

A STUDY ON SPLICING LOSSES IN OPTICAL FIBER COMMUNICATION SYSTEM FOR BRWZ

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Abstract: In this paper we report the splicing losses of a single mode optical fiber at different humid conditions and at different places of Bangladesh Railway West Zone (BRWZ). The location of the splicing points and their losses for a single mode step index optical fiber have been measured by optical time domain reflectometer before re-splicing. Fusion splicer is used to re-splice these points at different humid conditions to analyze the splicing loss dependency. From this study it has been found that different humid conditions affect the splicing losses to a large extent.

Key Words: Optical fiber, Optical Communication, Splicing Losses, Re-Splicing, Optical Network.

Introduction

The possibility of using an optical fiber carrier wave for telecommunication began soon after the invention of Laser in 1960. It was found that a shift from microwaves to light waves could increase the carrier frequency by a factor of 10^6 . It was considered that this transmission was possible using a pipe lining with a smooth, highly reflecting material (Eaglesfield, 1962). Also some people (Goubau et al., 1961) preferred to use a converging lens in such a pipe to protect the spreading of light. Another idea (Karbowski, 1964) was to guide light on a thin polymer tape. All of these ideas had some technical problems: costly and bulky and these were inflexible systems. At the end of 1966, Kao et al. first gave the idea of optical fiber to transmit light signal. They found that when a light signal was sent from one end of an optical fiber, some parts of the signal was absent at the other end. Later in 1970 Kapron and his colleagues at Corning Glass Works, USA, reported the fabrication of a single mode fiber with a comparatively low transmission loss (20 dB/km) (Kapron, et al., 1970). Since 1974 optical fibers have rapidly replaced copper wire in optical communication systems and now carry most of the world's telephonedata, video traffic and indeed a wide variety of information, more reliably and at a cheaper rate (Gambling, 2001).

Low loss and minimum distortion are considered as important aspects of optical fiber communication system. In order to achieve a low loss in efficient optical fiber communication system, some features should be ensured. Those features incorporate the better components (fiber sources and detectors etc.) and adopting necessary means to reduce losses. The losses that are responsible to degrade the quality of the information of the optical fiber communication system include absorption loss, scattering loss, bending loss, splicing loss etc (Senior, 1994).

In the existing optical fiber network technology it is not possible to minimize the absorption and scattering losses because these are introduced during the manufacturing period of the optical fiber. Bending loss can be minimized by placing carefully the optical fibers at the time of installation. The only scope to improve the performance of the existing network can be accomplished by reducing the splicing losses by re-splicing the joints. In this regard the splicing points having greater losses have been detected using an Optical Time Domain Reflectometer (OTDR). Then the re-splicing has been done to reduce the splicing losses by Fusion Splicer (Payne, et al., 1982). The effect of surrounding atmosphere (humidity) on splicing losses has also been studied.

From this study it has been found that the most probable sources of re-splicing losses are humid atmosphere, micro-particles and air bubbles present in the air between fibers, misalignments and fiber end preparation of the network system. The effect of the first source has been discussed and it is clear that the re-splicing time should be fixed in such a way that humidity in the air is low, when high quality fusion splicer is not available. The effect of humidity on re-splicing can be minimized by using fusion splicer with moisture free enclosure where re-splicing is completed. Other sources of losses can be minimized by proper re-splicing technique.

Splices and Fusion Splicing

A fiber optic splice is a permanent fiber joint whose purpose is to establish an optical connection between two individual optical fibers. Fiber splices are frequently used to establish a long haul optical fiber links. mechanical splicing and fusion splicing (Cherin et al., 1981). In this study the fusion-splicing technique is used to re-splice the splicing points. Splices may be divided into two broad categories depending upon the splicing technique utilized. These are.

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The purpose of fusion splicing is to melt or fuse the ends of two optical fibers together using localized heat. The process begins with fiber preparation, including fiber stripping, cleaning and cleaving, followed by fusion splicing. Each preparation process is done with a dedicated tool, and splicing is accomplished with a fusion splicer. A fusion splicer precisely aligns cores of two optical fibers to be spliced, produces an electrical arc that melts the ends of the fibers and finally pushes the melted ends together forming a highly reliable and high performance junction. The quality of each fiber end has been inspected using a microscope (Payne, et al., 1982).

In this work fusion splicer has been used (Fig.1) to re-splice the splicing points and also to measure the splicing losses. Humidity at the time of re-splicing is also displayed on the screen of the fusion splicer.

