High power effect in bend SMF fiber

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***Abstract* — In this work the effect of high power launching in bent fibers has been experimentally tested. The bending losses and the coating heating imposed by the high power propagation were measured.**

It was achieved coating temperatures surpassing 150 ºC, it was also observed a correlation between the losses and the coating heating as functions of the bending diameter.

I. INTRODUCTION

Nowadays the amplification in optical systems is supported by two main technologies: Raman and Erbium Doped fiber amplifiers (EDFA). In both situations the total power injected in an optical fiber can surpass 1 W. The high power propagation in conjugation with tight bending, usually occurring at the equipment cabinets, can result in optical fiber destruction [1].

This optical fiber destruction, also referred as fuse effect, is often observed in Raman amplified systems. In fact one of the challenges in the design of Raman Fiber Amplifiers (RFA) is to prevent the damage of the optical components due to the high powers [2].

The issue investigated in this work is the fiber coating damage in fibers under the simultaneous effects of high optical power and tight bending. We can assume that the power loss at the fiber bend is related to no propagated (leaky) modes, being absorbed in the coating and causing an temperature increase. The heating induces a coating degradation leading to the rupture of the fiber at the bend location. This can cause the fiber fuse effect ignition and the destruction of the optical fiber along kilometers [2-9].

Recent works are focused on finding single mode optical fibers that can resist to high power even for tight bends [8-9].

In this paper, we characterized the temperature reached by the optical fiber coatings when subjected to different injected optical powers and bend diameters.

II. EXPERIMENTAL SETUP

Figure 1 shows the implemented experimental setup. It consists of an optical fiber length placed in a hole of a wood slab. This slab has several holes with different pre defined diameters. A high optical power is launched into the fiber and measured after the bend with an optical power meter. The temperature is measured at the bend location with an infrared camera (ThermaCAM™ Flir i40). The optical signal is obtained from a 1550 nm laser and boosted by an EDFA, which achieves a maximum power of 2W. The tested fiber was the SMF28 G.652.D manufactured by Corning.

The local environment temperature was 23ºC and for all the measurements the fiber was exposed to the high optical power during 1 min.

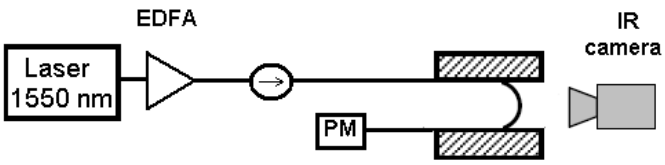

Fig. 1 Implemented experimental setup.

III. RESULTS AND DISCUSSION

A. Attenuation results

Figure 2 shows the fiber losses for a half turn bend. For bend diameters smaller than 5 mm the attenuation cannot be measured due to limitations of the power meter dynamic range.

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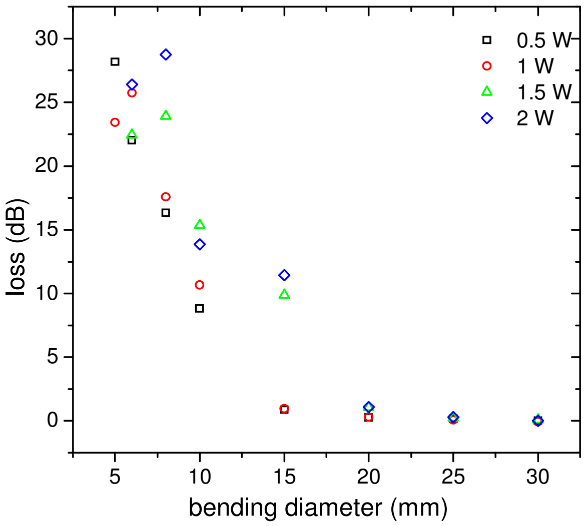

Fig. 2 Bending losses as function of the bending diameter for different values of the optical power

Figure 3 presents the average loss per meter as function of the bending diameter. The bend loss increases exponentially with the decrease of the bend diameter.

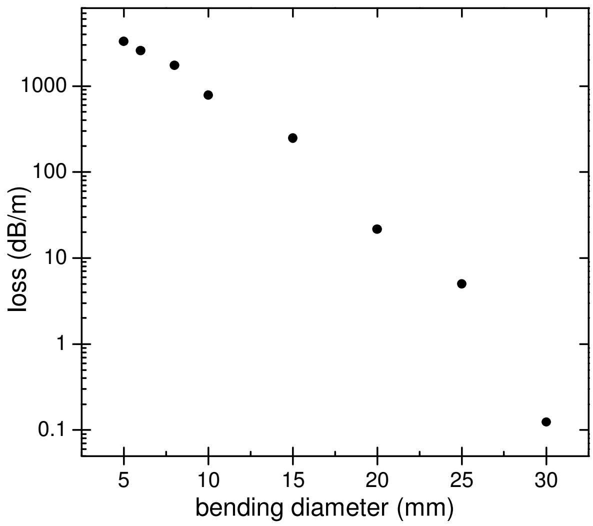

Fig. 3 Average bending losses as function of the bending diameter

B. Heating results

The local temperature at the bend location was measured. Figure 4 shows the thermal images obtained with the infrared camera for an optical power of 2 W and a bend diameter of 10 mm (left) and 4 mm (right). These images show that the heating occurs at the bend, the fiber local temperature increases to values of 78 ºC and 140 ºC for the 10 mm and 4 mm bend, respectively.

