NPL

OPTICAL FIBRE MEASUREMENT CONFERENCE

CONFERENCE DIGEST

OFMC

17 & 18 September 1991

York, U.K.

Organised by the
National Physical Laboratory
in cooperation with COST 217

MEASUREMENTS ON THE UNIFORMITY OF FIBRE CLADDING GEOMETRY

John R Colton, Andrew G Hallam

York Technology Ltd, School Lane
Chandlers Ford, Hants, SO5 3DG, UK

INTRODUCTION Over the past few years much effort has been spent in the development of measurement techniques for the accurate characterisation of optical fibre geometry. These range from interferometric methods, with absolute measurement capability, to automated microscope methods, which are particularly suited to the production environment. Factory instruments are usually calibrated using in-house 'reference' fibres which are generally not traceable to international standards. The need for traceable calibration standards has recently intensified and the National Institute of Standards and Technology (NIST) in the US and the National Physical Laboratory (NPL) in the UK have been investigating a variety of measurement methods in order to provide the industry with a calibrated reference material, [1,2]. Ideally the reference material would be a calibrated fibre end but cleaved fibre ends are notoriously difficult to preserve in good condition if used for routine calibration of measurement instruments. A fibre of uniform diameter could, however, be re-cleaved without loss of accuracy and it is the purpose of this work to investigate the uniformity of fibre diameter with length.

EXPERIMENTAL RESULTS The cladding geometry of 5 silica fibres from different manufacturers was measured using the grey-scale analysis technique [3] on a commercial video analyser system. Measurements were performed at 50mm intervals along the fibre lengths. The results are shown graphically in Figure 1 and are summarised in Table 1, below.

	peak–peak/um	mean/um	std dev/um
Fibre A	0.73	125.38	0.17
Fibre B	0.61	125.41	0.16
Fibre C	0.41	125.41	0.09
Fibre D	2.71	125.16	0.55
Fibre E	1.88	126.23	0.40

Table 1. Summary of fibre cladding diameter measurements.

It was noticed that the mean diameter of all of the fibres measured was slightly greater than the expected value of 125um. Previous work [2] had indicated that there was an error in calibration of the on-line laser scanning instruments normally used in the fibre pulling process. It was found that following calibration of the unit using calibrated wires supplied by the manufacturer, which were specified to an accuracy of +/-0.2um, the unit measured fibres to be 1.0um +/- 0.3um too small. The effect of this is the production of fibres larger than expected. It would appear from the values in Table 1 that manufacturers are to some extent aware of this calibration error and make some correction for it.

A summary of the ovality measurements is given in Table 2, below.

	maximum/%	mean/%	std dev/%
Fibre A	0.23	0.14	0.06
Fibre B	0.52	0.35	0.05
Fibre C	0.20	0.11	0.04
Fibre D	0.32	0.23	0.05
Fibre E	0.51	0.37	0.06

Table 2. Summary of fibre cladding ovality measurements.

<u>ACCURACY CONSIDERATIONS</u> The instrument was calibrated in two stages. Firstly the magnification of the system was calibrated using a chrome-on-glass annulus, which was certified to +/-0.1um. Next an additive offset correction to allow for diffraction effects at the fibre edge was determined using a calibrated fibre end. This was prepared using a microscope fitted with a vernier eyepiece, the accuracy of which was estimated to be +/-0.15um (95% confidence level) by comparing measurements made on the microscope with measurements made by NPL and NIST. In order to minimise errors in diameter using this technique a fibre of low ovality was used.

For a meaningful investigation of fibre uniformity it is essential that the measurement of geometry is not affected by variations in cleaved fibre end quality. The processing algorithm used in the present work was chosen to detect the presence of cleave damage and iteratively filter out corrupted edge data. In order to test the algorithm a series of cleaves were prepared using a range of different cleaver tension settings. The quality of cleaved ends obtained in this way ranged from the presence of minor blade impact damage for low tension settings to severe hackle for high tension settings. Figures 2a and 2b show measured diameter and ovality respectively, with and without the filter applied. The slight variation in diameter between cleaves was due to fibre non-uniformity of the type under study.

The measurement repeatability of the instrument was determined by re-positioning and measuring a fibre end several times. This was found to be 0.06um for diameter, (two standard deviations). The total uncertainty in calibration accuracy of the measurements performed was estimated to be +/-0.23um for diameter and +/-0.1% for ovality, (95% confidence levels).

DISCUSSION OF RESULTS It was observed that Fibres A and B both exhibited a variation in diameter with length of approximately 0.5m period. It was known that the pulling capstan used in the manufacture of fibre B was 150mm in diameter suggesting that the diameter variation may be related to some feature of the capstan such as non-circularity or eccentric axis of rotation.

Fibre D showed a similar variation in diameter, but of approximately 2.1m period. It was noticed that there also appears to be higher frequency components present in this fibre that cannot be resolved with the 50mm measurement interval used. In order to investigate this structure a short section of fibre was mounted on a translation stage in the laser-scanning instrument, described above, and measured at 0.25mm intervals. The results, shown in Figure 3, indicate that there are periodic components present with approximately 1mm and 20mm periods. Measurement repeatability was estimated to be 0.05um. Measurements on fibre D using contact micrometry indicated variations in diameter of 1um occurring over 4mm to 7mm sections of the fibre, [4]. The cause of this structure is under investigation by the manufacturer. Fibre A was also measured using laser-scanning; the presence of local structure was not observed in this fibre.

In the case of fibre C a particular effort had been made by the manufacturer to achieve a uniform diameter. The resulting standard deviation was 0.09um which was the lowest value measured of all of the fibres. The maximum diameter variation was, however, 0.41um which is considered to be too large for use of the fibre as a transfer standard.

