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Study of Intensity Modulated Fiber Optic Sensor - Effect of Length of Core Exposed in Guiding Liquid

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Abstract:- ***In the past two decades fiber optic technology has passed through many analytical stages. Commercially available fiber optic sensors are widely used in mechanical and industrial automation. They are also used in instrumentation and control. In the present work, an intensity modulated fiber optic sensor is used. A small portion of cladding (1cm, 2cm and 3cm) is removed in the middle of the fiber along its length. This portion is totally immersed in known concentrations of common salt solution which acts as guiding medium. One end of the fiber is connected to source of 820nm, 850nm for plastic fiber and 1300nm, 1550nm for silica glass fiber. The second end of the fiber is connected to a power meter through which the output power is measured. The power loss which is the difference of power launched into the fiber and power collected at the second end of the fiber is noted. A relation between the core exposed in guiding solution and the output power at the second end of the fiber is studied. This study helps in deciding the length of core of an optical fiber to be exposed to the environment.***

I. Introduction:

'Fiber optic sensors' is very promising area for commercial applications due to cost effectiveness, easy realization, sensitivity, small in size and free from EMI[1-4] . In view of the above advantages, fiber optic sensors have become very popular in the areas like process control, avionics, petrochemicals, pharmaceuticals [5-11]. These sensors are based on attenuated total internal reflections. When a ray of light travels from denser medium to rarer medium and if the angle of incidence is greater than the critical angle the ray reflects back in to the denser medium. If the rarer medium is an absorbing medium, the evanescent wave intensity gets attenuated and as a result the intensity of output power at the second end of the fiber decreases exponentially [12]. Thus an un-clad optical fiber can be efficiently used as intensity modulated fiber optic sensor. As intensity modulated sensors [13-14] are easy to realize and compact in size, they are being extensively used for sensing mechanism. In most of the intensity modulated sensors the core is exposed to the environment and the change in environment can be studied by measuring the output power at the second end of the fiber which is used as sensor. The output power changes depending on the length of the core exposed in the environment [15-16]

In the present work, core of different lengths is exposed in guiding solutions of various concentrations and optimum length of the core to be exposed is determined. The experiment is carried out with common salt solution as guiding solution at wavelengths 820nm and 850nm for plastic fiber and 1300nm and 1550nm for silica glass fiber.

II. Experimental Arrangement:

The experimental arrangement [16] is shown in figure 1. A white light source that gives wavelength 820nm, 850nm, 1300nm and 1550nm is used in the experiment. A plastic fiber (200 / 230μm) of 1m length and a silica glass fiber (62.5 / 125μm) of length 8800m are used in the present experiment.

Using suitable connectors, one end of the plastic fiber is connected a white light source at a wavelength 820nm and the second end connected to a power meter which records the output power at the second end of the fiber. The output power at the second end of the fiber is considered as power launched since the attenuation in one meter fiber is negligible. Now, 1cm cladding is removed in the middle of the fiber, the bare core is immersed in pure (distilled) water which acts as guiding liquid and the output power is noted. The experiment is repeated with guiding liquid of concentrations 16grams and 32grams of common salt dissolved in 100ml distilled water. The change in concentration of the guiding liquid changes its refractive index. The concentration and refractive index are linearly related. The output power in each case is noted. Next, 2cm cladding is removed and the experiment is repeated with same guiding liquids distilled water, solutions of 16grams and 32grams of common salt dissolved in 100ml of distilled water. The output power in each case is noted. The experiment is again repeated with 3cm and 4cm cladding removed and the output power in each case is again noted. The relation between core exposed in guiding liquid and the output power is shown in figure 2.

