Super High Temperature Resistant Optical Fibre

Optical fibre is not only widely used in conventional communication field, but also in other high-tech fields such as sensing, measurement, control, and data acquisition, including the mining industry, the aerospace industry, the military, oil and gas, and high temperature medical applications. These fields will involve some special application environments, such as high temperature environment.

As a kind of composite material, optical fibre is composed of inner layer of silica part and outer coating. Its environmental adaptability and service life are greatly affected by the coating. The outer coating of conventional optical fibre is generally acrylic resin, as shown in Figure 1; its operating temperature is generally -65 ~ 85 ℃. If the fibre with ordinary acrylic resin works for a long time in an environment higher than 85 ℃, thermal aging and thermal oxygen aging will occur, and the organic coating will generate hydrogen with stress corrosion effect on the silica fibre at high temperature, which will accelerate the fatigue process of the optical fibre, thus leading to optical fibre failure. With the extension of the optical fibre application environment, ordinary acrylic resin coated optical fibre could not meet the application requirements of high temperature environment.

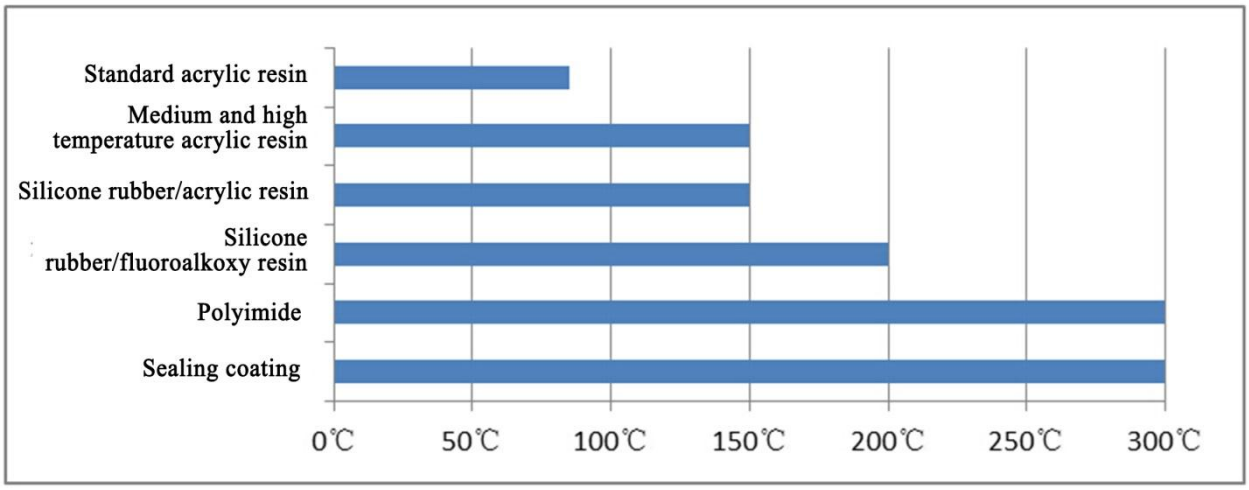

Figure 1 Temperature Resistance of Various Coating

1. High Temperature Resistant Optical Fibre Fabrication Technique

On the basis of conventional drawing platform and technique, Yangtze Optical Fibre and Cable Joint Stock Limited Company (hereinafter referred to as "YOFC") realized the development of high temperature resistant optical fibre coated with special polyester which can work at 150 ℃ in the early stage. In order to meet the requirement that the optical fibre shall be able to work in the environment above 300 ℃ for a long time, we apply new kind of coating materials and build more advanced process platform.

1) High Temperature Resistant Optical Fibre Coated with Polyimide

Polyimide is one of organic coating materials with the best high temperature resistance for optical fibre, and its advantages are incomparable to other materials.

