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Extrinsic Intensity Modulated U – Shaped Solid Glass Rod Probe Fiber Optic Sensor – Influence of Length of Liquid Cladding Exposed to the Core on the Transmission Characters of Light

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ABSTRACT

Fiber optic sensing technology is widely used in many applications throughout the world due to their versatility in measuring several environmental parameters which led to the emergence of variety of sensors for accurate sensing. In the present paper a U-shaped solid glass rod is used as a sensing probe in the design of the extrinsic sensor. The sensor is employed to study the variation of transmitted power with different liquid cladding (common salt solution) lengths exposed to the core of the fiber. In the architecture of the sensor, one end of the input fiber arm is connected to 850nm and 820nm sources, and the other end is connected to U-shaped glass rod which is connected to power meter via output fiber arm to measure the output power. The loss of power is recorded at the output end. The relation between the length of the liquid exposed to the core and the power output at the output end is studied. This study helps in predicting the optimum length of the liquid column exposed to the core of the sensing system to offer highest sensitivity.

Key words: *Extrinsic Sensor, Liquid cladding exposed to core, Loss of power, Optimum length of liquid column, Sensitivity and U- Shaped solid glass rod.*

I. Introduction

Fiber optic sensors are expected to play a major role in future medical, industrial, consumer, and aerospace applications due to signal is immune to electromagnetic interference, overall cost effectiveness, safe in explosive environment, reliability, low volume and weight, high voltage insulation, sensitivity, easy realization [1-6]. These advantages were led to the emergence of fiber optic sensors in the areas of avionics, pharmaceuticals, petrochemical and process control [7-10]. The process of light transmission through optical fibers takes place by the phenomena of total internal reflection of light. If the fiber is straight, the ray enters from core (R. I. = n_1) to cladding (R. I. = n_2) ($n_1 > n_2$) with an angle greater than the critical angle, it reflects back into the core and will transmit through the fiber and reaches to the receiver end. When the cladding is an absorbing medium, a fraction of light, that travel through the core of the fiber escapes into the cladding evanescent wave and gets attenuated in the cladding and as result the output power intensity at the receiver end of the fiber decreases exponentially.

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Thus, the liquid column around the U-shaped glass rod, whose refractive index is more than the cladding of the fiber would operate as extrinsic intensity modulated fiber optic sensor. The advantages of intensity modulated sensors lies in the construction simplicity and being compatible in fiber optic multimode technology [11-14]. In the case of intensity modulated sensors, the core of the fiber is exposed to the environmental parameter and the change in the magnitude of the environmental parameter is directly related to the output power reaching the detector. The variation of output power further would be enhanced by the bend radius of the U-shaped glass probe, and also on the length of the liquid column exposed to the core (U-shaped solid glass rod) [15-16].

The present study predicts the optimum length of the liquid column required to be exposed to the core to achieve maximum possible sensitivity of the sensing system by selecting different lengths of liquid columns. In the experiment, a common salt solution is used as a liquid cladding at wavelength 820nm. One end of the input fiber arm is connected to the source and the second end of the output arm is connected to the power meter using suitable connectors to note the output power values. Initially the U-shaped glass rod with different prong heights have been taken and immersed in pure water (distilled) and the power is recorded from the power meter. By following the similar procedure, the experiment is repeated by taking the mixtures of 20gm, 40gm of common salt dissolved in 100ml of distilled water. The refractive index of the liquid mixture changes as the amount of salt added to the distilled water. The experiment is repeated using a light source of 850nm and without changing the optical fibers used earlier.

II. EXPERIMENTAL ARRANGEMENT

In the experimental arrangement [Fig. 1] a plastic input fiber (200/230µm) arm of 40cm and an equivalent length of output fiber arm were used.

