Optical Fiber Mechanical Testing Techniques

White Paper

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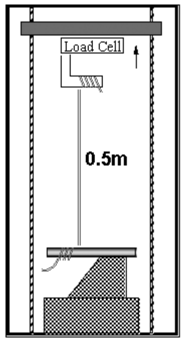
Introduction

The strength of brittle materials (i.e. optical fiber) is determined by flaws or defects in the material, and the way in which these flaws grow. The mechanical behavior of optical fiber is described by parameters such as the strength distribution and fatigue. Fatigue is the measure of how fast a flaw grows when exposed to both water and stress. The strength distribution is statistical in nature, and generally is described by a weibull function, characterized by a slope and intercept parameter. It is necessary to test an appropriate number of samples and fully characterize the distribution in order to have confidence in the information.

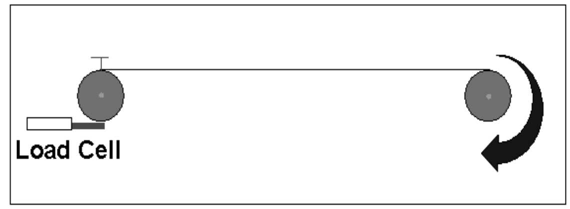
Tensile Dynamic Strength and Fatigue Testing

Tensile strength measurements impose a tensile force on the fiber, and measure the stress at which the fiber breaks. With the dynamic testing method, a constant strain rate is applied, usually by one of two common testers. A stationary capstan fiber tester (SCFT) strains the fiber by having the frame that one capstan is attached to move away at a controlled rate, as illustrated in Figure 1. A rotating capstan fiber tester (RCFT) strains the fiber by rotating one capstan at a controlled rate as illustrated in Figure 2. A load cell records the load at failure. The strain rate is described in terms of the percent change in length per minute, relative to the gauge length. The standard method for performing dynamic tensile strength measurements is described in FOTP-28.[1] In general, 30 samples are tested at a strain rate of 3-5%/min to determine the tensile strength.

Stationary Capstan Fiber Tester
Figure 1



Rotating Capstan Fiber Tester
Figure 2



The dynamic fatigue parameter, n_d, is determined by measuring the strength at several strain rates, ranging from 0.003 to 30%/min. The median failure stress will vary with the strain rate, and the fatigue parameter can be calculated from the slope of the line. The standard method for performing dynamic fatigue measurements is described in FOTP-76.[2] A minimum of 15 samples are required per strain rate to determine the dynamic fatigue parameter.

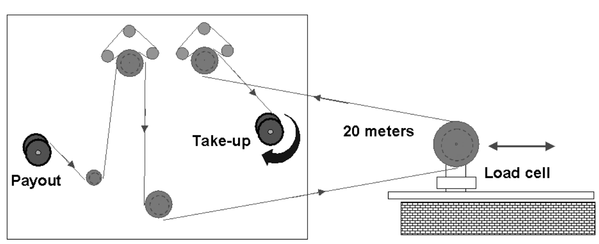
Test Environment

The environment under which the mechanical testing takes place can influence the results. In order to standardize testing, most tests are performed at a nominal of 25ºC and 50% relative humidity, although testing can take place in a range of environments. More typically, the effects of long term aging are simulated by aging of the fiber at extreme conditions prior to testing. A typical accelerated aging condition would be 85ºC and 85% relative humidity for 30 days.

Gauge Length

Random extrinsic flaws introduced during processing typically define the strength of long lengths of fiber; short lengths of fiber typically are approaching the inert strength. Given that, a long gauge length usually is weaker. Most testing is done on 0.5 m or 20 m gauge lengths. The 0.5 m samples provide information on the intrinsic strength of the fiber; the 20 m samples characterize the extrinsic strength of the fiber.[3] The continuous rotating capstan fiber tester (CRCFT) can be used to test the low strength (< 350 kpsi) distribution on very long lengths of fiber (hundreds of km).[4] This is done by continuously testing 20 m sections of fiber up to 350 kpsi. If the fiber breaks, the load at failure is recorded; if not, then another 20 m section is paid out and tested. The CRCFT apparatus is illustrated in Figure 3.

Continuous Rotating Capstan Fiber Tester[4]
Figure 3



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2. TIA/EIA-455-76, Method for Measuring Dynamic Fatigue of Optical Fibers by Tension, May 1993.

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4. G.S. Glaesemann, D.J. Walter, "Method for obtaining long-length strength distributions for reliability predictions," *Opt. Eng.* **30**(6) (1991).

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