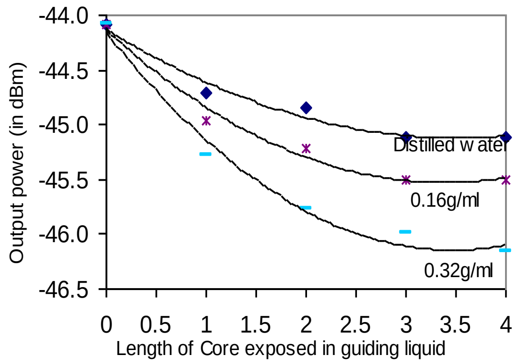

Fig 2. Graph show ing core exposed in guiding liquid (at various concentrations of common salt solution) Vs output pow er at 820nm.

Power loss is calculated in each case and a relation between core exposed in guiding liquid and the power loss is shown in figure 3.

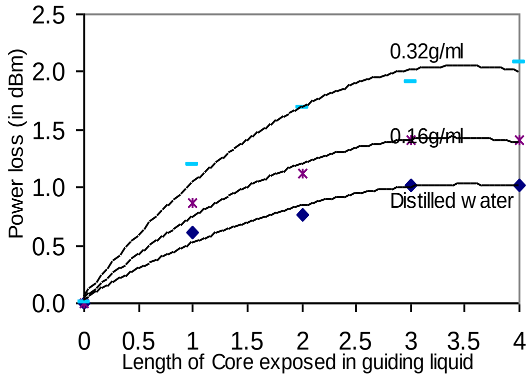

Fig 3. Graph show ing core exposed in guiding liquid (at various concentrations of common salt solution) Vs pow er loss at 820nm.

The experiment is repeated for wavelength 850nm. The results are shown in figures 4 and 5.

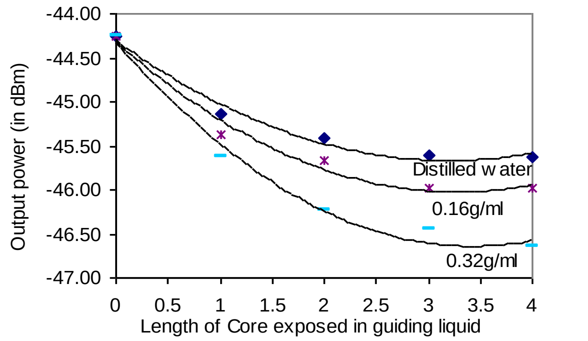

Fig 4. Graph show ing plastic core exposed in guiding liquid (at various concentrations of common salt solution) Vs output pow er at 850nm.

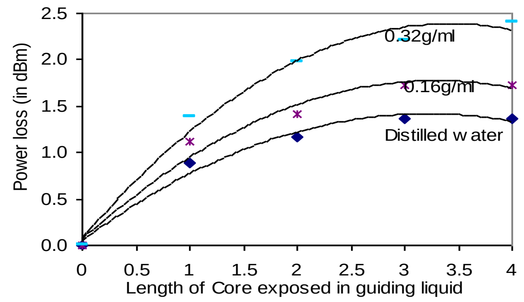

Fig 5. Graph show ing plastic core exposed in guiding liquid (at various concentrations of common salt solution) Vs pow er loss at 850nm.

Now, the plastic fiber in the experiment is replaced by a silica glass fiber (62.5/125μm) of length 8800m.The experiment is further repeated at wavelengths 1300nm and 1550nm. The output power at 1cm, 2cm, 3cm and 4cm core exposed is noted for guiding liquids pure (distilled) water and 16grams, 32grams of common salt dissolved in 100ml distilled water. The relation between length of core exposed in guiding liquid and output power is shown in the figures 6 and 7.

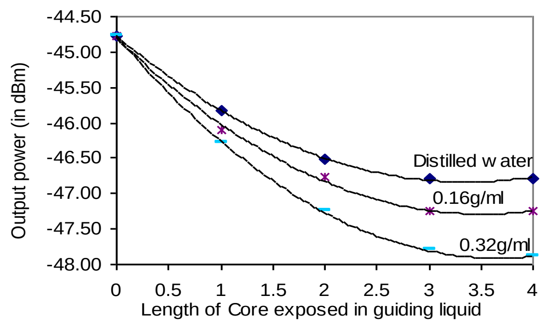

Fig 6. Graph show ing glass core exposed in guiding liquid (at various concentrations of common salt solution) Vs output pow er at 1300nm.