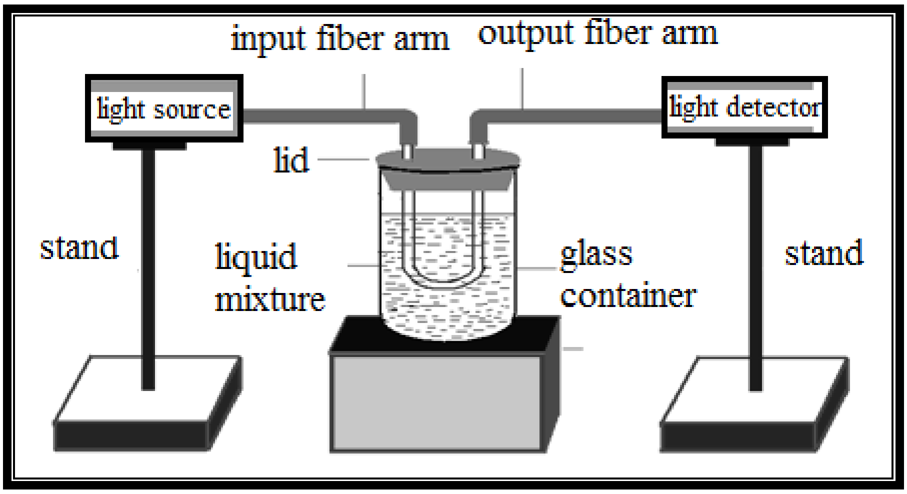

Fig. 1: Experimental arrangement

The optical light source (820nm & 850nm) and the bench mark optical power meter are placed at equal distances from the sensing zone maintaining the same heights by using suitable stands. And the U- shaped glass rods of different prong height (lengths) of 1cm, 2cm, 3cm, and 4cm are used in the experiment [Fig.2].

There is a linear relationship between the refractive index of the liquid mixtures and the concentration. Initially 100ml distilled water is maintained around the U-shaped glass rod and the powers with different prong length rods taken were noted. The results of output power at different length rods used were recorded and tabulated.

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Then the output power when each mixture (100ml of pure water + 20gm salt) exposed to the U-shaped glass rod of prong height 1cm is noted, and the output power and concentration is tabulated, and the results are plotted graphically to analyze the variation of power output with concentration. The procedure is repeated with (100ml of pure water + 40gm of common salt). The results are plotted graphically in Fig. 3.