Polyimide has high modulus, high tensile strength and good chemical stability. It can endure 300℃ high temperature for a long time and 490℃ high temperature for a short time. In addition, it has excellent mechanical property, fatigue resistance, flame retardancy, dimensional stability, and electrical property. Therefore, the optical fibre coated with this material has the characteristics of high temperature resistance and corrosion resistance, and can be used in the environment of 300℃ for a long time.

2) Special Drawing Process with Step-by-step Multi-layer Coating

The difficulty of fabricating this kind of fibre lies in the special drawing process of step-by-step multi-layer coating. After years of exploration and improvement on the basis of mature equipment manufacturing and drawing process, YOFC has finally realized the preparation of this kind of drawing tower and the confirmation of the drawing process, and successfully developed **a high temperature resistant optical fibre coated with optimized polyimide, which can work at 300℃ for a long time** and can withstand high pressure and chemical erosion.

Different types of PI optical fibre developed by YOFC can be selected according to different needs in terms of waveguide structure, such as single-mode, multi-mode, pure silica core, or customized. For some hydrogen-rich and high temperature environment, such as oil well and coal mine, the pure silica core PI optical fibre can be selected.

2. Introduction to the Performance of the PI Optical Fibre Developed by YOFC

PI optical fibre developed by YOFC includes mainly HT1510-B single-mode optical fibre and HT2512-B and HT2515-B multi-mode optical fibre. See Table 1 and Table 2 for their main performance parameters.

Table 1 Parameters of High Temperature Resistant Single-Mode Optical Fibre Products

Product Number	**HT1510-B**
Geometrical Characteristics	
Cladding diameter (μm)	125±1
Coating diameter (μm)	155±5
Non-circularity of cladding (%)	≤ 1
Core/cladding concentricity error (μm)	≤0.8
Coating/cladding concentricity error (μm)	≤ 12
Optical Characteristics	
Mode field diameter@1310nm (μm)	9.2±0.4
Mode field diameter@1550nm (m)	10.4±0.8
Optical fibre cutoff wavelength (nm)	1180-1330
Attenuation@1310nm (dB/km)	≤1.0
Attenuation@1550nm (dB/km)	≤0.8
Environmental and Mechanical Characteristics	
Proof test (kpsi[GPa])	≥100 [0.69]
Operating temperature range (℃)	**-65 to +300, and +350 for short term**
Coating material	Polyimide

Table 2 Parameters of High Temperature Resistant Multi-Mode Optical Fibre Products

Product Number	**HT2512-B**	**HT2515-B**
Optical Characteristics		

Attenuation@850nm (dB/km)	≤3.0	≤3.5
Attenuation@1300nm (dB/km)	≤1.0	≤1.2
Bandwidth @850nm (MHz·km)	≥400	≥160
Bandwidth @1300nm (MHz·km)	≥600	≥500
Numerical aperture	0.200±0.015	0.275±0.015
Geometrical and mechanical performance		
Core diameter (μm)	50±2.5	62.5±2.5
Cladding diameter (μm)	125±2	125±2
Fibre diameter (μm)	155±5	155±5
Non-circularity of cladding (%)	≤ 2	≤ 2
Core/cladding eccentricity (μm)	≤1.5	≤1.5
Proof test (kpsi)	≥100	≥100
Coating material	Polyimide	
Operating temperature range (℃)	**-65 to +300, and +350 for short term**	

1) **PI optical fibre of YOFC has excellent high temperature stability**.

The high temperature stability of YOFC PI fibre and PI fibre made by a famous international manufacturer was verified in an experiment. Two kinds of PI optical fibres were stored at 300℃ for more than 700 hours, and their additional attenuation was measured. From Figure 2, it can be seen that the PI optical fibre produced by YOFC shows better stability at high temperature, **and the additional attenuation is less than 0.2 dB/km at 1310 nm and 1550 nm**. Its additional attenuation value is far lower than that of the PI optical fibre produced by that famous international manufacturer.