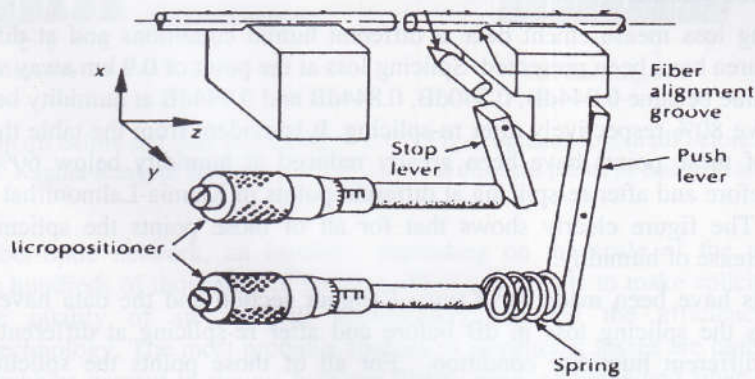


Figure:1: Fusion splicing apparatus

Optical Time Domain Reflectometry

OTDR is a very sophisticated measurement technique, which has a wide application in the optical communication system. OTDR uses the reflective light backscattered (Rayleigh scattering) from the fiber (Senior, 1994). The reflective light is compared to a normal decaying light pulse from a light source focused through a beam splitter to produce a visual display on a CRT to detect the location of the splice and connector losses as well as the rotation of any fault on the link (Kennedy et al., 1999). Thus it provides measurement of the attenuation of an optical link down to its entire length giving information on the length dependence of the link loss.

A backscatter plot has been displayed in Fig.2, which shows the initial pulse caused by reflection and backscattered from the beam splitter followed by a long tail caused by the distributed Rayleigh scattering from the input pulse as it travels down the link.

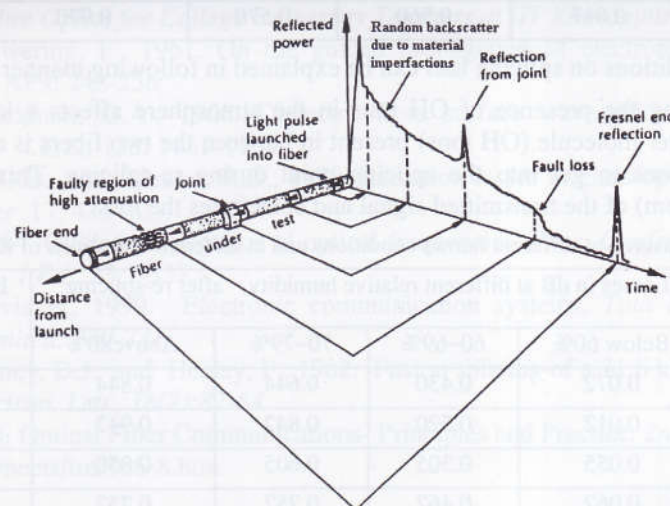


Fig.-2. An illustration of a possible backscatter plot from a fiber under test.

Fig.-2 also shows a pulse corresponding to the discrete reflection from a fiber joint, as well as discontinuity due to random backscatter produced by material imperfections in the fiber (Kennedy et al., 1999). The end of the fiber is indicated by a pulse corresponding to the Fresnel reflection incurred at the output end face of the fiber. The location and insertion losses of the joint faults can be obtained from the power drop at their respective position on the link.

Experimental Results and Discussions

In this section the results are discussed on the splicing loss measurement in two different areas of the optical fiber network system of the Bangladesh Railway in the West Zone. Single mode step index fibers have been used in the area of investigation. After an extensive investigation these areas of greater losses were explored by OTDR. Data have been collected by fusion splicer.

Experimental data have been taken by the use of two types of fusion-splicer: one from railway and the other from Grameen Phone, which were much more precise. Fusion splicer gives the reading of splicing loss of a particular joint (splicing point) digitally (in dB) when that splicing joint is taken to that machine and it also gives the reading after resplicing is done. These data have been taken at different humid conditions from the starting of March to mid October.

In Table 1 the splicing loss measurement data at different humid conditions and at different locations of Kaunia-Lalmonirhat area have been presented. Splicing loss at the point of 0.9 km away was 0.440dB before re-splicing and the value became 0.044dB, 0.340dB, 0.844dB and 0.944dB at humidity below 60%, 60-69%, and 70-79% and above 80% respectively after re-splicing. It is evident from the table that after re-splicing, the splicing losses of these points have been greatly reduced at humidity below 60%. Fig.3 shows the splicing loss in dB before and after re-splicing at different points in Kaunia-Lalmonirhat section at different humidity condition. The figure clearly shows that for all of those points the splicing losses gradually increases with the increase of humidity.

