Application Notes

Sterlite Tech

Optical Fiber Curl

Author
Sudipta Bhaumik

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Abstract
Curl is one of the geometrical attributes of optical fiber.
This paper describes measurement and importance of Fiber Curl.

Keywords
Optical fiber, Fiber Curl

What are Optical Fiber Curl and its importance?

Optical fiber curl is a characteristic related to the glass geometry. It is defined as the amount of curvature over a specified length of uncoated fiber. Fiber curl results from thermal stresses during fiber manufacturing and thus needs to be measured and controlled closely.

Curled fiber has an impact on fiber splice loss by fiber misalignment during the splicing process. This impact is predominant during mass splicing in ribbon or tape structures. Fiber curl is a critical glass geometry parameter, not only important in determining a fiber's suitability for use in ribbon or tape structures, but it is an indicator of presence of thermal stress in the fiber and performance of other parameters such as polarization mode dispersion (PMD) which is also impacted by thermal stress.

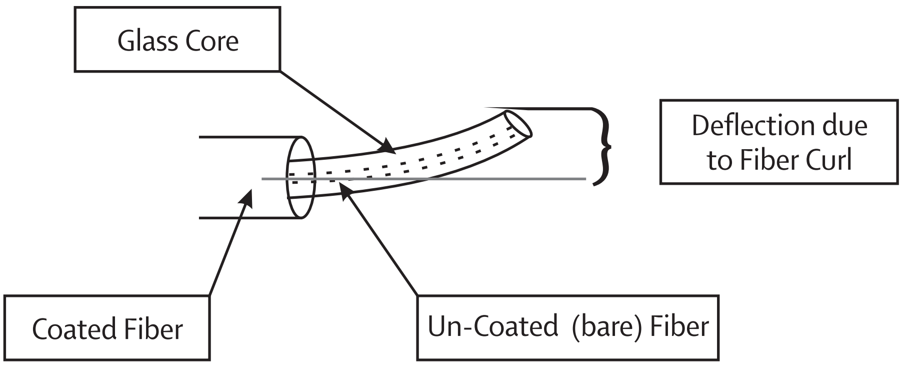


Figure 1

How is Fiber Curl measured?

Fiber Curl (also known as latent curvature) is measured by determining the amount of deflection that occurs when an unsupported un-coated (bare) fiber end of known length is rotated about fiber axis. An international standard has been published describing various methods of measuring fiber curl. By measuring the extent of deflection as it is rotated about its axis and from the known length of the bare & overhang fiber, the fiber radius of curvature can be calculated by circular mathematical models.

Although curl is defined by a value that measures the amount of deflection (Figure 1), it is preferred to represent curl by a measurement of the radius of curvature. This is because the deflection is proportional to the length of unsupported/uncoated fiber, and this representation would be cumbersome in practice. The radius of curvature is now the accepted means to specify fiber curl.

The mathematical formula that converts amplitude of deflection to radius of curvature (Fiber Curl) is shown in Figure 2.

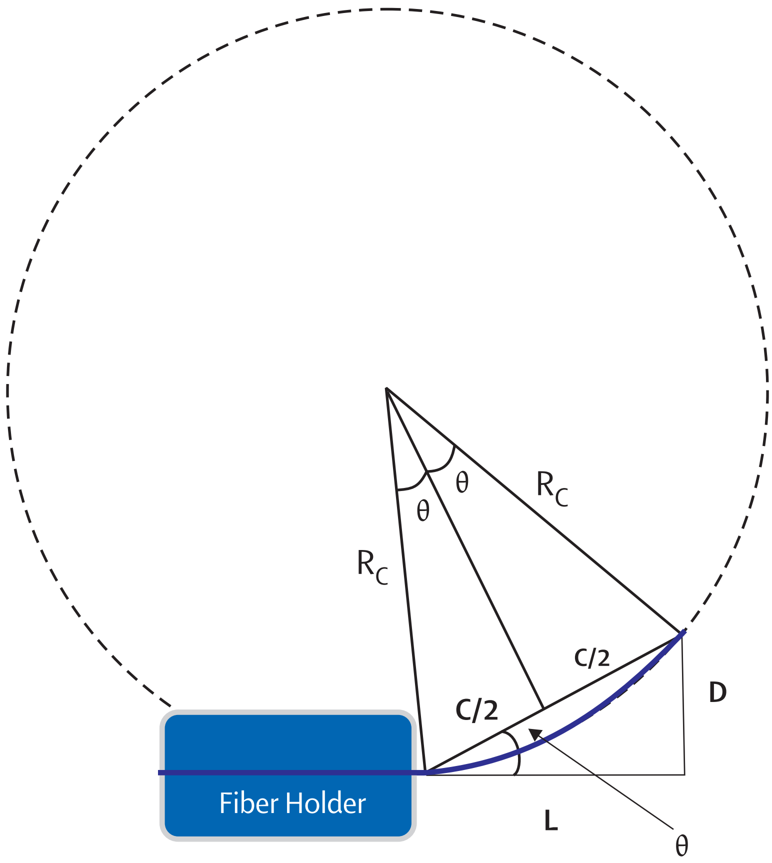


Figure 2.