No correlation between diameter and ovality variation was observed for any of the fibres measured.

REFERENCES

[1] Young M, 'Fiber Cladding Diameter by Contact Micrometry', submitted to Optical Fiber Measurement Conference, York, 1991.

[2] Baines J G N, Raine K W, Hallam A G, Turner N P, 'Fiber Diameter Measurements and their Calibration', JLT, vol 8, no 9, Sept 1990.

[3] Fiber Optics Test Procedure FOTP-176, 'Measurement method for Optical Fiber Geometry by Automated Grey-scale Analysis', TIA/EIA, 2001 Pennsylvania Avenue, N.W., Washington, D.C. 20006-1813.

[4] M.Young, NIST, private communication.

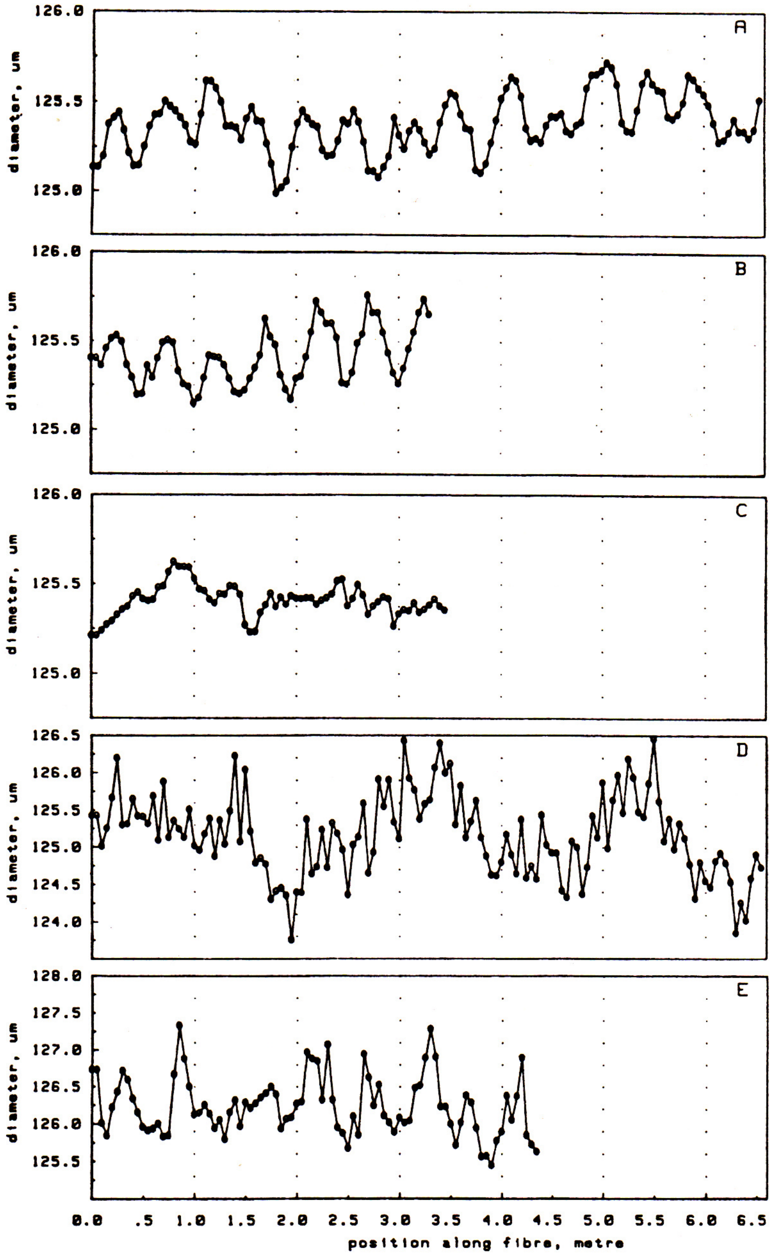

Figure 1. Cladding diameter vs position for Fibres A to E

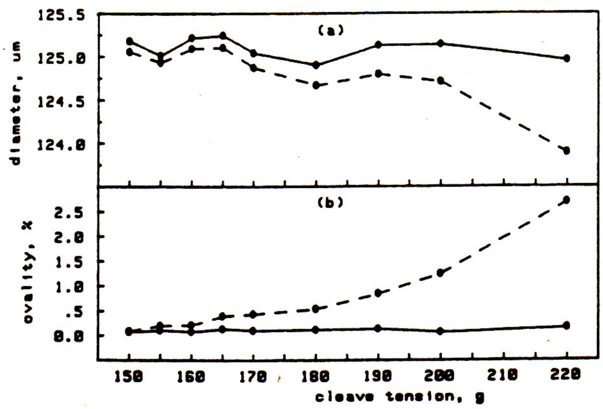

Figure 2. Cladding geometry variation vs cleave tension
(—— filtered, - - - unfiltered)

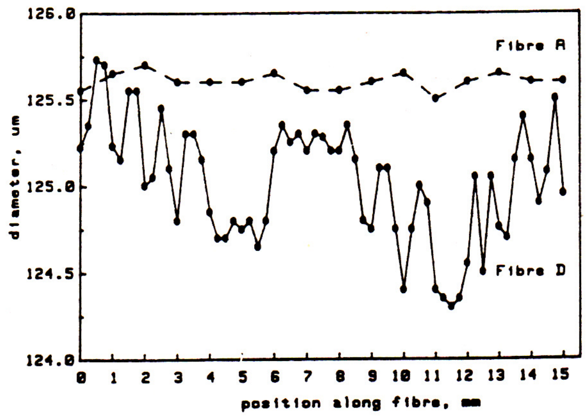

Figure 3. Local cladding diameter variation of Fibres A & D