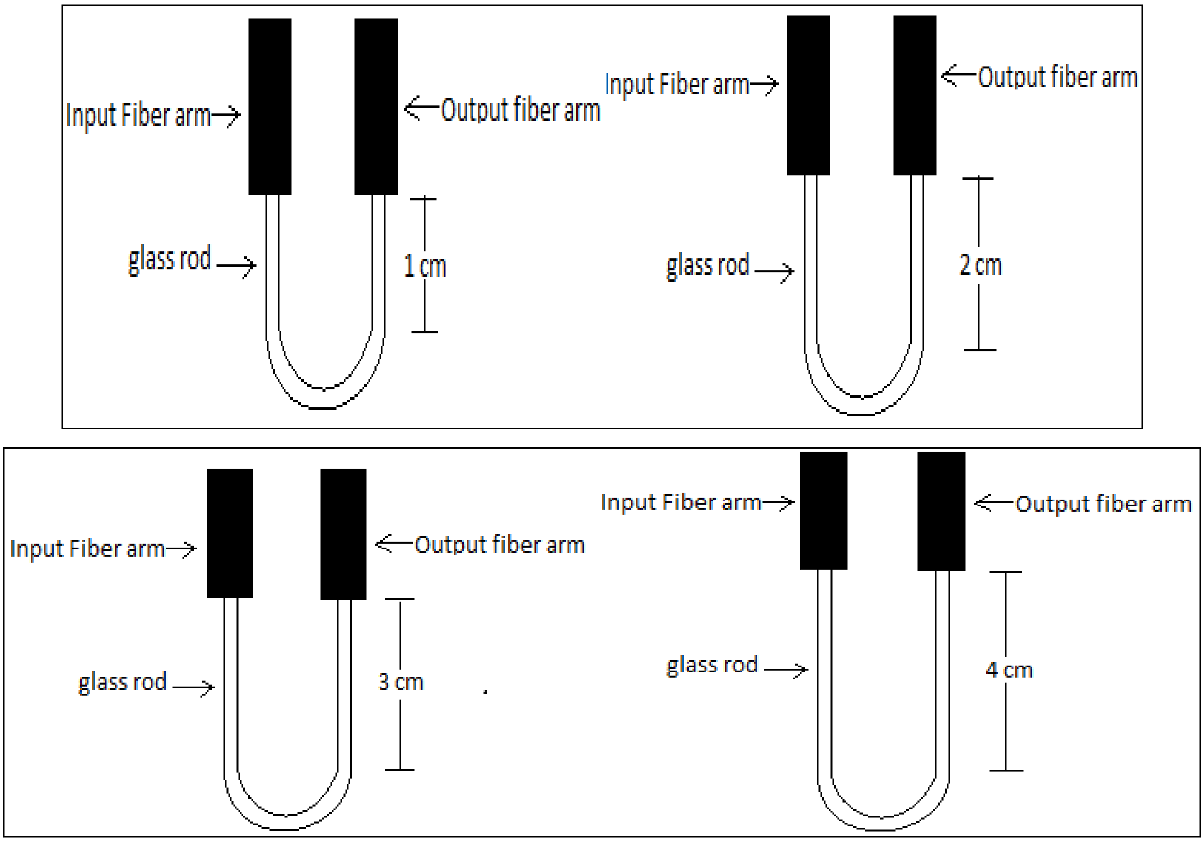

Fig. 2: U- shaped glass rods of different prong height

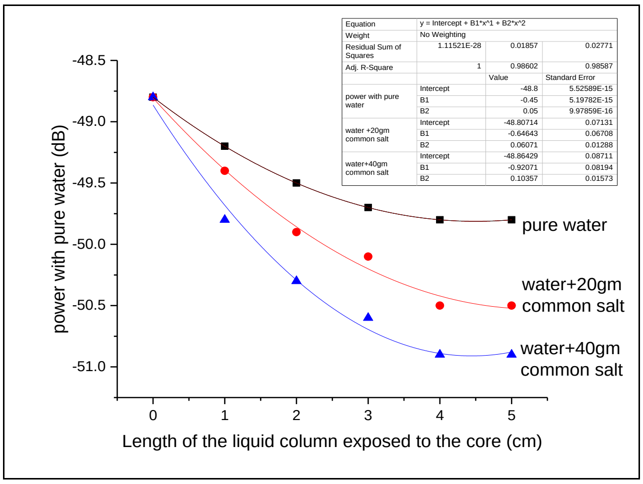

Fig. 3: Variation of power at 820nm

The experimentation was repeated using another optical source 850nm. With 850nm source and by maintaining the parameters of other components of the experiment the power output and the concentrations are tabulated,

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and the results are represented graphically by plotting the graphs taking the different lengths of U-shaped glass rod on x- axis and the output power values on y- axis [Fig. 4].

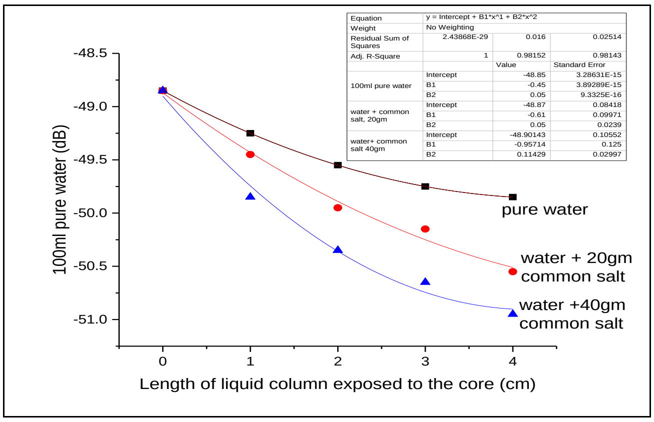

Fig. 4: Variation of power at 850nm

III. RESULTS AND DISCUSSION

From the results and from the graphs drawn it is observed that the loss of power is linear up to certain length of the liquid column, and then it decreases exponentially up to certain value and then after some value the power loss is almost negligible for core exposed to all the concentrations of liquid columns as evident from the graphs. It is again observed that using the same wavelength and with same fibers, as the concentration or refractive index increases, the slope of the linear region also increases.

When the larger core exposed to liquid column, the difference in power loss is more at higher concentrations. The slope of the linear region increases with wavelength for the same fiber at the same concentration.

IV. CONCLUSIONS

Fiber optic sensors may be broadly classified as intrinsic and extrinsic. In the intrinsic sensor, the physical parameter to be sensed modulates the physical properties of light inside the fiber whereas in an extrinsic sensor the modulation takes place outside the fiber. In the intrinsic optical fiber sensor, fiber merely acts as a light conductor to transport the light signal to and from the sensor head. In this case light modulation takes place outside the medium. Out of the four modulation schemes i.e. phase modulation, wavelength modulation, polarization modulation and intensity modulation, the intensity modulated sensors offer the widest range of optical fiber sensors. The advantage of intensity modulated sensors lies in their simplicity of construction and being compatible to the multimode fiber technology.

In the present paper the U- glass used as a sensing probe provided the quick response in measuring the parameter. It is much useful especially in the study of chemical analysis as it is being inert for most of the chemical reactions. This apart as the melting point of the glass is very high, the glass probes as sensing elements helps in measuring several environmental parameters at different temperatures especially at high temperatures i.e. temperatures more than 1000°C. Thus by proper constitution of the sensing system using glass rods as sensing elements in the extrinsic sensor design enables measurement of innumerable environmental parameters with ease, convenience and flexibility.

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