Manipulation Of Fibre Optic Cables for use in the Telecoms Industry

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Objectives

- Manufacture an optical fibre device.
- Test and refine the device.
- Use techniques from first two steps to produce an optical fibre splitter.

Introduction

Fibre optic cables are constructed similarly to an electrical cable, however, differ in that they are produced entirely from glass. They work by exploring the principle of internal reflection, where an inner glass cylinder (the core) is surrounded by a cladding of different material with a large enough difference in optical properties that light travelling within a fibre will be reflected at the boundary between the two layers entirely back towards the centre of the core meaning when light is introduced at one end of the fibre, it travels for the entire length of a fibre. This is very advantageous as power loss across a large length of fibre is significantly lower than that of traditional copper cable, however optical devices are inherently more complex in nature, and therefore lossy. This projects main objective is to construct a low loss fibre optical device, first a taper with the end goal of producing an optical light splitter, from one to many fibres without the introduction of other materials or devices.

Methods / Approach

To produce tapered fibres, a procedure was developed using a large diameter splicing machine, where a $125\mu m$ diameter fibre, would be tapered down to $20\mu m$. Major steps included cutting a $0.5m$ length of fibre, a $10cm$ section stripped of buffer material (which is fibre optic "insulation"), then cleaned and mounted in the machine as pictured in fig. 1 where then various variables of temperature, speed and dimensions are configured in the LDS software to get a desired profile.

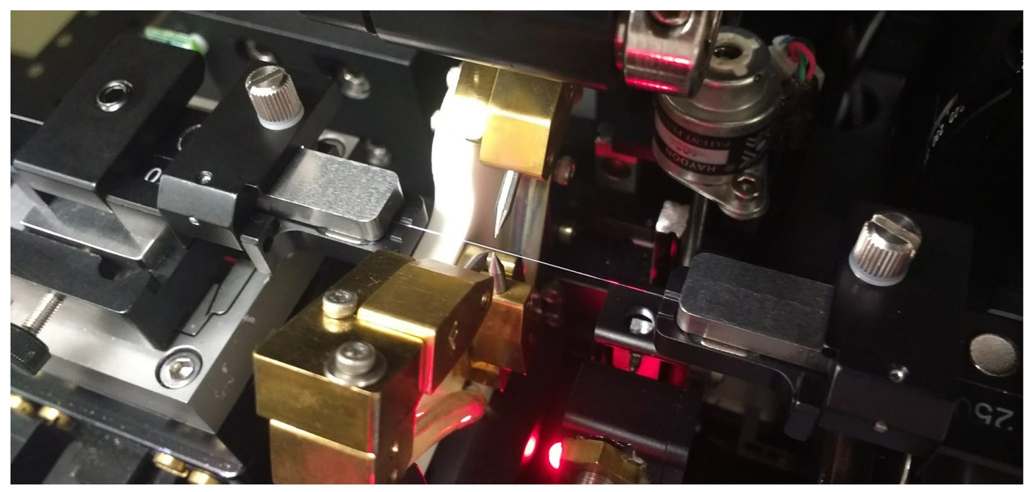

Figure 1:Large Diameter Splicer, with fibre mounted.

After acceptable taper dimensions where achieved, next testing to further the perfection of the device, this was done by first measuring the length of fibre as is, then removing the device, in this case, the section containing the taper and testing the remaining fibre, this, therefore, minimises the number of reconnection which is the largest lossy factor.

Results / Discussion

Many variations were seen in producing tapers with very thin dimensions, therefore taking a lot of time to get any measurable worthy devices, for example fig. 2 shows one of my best tapers of the project. The graph shows the diameter of the fibre in green/red and the tension (labelled load) of the fibre through the process, the set dimensions were set at $4mm$, $2mm$, $4mm$ for the down slope, waist and up slope respectfully, with the waist diameter set at $20\mu m$.

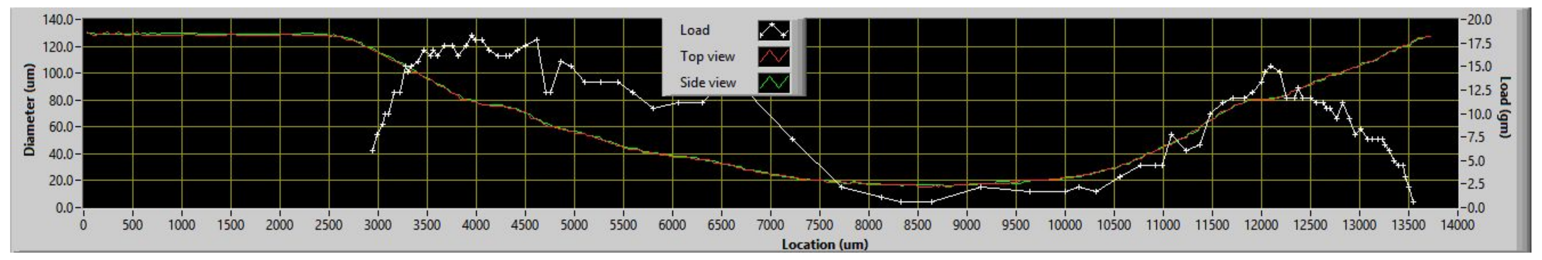

Figure 2:Taper no. 82, diameter profile

The second figure, fig. 3, shows the results of testing the optical fibre, losses correspond to the difference in power intensity before and after removal of the tapered section of the fibre.