Similar measurements have been made for Kaunia-Rangpur section and the data have been presented in Table 2. Fig.4 shows the splicing loss in dB before and after re-splicing at different points in Kaunia-Rangpur section at different humidity condition. For all of those points the splicing losses gradually increases with the increase of humidity.

Table 1. Splicing losses measured at different humid conditions and at different locations of Kaunia-Lalmonirhat section

Splicing points in km	Losses in dB at different relative humidity after re-splicing				Losses in dB before re-splicing
	Below 60%	60~69%	70~79%	Above 80%	
0.90	0.044	0.340	0.844	0.944	0.440
2.10	0.022	0.442	0.742	0.842	2.342
3.56	0.025	0.505	0.705	0.750	0.105
5.60	0.042	0.452	0.852	0.952	0.652
7.80	0.051	0.435	0.935	0.835	1.535
9.01	0.016	0.556	0.656	0.746	1.386
12.50	0.043	0.363	0.663	0.763	0.063
14.01	0.045	0.534	0.734	0.845	0.534
16.50	0.017	0.560	0.570	0.970	1.520

The effect of humid conditions on splicing loss can be explained in following manner.

At the time of re-splicing the presence of OH ions in the atmosphere affects a lot. Therefore when the humidity is high, the water molecule (OH ions) present in between the two fibers is also high, this increases the probability of OH ions to get into the splicing point during re-splicing. This causes ion resonance absorption (www.tyub.com) of the transmitted signal and constitutes the loss.

Table 2: Splicing losses measured at different humid conditions and at different locations of Kaunia- Rangpur section.

Splicing points in km	Losses in dB at different relative humidity after re-splicing				Losses in dB before re-splicing
	Below 60%	60~69%	70~79%	Above80%	
1.20	0.072	0.430	0.644	0.844	1.642
2.50	0.012	0.520	0.842	0.942	1.105
3.80	0.055	0.305	0.605	0.850	0.852
5.20	0.062	0.462	0.752	0.752	1.035
7.30	0.091	0.535	0.835	0.735	0.586
9.50	0.076	0.336	0.756	0.946	0.363
11.40	0.083	0.430	0.863	0.663	1.534
13.50	0.055	0.744	0.834	0.545	0.820
14.40	0.077	0.860	0.737	0.870	0.978

As splicing loss increases with humidity so to minimize it re-splicing time should be chosen to have low humidity in the air or re-splicing is done in air conditioning environment (moisture free).

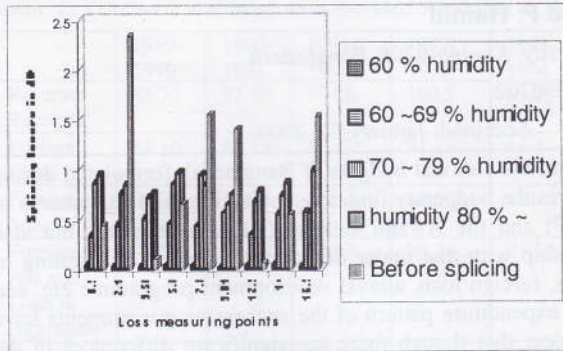


Fig.3: Splicing loss in dB before and after re-splicing at different points in Kaunia-Rangpur section.

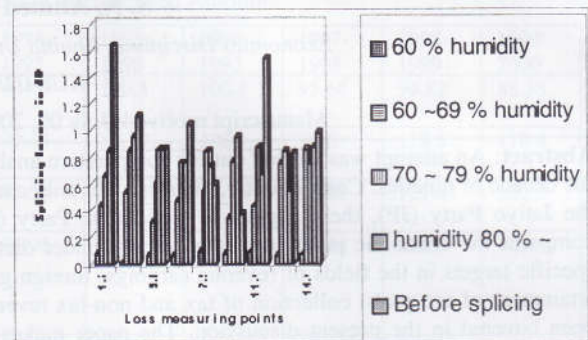


Fig.4: Splicing loss in dB before and after re-splicing at different points in Kaunia-Lalmonirhat section.

Conclusion

To establish a fiber-optic network, an installer, depending on the scale of the network, has to make thousands or even hundreds of thousands of splicing. Thus any efforts to make splicing more cost-effective and improve the quality of splices will significantly increase the efficiency of the fiber-optic communications technology. The most probable sources of re-splicing losses are humid atmosphere, micro-particles and air bubbles present in the air between fibers, misalignments and fiber end preparation of the network system. In this study the effect of the humidity has been discussed and from the present study it is clear that the re-splicing time should be fixed in such a way that humidity in the air is low, when high quality fusion splicer is not available. The effect of humidity on re-splicing can be minimized by using fusion splicer with moisture free enclosure where re-splicing is completed. Other sources of losses can be minimized by proper re-splicing technique.

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