In Figure 2,

L = Overhang distance of the unsupported/ bare fiber end
D = Fiber deflection from the fiber holder's axis
C = the hypotenuse formed of right triangle formed by L, D and C
Rc = Radius of curvature (Fiber Curl) of the circle formed by the deflected fiber

$$R_C = \frac{L^2 + D^2}{2D}$$

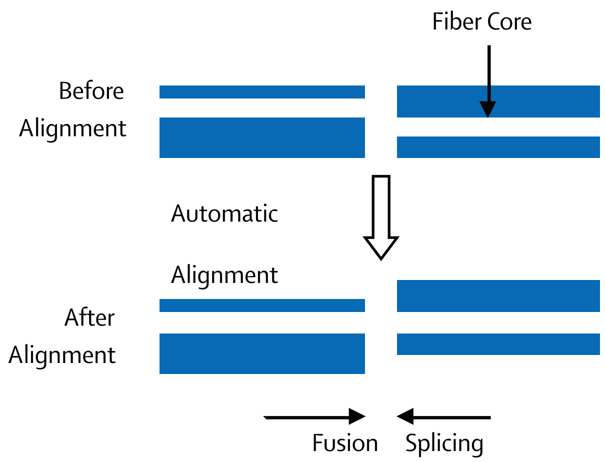
Fiber curl is therefore a function of the length of the unsupported bare fiber end and fiber deflection while rotating against fiber axis. The deflection is directly proportional to the overhang length for a given radius of curvature, while the radius of curvature is inversely proportional to the deflection for a given overhang length.

Illustration:
The measured deflection is 20 µm for a 10 mm overhang bare fiber sample. The fiber curl will then be 2.5 meter.

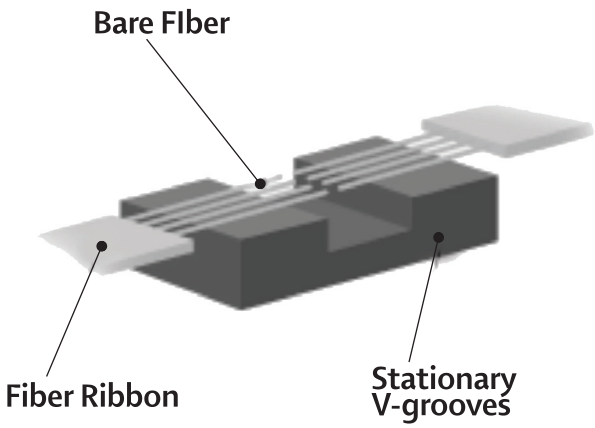
Similarly, if measured deflection is 10 µm for a 10 mm overhang bare fiber sample, the fiber curl will be 5 meter.

What is the importance of Fiber Curl in splicing?
One of the most important part of fusion splicing is to align optical fibers before a splicing event. Fiber misalignment results in higher splice loss. Fiber misalignments are classified into three categories - lateral, longitudinal and angular. Lateral misalignment happens when the core axis of both the fibers to be spliced are misaligned. Longitudinal misalignment occurs when there is a gap between two fiber end-faces. Angular misalignment occurs when the end-faces of the two fibers are not parallel to each other.
There are two main methods of fusion splicing a fiber as discussed below:

Core Alignment Method : Optical fiber cores observed with a microscope are positioned with the help of image processing so that they are concentrically aligned.



Cladding Alignment method: This fusion splicing method uses V-grooves produced with high precision to position and orient optical fibers. This method is primarily used for splicing a multi-fiber (ribbon) cable in a single action.



Fiber curl becomes important parameter when the fusion splicing machine does not have adequate fiber alignment features and/or during multi-fiber (ribbon) splicing operations. Deflection from the axis due to fiber curl contributes to core misalignment and leads to considerable difficulty in achieving low splice loss.

Internationally, fiber curl value of above 4 meter is specified by fiber manufacturers and consumers. The international standard IEC 60793-2-50 (Edition 3.0) specifies a minimum curl of 2m and specified minimum 4 rneter fiber curl for ribbon.

A fiber curl of ≥ 4 meter is equivalent to deflection of ≤12.5 µm over a 10 mm length (10mm being the most common fiber overhang length during fusion splicing). During single fiber splicing either the core or clad alignment method can align fiber well and tolerate some amount of deflection. However, during simultaneous fusion splicing of a large number of fibers requiring a uniformly low splice loss this becomes very difficult to achieve with excessive fiber deflection and low fiber curl radius.

Reference

1. “Measurement method and test procedures - Fiber Curl”,
International Electrotechnical Commission (IEC) 60793 -1- 34