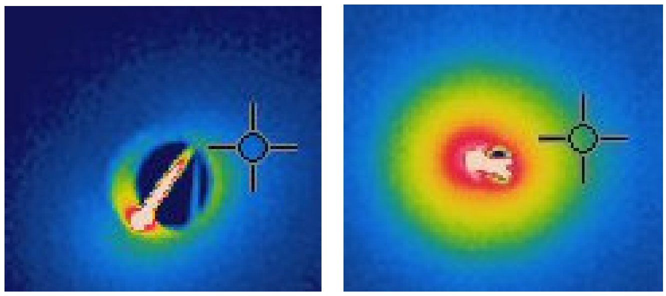

Fig. 4 Images obtained with the infrared camera.

The coating temperature increases with the launched power and decreases with the bend diameter. For diameters up to 20 mm (loss smaller than 1dB) the temperature increase is negligible, growing exponentially with the further decrease of the bend diameter. The maximum temperature at the fiber is displayed in figure 5, the observed results are consistent with bending loss data.

The temperature achieved a value of 150ºC for the 2 W optical power signal and small bend diameter (3 mm).

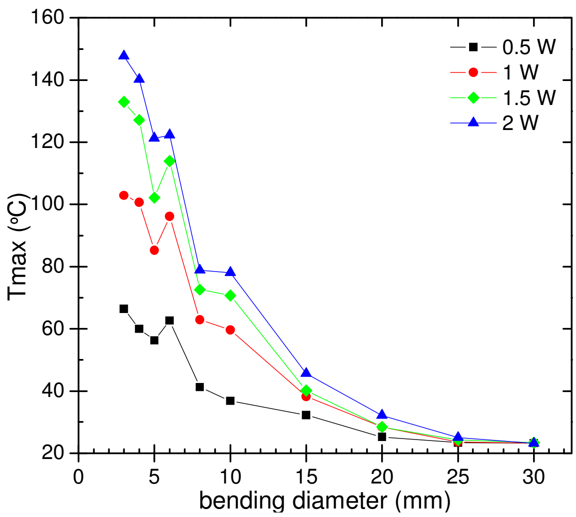

Fig. 5 Coating maximum temperature as a function of the bending diameter.

Figure 6 shows that for small bending diameters the temperature increases nonlinearly with the optical power. This can be explained by the temperature dependence of the intrinsic fiber absorption.

These results clearly shown that the optical fiber temperature increase is due to the mechanical bend conjugated with high propagated power. This can result in a severe degradation on the optical fiber coating, limiting here its lifetime.

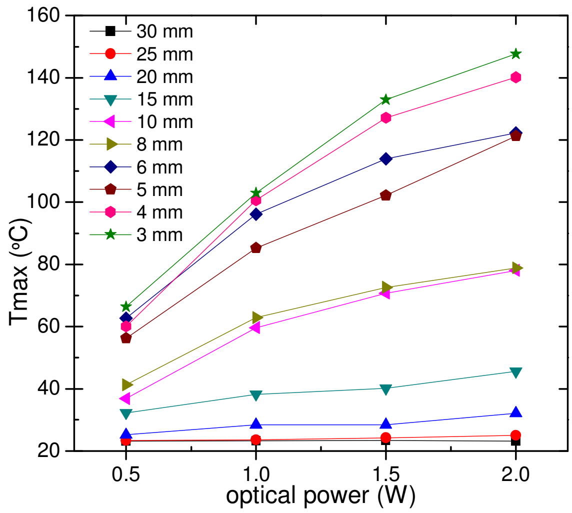

Fig. 6 Coating maximum temperature as a function of the optical power for the different bending diameters.

IV. Conclusion

The bending losses and coating heating have been measured in a SMF28 fiber, tightly bent and exposed to high optical power.

The results show that heating depends on the bend diameter and on the optical power level. We confirmed that the coating temperature reaches high values for small bend diameters.

Furthermore, the results suggest a correlation between the losses and coating heating both as function of the bending diameter.

This study can be a roadmap to the planning of future optical networks involving propagation of high powers.

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