber loss.

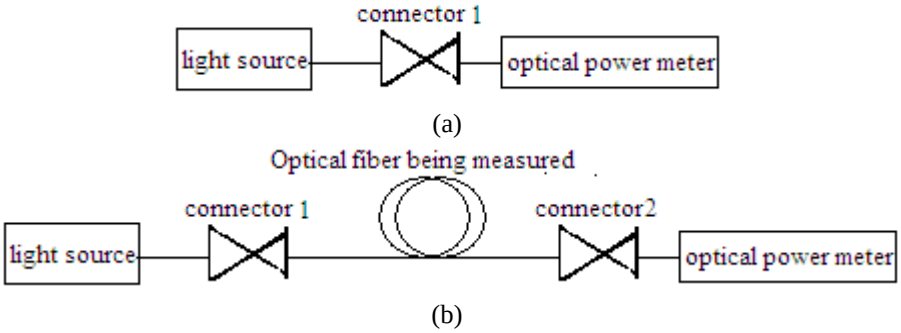


Fig.3 diagrammatic sketch of inserted method

The inserted method shows as Fig. 3. First, light source is connected with power meter by connector 1 and the power P_1 of light source is measured, show as Fig. 3(a).Then the optical fiber being measured and connector 2 are inserted between connector 1 and power meter (Fig. 3(b)), and the power P_2 is measured. The optical fiber loss is $A=P_2 - P_1$ (dB).Attenuation constant is $(P_2-P_1)/L$ (d B/km).Where L is the length of the optical fiber being measured.

The welding machine method . Join point of the fiber is illuminated from the vertical side of the fiber by parallel light, the light through join points is received, and the value of contact loss is estimated and shown on the screen.

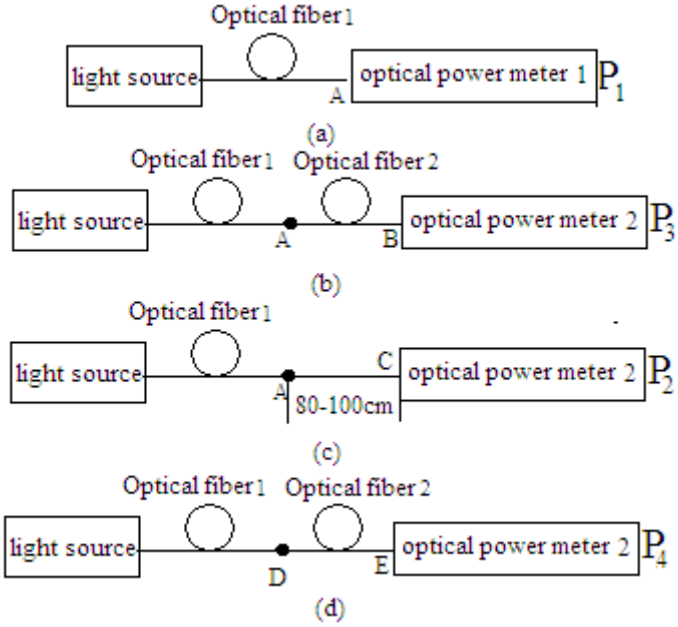


Fig.4 diagrammatic sketch of four power method

The four power method shows as Fig. 4. Light power meter measured light output power P_1 (fig. 4(a)) in point A of optical fiber 1. And then use power meter measured light power P_3 (fig. 4(b)) in the point B of optical fiber 1. Cuts off the optical fiber at point C (80 ~ l00cm distance from point)shows as fig. 4(c),and power meter measured light power P_2 in point C. Cut at point D fiber for permanent weld, in point E of optical fiber measured light power P_4 (fig. 4(d)).The joint connection loss is: A = (P1- P2)-(P3-P4) dB

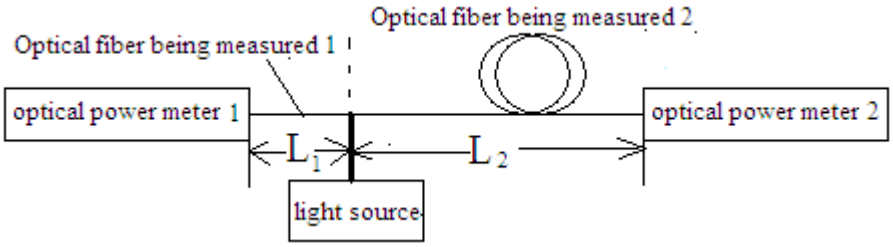


Fig.5 diagrammatic sketch of lateral scattering method

The lateral scattering method shows as Fig. 5. The optical fiber being measured is illuminated from the side by light source. The left side power P_1 and right side power P_2 of optical fiber being measured are measured. If the power of irradiation point is P_0, According to the formula (1), the loss of fiber L_1 and the loss of fiber L_2 are Shown by the following, respectively:

$$A_1 = 10\log(\frac{P_0}{P_1}) \quad (2)\ ; \qquad A_2 = 10\log(\frac{P_0}{P_1}) \quad (3)$$

