Photonic Lantern with Tapered Multi-core Fiber

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ABSTRACT

In offshore platforms, the need of multi-mode fiber and single-mode fiber exist at the same time for condition monitoring. In order to use those fibers simultaneously, photonic lantern is designed. However, complicated fabrication process and lack of study about response of parameters are still unsolved problem. In this paper, a simple photonic lantern scheme based on a tapered multi-core fiber fabricated by stack and draw method is proposed. The photonic lantern was fabricated by tapering and splicing between a single mode fiber and a multi core fiber. Additionally, parameters, that affect number of modes, such as wavelength of the light, diameter of tapered region and refractive index at the outside of the tapered region, were studied

KEY WORDS: Multi-core fiber; Photonic lantern; Tapered fiber; Single mode fiber; Fiber splicing; Number of modes; Fiber fabrication.

INTRODUCTION

In offshore oil platforms, risers are the most important component. However, deepwater risers cannot avoid damage due to the harsh environment in deepwater and motion of vessel. The risers vibrate easily under the excitation of current flow and the vibration cause fatigue damage which may lead suspension of production. To prevent this riser failure, in-service monitoring system is indispensable.

Optical fiber sensors are regarded as suitable monitoring systems for subsea risers because of some advantages. Optical fiber sensors can provide temperature or strain information with location in real time. It means that operators can notice abnormalities of risers before the riser reaches fatigue failure due to the fact that stress and temperature is major factors of fatigue. Moreover, optical fiber does not affect the operation of the risers so that in-service monitoring system can be achieved.

Among many different schemes of optical fiber sensors, distributed fiber optic sensor has a special feature for riser monitoring. While other sensors such as Fiber Bragg Grating (FBG) sensors have limitation in measuring range, distributed fiber optic sensor can reveal temperature, strain and vibration information form any point along an optical fiber with location information. One major scheme of distributed fiber sensors is Optical time-domain reflectometer (OTDR). OTDR uses multi-mode fiber (MMF) to maximize Rayleigh scattering. However, filtering out specific wavelength of light which is essential for making a sensor system cannot be achieved by FBG due to the fact that FBG cannot be applied to MMF. Consequently, bulky and complex filter was used for filtering out. (Barden S. C, 1981)

In astronomy, a Photonic lantern (PL) is used to filter out unwanted noise concentrated in some specific wavelength. PL is a device that has simple structure and small loss simultaneously. If a PL is used in OTDR system, bulky and complicated filtering out system is not needed. In this paper, a new scheme of PL is proposed.

STATE OF THE ART ON PHOTONIC LANTERN

Photonic Lantern

Photonic lantern is a device that can couple light from MMF to a number of single mode fiber (SMF)s or Multi-core fiber (MCF), and vice versa with very low-loss. This MMF-SMF converter was first demonstrated in 2005(J. Bland-Hawthron, 2006). Generally, the structure of PL is that a bundle of SMFs or MCF is tapered down and connected with a MMF adiabatically with low index jacket outside of the interface of SMFs and a MMF. Figure 1 shows several types of PL.

When the number of excited modes in the MMF is equals to the number of SMFs or The number of cores in the MCF, efficient coupling is occurred in both directions. If the fiber is tapered adiabatically enough, then the modes of MCF core evolve independent modes of SMF bundle or MCF cores without loss (J. Bland-Hawthron, 2004). It means that PL is a good implement which can apply SMF photonic technologies such as FBG into fiber-fed instruments in astronomy.

Furthermore, size of the fiber core at the input slit of the spectrograph influence the spatial and the spectral resolutions., Size of the fiber is in inverse proportion of the spectral resolution of the instrument that can