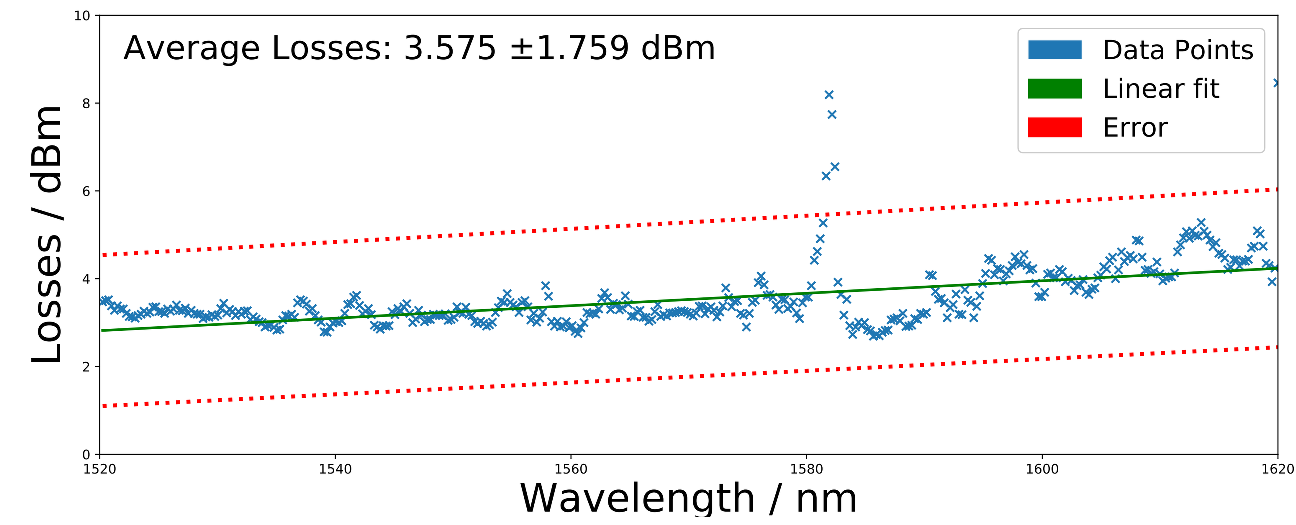

Figure 3:Taper no. 82, Measured at 0.1mw power

As you can see the linear fit shows an overall increase in loss towards longer wavelengths, this should, in reality, be a constant value across all wavelengths, but I suspect this is probably caused by movement of the fibre during testing or other factors such as the connection of each end of the fibre to either of the testing machines. Also worthy of note is the apparent increase in variability towards the longer wavelengths, this appears to be an increase in noise, probably again due to similar outside factors. However, these do not explain the relatively large loss of 3.575 ± 1.759 dBm, which is purely down to the imperfect taper profile, as seen from fig. 2 the left-hand side slope has bumps and is much longer than the right-hand side slope, this is likely due to tension issues, as seen by the white line in fig. 2 the tension varies wildly, causing an imperfect transition and chances that the light evolving through the taper has chances to escape the fibre, leading to overall losses, whereas from earlier tapers with larger waist diameters, the tension was constant, and the diameter profile was much more perfect, leaving the idea that it was a calibration accuracy problem, which was not solved during the placement time.

Although a perfect low loss taper was not completed, a variety of important hurdles where overcome, for example, one of the first tasks completed was producing a reliable way of repeating a taper, this was problematic as in order to improve, all outside variables need to be maintained while then changing the variables in the software to improve production, these outside variables included fibre diameter, fibre contaminants, ambient temperature and position of the fibre in the clamps (visible in fig. 1) This proved very difficult, especially the latter where fibres where not kept in exactly the same position due to variations in the clamp positions, this was later solved by shimming the clamp mounting mechanism but still proved to be difficult to manage.

Another major task was the automation of the testing procedure of the optical fibre devices, this was accomplished by using a tunable laser source and an optical spectrum analyser, both of which controlled by a computer where python was used to produce a script to measure light intensity through the fibre over a range of wavelengths automatically, downloading the data and producing graphs within seconds, only requiring the user to attach fibres.

Conclusion

With two out of three objectives complete, I believe this project was a success, building valuable skills of lab etiquette, programming, and production of a repeatable $20\mu m$ waist taper.

This project could easily be furthered and I believe that successful production of a optical splitter would be incredible for the Telecom industry as current splitters are very sensitive to temperature and humidity, of which this device would not be.

References

[1] The Fiber Optic Association, "The FOA Reference For Fiber Optics - Understanding dB," 1999. [Online]. Available: http://www.thefoa.org/tech/ref/basic/dB.html

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Acknowledgements

Thanks to Dr. Noel Healy and the School of Electrical and Electronic Engineering on the 5th floor, Mertz Court for use of the Photonics lab.

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