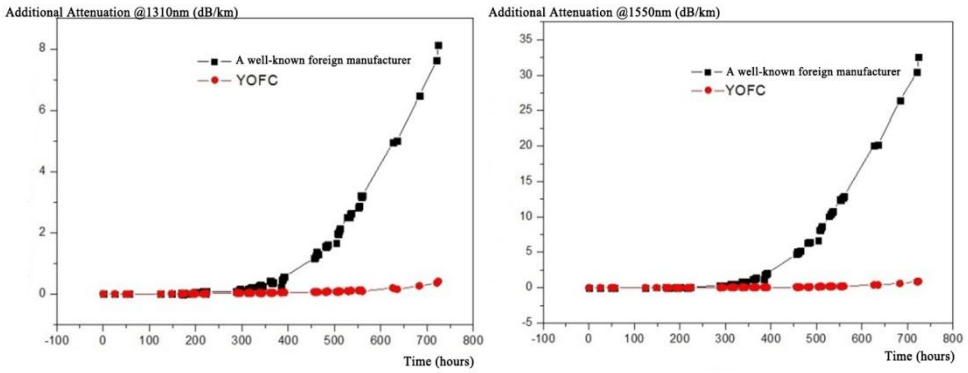

Figure 2 High Temperature Performance of PI Optical Fibre (Red dots indicate the PI optical fibre manufactured by YOFC)

2) **PI optical fibre of YOFC has excellent mechanical properties**.

As for mechanical properties, the tested dynamic fatigue parameter Nd of tensile strength of YOFC PI optical fibre reaches 25.4, and the M value reaches 5.35 GPa, which exceeds the requirements of IEC for standard communication optical fibre. The theoretical life of PI optical fibre is increased by 5 times, which ensures the strength after cabling and its stable application in harsh environment.

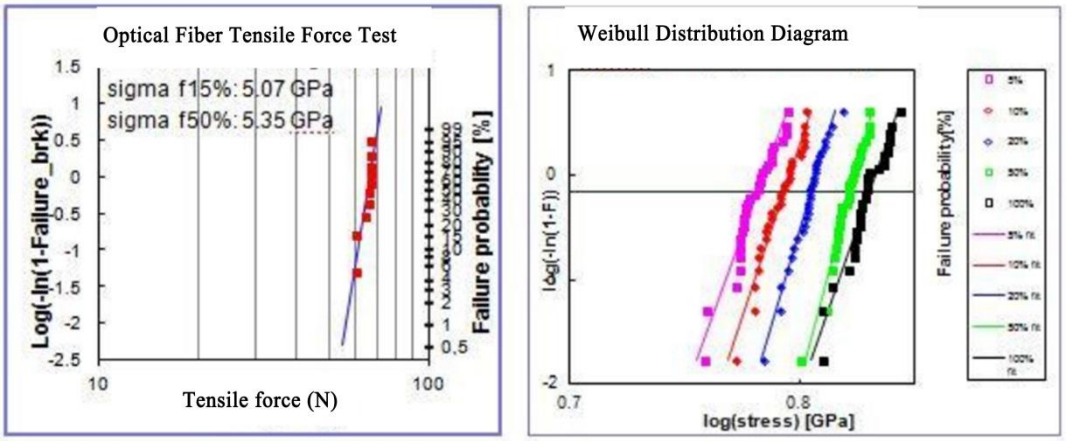

Figure 3 Mechanical Performance Parameters of YOFC PI Optical Fibre

The PI optical fibre developed by YOFC through its own platform has excellent performance. Under the long-term high temperature environment of 300℃, it has extremely low additional loss at 1310 nm and 1550 nm and high mechanical reliability. It can be widely used in various high temperature environments, such as petroleum and natural gas, medical treatment, automobile, new energy, and food processing. In the future, we will further optimize the platform and the process to develop high temperature resistant optical fibre with higher performance, so as to escort the security and information transmission of related industries!

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