Where the A_1 is the loss of fiber L_1, and A_2 is the loss of fiber L_2. Comparing loss of long fiber with short fiber, if the length of the fiber L_1 is very short, the short fiber loss A_1 can be ignored, so loss of the fiber is easily calculated from (1) and (2):

$$A = A_2 = 10\log(\frac{P_1}{P_2}) \quad (4)$$

Analysis on the advantages and disadvantages of various test methods . The advantages and disadvantages of various test methods shows as tab.1.

Tab .1 comparison of advantages and disadvantages of various test methods

test method	advantages	disadvantages
Cutting method	Accurately results	Optical fiber has been destroyed
Backward scattering method (OTDR)	1) Nondestructive measurement 2)More functions 3)Easy to use	There is always a blind area
Inserted method	Simple and convenient	Great error in the measurement
Welding machine method	Measuring blind area of OTDR	estimated value
Four power method	High precision	Spend more time
Lateral scattering method	1)Nondestructive measurement 2) Simple 3)Accurately	Measured value is not stable

RESULTS AND DISCUSSION

The Causes of Optical Fiber Loss

The causes of optical fiber loss in the transfer process . Optical fiber transmission loss can be divided into the intrinsic loss and the extrinsic loss. Intrinsic transmission loss mainly includes absorption loss, scattering loss and radiation loss. Intrinsic transmission loss refers to the light is converted into other energy by some material impurities and intrinsic surface, or the scattering loss caused by the change of the light direction and outward radiation loss caused by radiation. Refractive index of optical fiber is uneven, the fiber core diameter is not a circle, the interface of fiber core and cladding is rough, and there are air bubbles or impurities in crystal all can cause energy loss. The extrinsic loss in the transfer process of the fiber optical fiber due to the bending of the fiber and extrusion deformation .The factors that affect fiber bending loss mainly is the degree of bending.

The causes of optical fiber loss in the process of use . The coupling loss refers to the optical fiber welding, adapter when the connection loss. Optical fiber loss mainly connecting and coupling loss in the process of use .Coupling loss refers to the optical fiber loss when the optical fiber is welded. Connecting loss is divided into the intrinsic loss and extrinsic loss. The Connecting loss which is caused by intrinsic factors such as mode field diameter mismatch , refractive index mismatch, numerical aperture mismatch , the concentricity of fiber core and cladding is not good and mode field is not enough round .Extrinsic factors refers to various coupling loss caused by human factors, the precision of the welding process and welding instrument of factors caused the loss in the process of welding, such as the space between the connector, optical fiber end face is uneven or coarse, not clean, low welding personnel operating level .

Reducing Measures of Optical Fiber Loss

The reduction of optical fiber loss which caused by intrinsic factors in the process of transmission. The optical fiber loss that caused by the intrinsic factors in the process of transmission is mainly due to the uneven refractive index of the optical fiber, the core diameter of the optical fiber is not round, the interface of fiber core and cladding is uneven, and there are air bubbles or impurities in crystal et.al. All of above factors caused loss by absorption, scattering and radiation. After the fiber manufacturing, such loss has been determined. This kind of loss can be reduced by increasing or improving the accuracy of the manufacturing process of the fiber, improving the evenness of optical fiber refractive index, making fiber has more symmetrical core diameter, making the interface of fiber core and cladding more smoother, reducing air bubbles or impurities in crystal. The other kind of intrinsic loss can be reduced through a variety of methods to improve the mode field matching conditions in the process of optical fiber use. With the progress of science and technology and improvement of manufacturing process, the part of the loss has become less important.

The reduction of optical fiber loss which caused by extrinsic factors in the process of connection. The extrinsic factors loss is mainly caused by the human factors, such as welding, bending et.al in the process of transmission and use. These losses can reduced by improving the level of welding workers, trying to reduce the space between the connector , keeping the joint surface clean and smooth, trying to reduce the chance of bending and compression the fiber.

CONCLUSION

Intrinsic and extrinsic losses can be reduced in the process of transmission and use of optical fiber. It can be reduced by follow methods:

1) The intrinsic loss of optical fiber in process of transmission and use can be reduced by improving the

manufacturing process of the fiber and the mode field matching method.
2) The extrinsic loss of optical fiber in process of transmission and use can be reduced by raising the level of welding workers and reduce the chance of bending the fiber.

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