Fiber Optic Pressure Transducer

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ABSTRACT
This paper deals with pressure measurement, which plays a crucial role in deducing new parameters in research laboratories as well as industrial plants, although number of devices are used for this purpose. The present work combines the extraordinary properties of optical fiber with that of diaphragms to measure pressure accurately and precisely. The present technique uses a Y-coupler fiber optic probe which consists of two fibers cemented along some portion of their length. The cemented end is made to face a light reflected diaphragm and light is injected through one port, the intensity of reflected light that is collected by the other fiber and exit through another port will depend upon the distance of the reflecting target from probe. The measurement range is from 0.16 to 13.5 KN/m². In the fabrication of fiber optic pressure transducer, the functioning of proposed sensor is based on known laws of optics i.e., when light is projected on a reflecting surface the relative intensities of incident and reflected rays are dependent on the angle of incidence, the reflectivity and the smoothness of the surface. Thus, the topic fiber optic pressure transducer concludes that as the input pressure increases, the output voltage also increases. This conserves the energy and reduces the transmission losses occurring during ordinary transmission to a great extent.

KEYWORDS
Y-coupler, Fibre Optic, diaphragms

1. INTRODUCTION
Measurement of pressure is a part of research laboratories as well as industrial plants and numbers of devices are used for this purpose. Optical fiber is used for transmission of signals from one place to other with a little attenuation. The present work is a successful endeavor to combine the extra ordinary properties of optical fiber with that of diaphragms to measure pressure accurately and precisely. The Y-coupler fiber optic probe is used which consists of two fibers cemented along some portion of their length. The cemented end is made to face a light reflecting diaphragm and light is injected through port A, the intensity of the reflected light that is collected by the other fiber and exit through port B will depend upon the distance of the reflecting target from the probe. The measurement range is from 0.16 to 13.5 KN/m². Pressure is defined as force per unit area measured at a given point or over surface this can be absolute pressure measured relative to vacuum, Gauge pressure measured relative to ambient pressure. Differential pressure is the pressure difference between two points of measurement.

2. FABRICATION
The functioning of the proposed transducer is based on known laws of optics i.e. when light is projected on a reflecting surface the relative intensities of incident and reflected rays are dependent on the angle of incidence, the reflectivity and the smoothness of the surface. In the designed sensor the reflected ray is detected whose intensity is low in comparison to incident ray depending upon various aspects of incidence and reflected ray, index of media, reflectivity of the surface and distance from the target. This transducer uses two optical fibers one as transmitting fiber and the other as receiving fiber. The transmitting fiber is exposed to the light source and thus carries light to the probe tip where light is emitted and reflected by the target surface (diaphragm). The receiving fiber picks up the reflected light and focuses it on a photo detector which produces an output proportional to the received light. This received light depends on the two factors; reflectivity of the target and distance of the probe tip from the target.

In the present work, Y-coupler fiber optic probe is used which consists of their length as shown in Figure 1. In this reflective fiber optic sensor, the cemented end is made to face a light reflecting diaphragm and light is injected through port A, the intensity of the reflected light that is collected by the other fiber and exit through port B will depend upon the distance of the reflecting target from the probe.

Fig 1: Y-coupler fiber optic probe.
These types of probe display two measuring ranges: steep front slope and back slope, as shown in Fig. 2. At zero gaps, no light can escape from the transmitting fiber and output is zero. As the gap increases more of the target surface is illuminated and reflection increases giving a very sensitive and nearly linear range of measurement (front slope) as the gap goes on increasing and finally the entire surface is illuminated giving the peak output. Movement beyond this point causes a reduction in response since both target illumination and fraction of reflected light gathered by the sensor decreases roughly according to the inverse square law the whole function depends on the principle of operation of intensity modulation type displacement transducer.

Fig 2: Steep front slope and back slope of Y-coupler fiber optic probe.

In the present work, back slope of response curve of reflective fiber optic transducer is used to increase the range of pressure measurement. The instrument is so designed that when positive pressure is applied the readings move on the upper side of the curve towards peak voltage point whereas for negative pressure the readings changes according to lower side of the back slope.