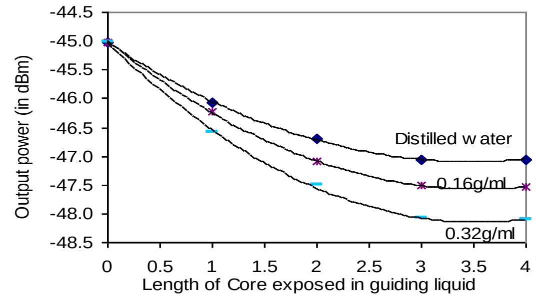

Fig 7. Graph show ing glass core exposed in guiding liquid (at various concentrations of common salt solution) Vs output pow er at 1550nm.

The power loss is calculated in each case and the relation between length of core exposed in guiding liquid and the power loss is shown in the figures 8 and 9.

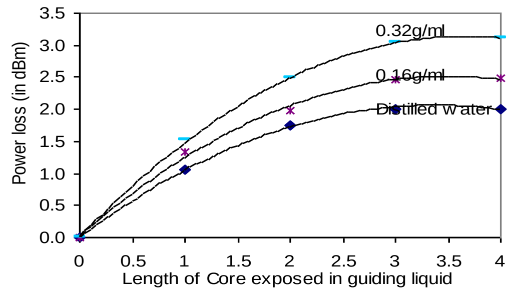

Fig 8 . Graph show ing glass core exposed in guiding liquid (at various concentrations of common salt solution) Vs pow er loss at 1300nm.

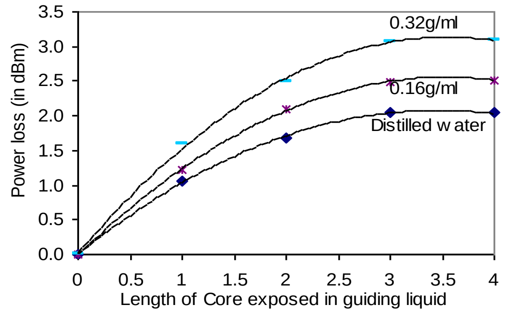

Fig 9 . Graph show ing glass core exposed in guiding liquid (at various concentrations of common salt solution) Vs pow er loss at 1550nm.

The linear region of core exposed in guiding liquid Vs power loss can be studied from the following graphs shown in figures 10 to 15.

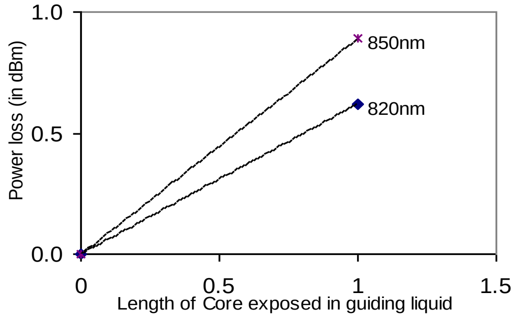

Fig 10. Graph show ing core exposed in guiding liquid (pure w ater) Vs pow er loss at 820nm and 850nm.

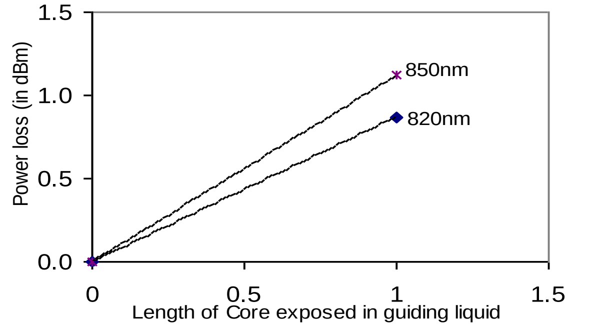

Fig 11. Graph show ing core exposed in guiding liquid (16gram common salt disolved in 100ml w ater) Vs pow er loss at 820nm and 850nm.

