

# Spun Optical Fibre for Optical Fibre Current Transformer

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**Abstract:** Spun optical fibre is a special kind of polarization-maintaining optical fibre, which has the capability to maintain circular polarization and is mainly used in current transformer as an important part of its performance stability. In this paper, the properties, fabrication methods and industry status of spun optical fibre are described.

**Key words:** Current transformer, Spun optical fibre, Circular polarization maintaining

## 1 Introduction

With the vigorous promotion of smart grid construction during the 13th Five-Year Plan period and the steady progress of the Belt and Road Development Strategy, the process of building a global energy internet and the rapid development of low-energy metallurgy and other industries have been promoted. With the rapid development of these industries, the demand for accurate measurement of UHV and large current is becoming more and more urgent. The optical fibre current transformer based on Faraday magneto-optical effect has a wide application prospect in the field of large current measurement because of its advantages such as high measurement accuracy, wide frequency bandwidth, large dynamic range, simple insulation and flexible installation. At the same time, due to the complexity of the field application environment, the optical fibre current transformer should have good temperature performance and anti-vibration ability in addition to high measurement accuracy. For the measurement of super-large current in electrolytic metallurgy field, current transformer should also meet the requirements of flexible installation and measurement accuracy when the sensitivity is low due to the loop shape, bus eccentricity and stray magnetic field interference, etc. Based on the above background, Yangtze Optical Fibre

and Cable Joint Stock Limited Company (hereinafter referred to as YOFC) has promoted a specialty optical fibre for optical fibre current transformer that is spun optical fibre. As the core component of optical fibre current transformer, spun optical fibre ensures the practical application requirements of optical fibre current transformer.

Spun optical fibre is a special kind of polarization-maintaining optical fibre, which introduces circular birefringence through the axis rotation of the optical fibre, which forms elliptical birefringence together with the high-linear birefringence of the optical fibre itself. When the rotation period is small enough, this kind of optical fibre has good circular polarization-maintaining capability. At the same time, due to the high internal stress of optical fibre, the polarization-maintaining optical fibre retains the capability of resisting external interference and internal defects, which can essentially improve the environmental adaptability of optical fibre current transformer, which ensures that the transformer can meet the practical application needs and is suitable for the application of all-optical fibre current transformer. Therefore, it is the most promising research direction at present.

## 2 Circular polarization-maintaining mechanism of spun optical fibre

The fundamental mode of optical fibre has two polarization states. It is assumed that their propagation constants (i.e. wave number,  $\beta = 2\pi \cdot n_{eff}/\lambda$ ) are  $\beta_1$  and  $\beta_2$  respectively, and  $\beta_1 \approx \beta_2$  is required for circular polarization maintaining. The difference of propagation constants  $\Delta\beta$  ( $\beta_1 - \beta_2$ ) between the two polarization states in birefringent optical fibre is large (e.g. the difference in propagation speeds is large), and the delay difference (corresponding to phase difference) between modes increases linearly with the increase of propagation distance.

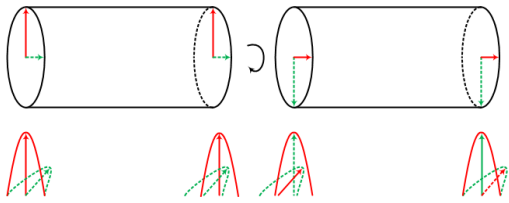


Figure 1 Schematic diagram of circular polarization-maintaining mechanism of spun optical fibre

Using the discrete concept, a spun optical fibre can be considered as an unprocessed birefringent optical fibre slice of a quarter of the rotating period connected to another same optical fibre section, but the direction of the principal axis is rotated by  $\pi/2$ . In this way, the mode delays of the two optical fibres can be offset completely, as shown in Figure 1.

Such spun optical fibre locally consists of linear polarization-maintaining optical fibre, and the whole consists of circular polarization-maintaining optical fibre. The shorter the rotation period is, the shorter the length of the slice is; and the smaller the local maximum phase difference is, the closer it is to the ideal circularly polarized light.

## 3 Fabrication of Spun Optical Fibre

The fabrication of spun optical fibre is usually divided into two methods: one is the post-treatment of polarization-maintaining optical fibre, the other is the line rotating drawing of polarization-maintaining stress

rod. Although the former method is flexible, it is difficult to guarantee the mechanical reliability of optical fibre because of the stripping and re-coating of optical fibre coating. The latter method is similar to the production of conventional polarization-maintaining optical fibre, which is directly drawn and coated with fibre preform. This method ensures not only the optical fibre strength, but also the production capacity for enough fibre spool length.

Ultra-high speed rotation of preform and ultra-low speed drawing of optical fibre are very challenging for preform, rotating drawing tower and process control. At present, the spun optical fibre sold in the domestic market is mainly monopolized by foreign suppliers. Most of the optical fibre current transformers in domestic pilot projects adopt imported spun optical fibre. However, there are some problems in the imported spun optical fibre, such as high unit price, limited section length of optical fibre, uncontrolled supply batch and delivery time.

YOFC, as a professional manufacturer and designer of optical fibre and cable, has always kept an eye on and continuously followed the development of current transformer technology. Relying on *Development and Application of Broadband Large Current Measuring Instrument*, the special project of major science instrument led by National Institute of Metrology, based on years of accumulation on the mature technical platform of conventional optical fibre, continuously adopting the panda-type production process of polarization-maintaining optical fibre, YOFC has overcome the process difficulties in turn, including a) the stress fibre preform with high collimation degree (geometry, gravity center), b) the dynamic vertical precision and stability of the high-speed rotating drawing tower, c) the automatic control of ultra-low speed drawing, etc., and formed a complete set of spun optical fibre fabrication and testing platform with YOFC characteristics. The first high birefringence spun optical fibre SH1016-A promoted on this basis has a rotating pitch of 5mm, a section length of  $\geq 500m$  and a proof test level of 100kpsi. Related products have been recognized by authoritative application units in the industry, and the



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product performance reaches the leading level at home and abroad. The exchange and cooperation between YOFC State Key Laboratory of Optical Fibre and Cable Fabrication Technology and Wuhan Branch of China Electric Power Research Institute will provide a broader research platform for the specialty optical fibre to better serve the power industry.

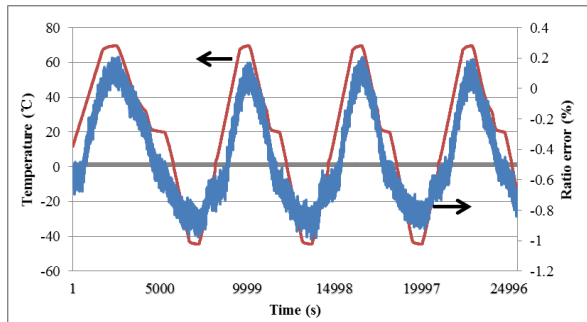


Figure 2 Ratio Error VS Temperature Linearity of YOFC Spun Optical Fibre Verified by Customers

#### 4 Summary

At present, the spun optical fibre has been localized and its performance is well matched with the international advanced level, which provides a reliable guarantee for the development of optical fibre sensor and power security in China. The derived rotating drawing platform also provides a basis for the development of other products, such as 3C optical fibre, chiral grating and other industrial fabrication.

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