3. INSTRUMENT DESIGN
A cylindrical instrument with a diameter of 45 mm and height of 80 mm is designed; the mid section is 65 mm diameter and hollow from inside to allow diaphragm movement. The inlet for the optical fiber probe and pressure are provided as shown in Fig 3, the set of optical fiber probe are connected to the electronic circuitry for further processing. Benefit of a sapphire substrate is the enabling of high levels of RF integration, especially the ability of including a high-percentage of passive devices [3]. Down conversion technique is best suitable for satellites when there is a need for isolated output.

4. TRANSMITTER AND RECIEVER CIRCUITRY
In transmitter circuit a multi mode fiber is coupled with an LED (MOFOE-71). The fiber carries light to the other end of the probe. These types of LED are relatively simple and operating current density is relatively low. They can tolerate variations in fabrication process they can operate over wide ranges of temperature and require simple circuitry to maintain a stable output. The LED is supplied with +5V DC supply. A photo detector MFOD-71 is used because of its size compatibility with optical fiber and sensitivity at desired optical wavelength 820 nm (1 mm core) and fast response time. The photon detector senses the light falling upon it and converts the variations in this light to correspondingly varying electric current. A current to voltage converter is used to convert this current to proportional voltage. The output voltage acts as input for inverting amplifier whose is gain is:

$$A_v = \frac{R_f}{R_i} = \frac{560}{56} = 10$$

Where, $R_f$ = Feed Back resistance $R_i$ = Input resistance

The output of inverting amplifier acts as input to non inverting amplifier whose gain is given by:

$$A_v = \frac{V_o}{V_1} = 1 + \frac{R_f}{R_i} = 1 + \frac{560}{22}$$

$V_o$ and $V_i$ are output and input voltages respectively.

5. EXPERIMENTAL SETUP
The experiment is performed on the designed intensity modulation type displacement transducer to obtain the characteristic slope and then the calibration of the transducer is done to measure the pressure. The distance of the optical fiber
Fiber Optic Pressure Transducer

A probe is varied with respect to the diaphragm to give readings in terms of output voltages using a millimeter corresponding to its position to get the characteristic slope. When the distance between the probe and diaphragm is zero, the output voltage is negligible. As the distance increases, corresponding voltage is obtained, which is according to the front slope. The maximum voltage occurs at a distance of 1.3 mm. After this, any further movement leads to a decrease in voltage (back slope). In this setup, only the back slope of the characteristic is used.

![Experimental Setup](image)

**Fig 4:** Experimental Setup

### 5.1 ADVANTAGES
1. **Noise Resistance:** Because fiber optic transmission uses light rather than electricity, noise is not a factor. External light, the only possible interference, is blocked from the channel by the outer jacket.
2. **Less signal attenuation:** Fiber optic transmission distance is significantly greater than that of other guided media. A signal can run for miles without requiring regeneration.
3. **Higher bandwidth:** Fiber optic cable can support dramatically higher bandwidth than either twisted-pair or coaxial cable. Currently, data rates and bandwidth utilization over fiber optic cable are limited not by the medium but by the signal generation and reception technology available.

### 6. CONCLUSION
In the light of experimental work, the optical fiber is fixed at a distance of 5 mm from the diaphragm, corresponding to a voltage of 1.3 volts. Now, pressure is applied through a pressure inlet using a plunger and T-joint in such a way that an equal pressure is applied to both the transducer and manometer simultaneously.

When pressure is applied, the diaphragm moves towards the probe decreasing the gap and hence an increased voltage reading is observed. This reading is then calibrated with the readings of the manometer to obtain a calibration chart giving a relation between applied pressure and output voltage of the transducer.

### 7. FUTURE SCOPE
This transducer works on back slope, and the range of this back slope is very important for working of this device. As it provides very less voltage range, so its applications are restricted and it cannot use for wide applications, that is, in mining industries. Future scope entails increasing the back slope range so that we can obtain a large range of voltage and further applications.

### REFERENCES

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