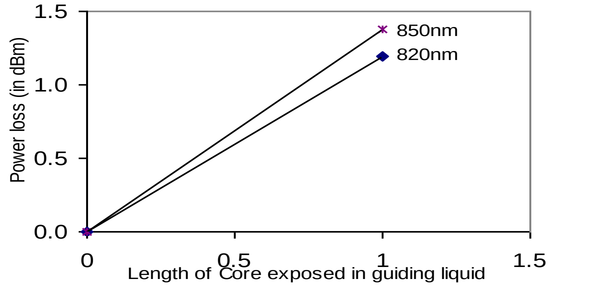

Fig 12. Graph show ing core exposed in guiding liquid (32gram common salt disolved in 100ml w ater) Vs pow er loss at 820nm and 850nm.

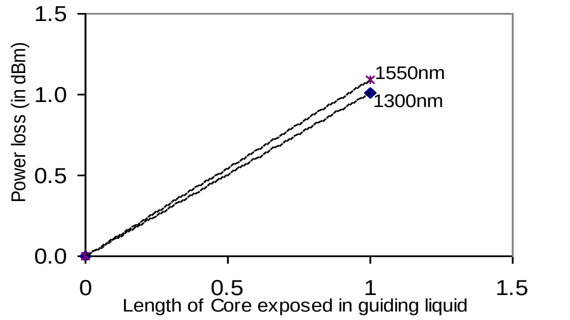

Fig 13. Graph show ing core exposed in guiding liquid (pure w ater) Vs pow er loss at 1300nm and 1550nm.

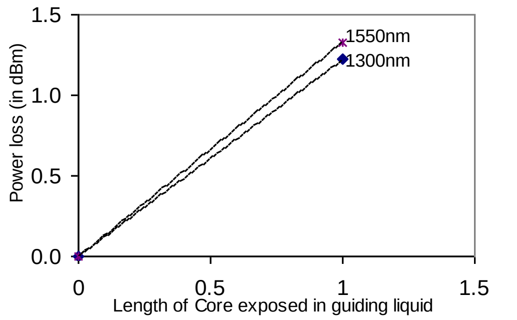

Fig 14. Graph show ing core exposed in guiding liquid (16g common salt dissolved in pure w ater) Vs pow er loss at 1300nm and 1550nm.

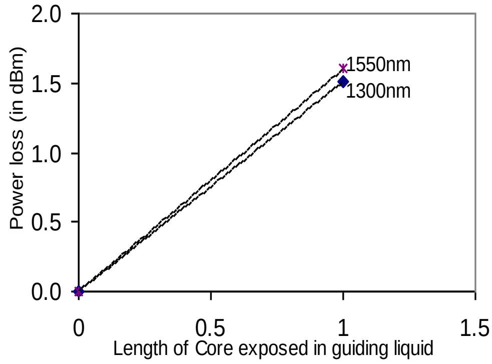

Fig 15. Graph showing core exposed in guiding liquid (32g common salt dissolved in pure water) Vs power loss at 1300nm and 1550nm.

III. Results and Discussion:

1. From the above figures, it is observed that, the power loss is almost linear up to 1cm of core exposed in all guiding liquids, and then it decreases exponentially up to 2cm. The power loss is almost negligible beyond 3cm of core exposed in all concentrations of guiding liquid.
2. It is also observed that, for the same fiber, at the same wavelength, the slope of the linear region increases as the concentration or refractive index of guiding liquid increase.
3. For the same fiber, at the same concentration, the slope of the linear region increases with wavelength.
4. The difference in power loss is more at higher concentrations at 3cm of core exposed in guiding solution.

IV Conclusions:

Power loss is linear up to 1cm of core exposed in guiding liquid which acts as cladding, and it is almost negligible beyond 3 cm.

The slope of the linear region increases with increase in concentration of guiding liquid and also with increase in wavelength.

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