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A REVIEW ON TYPES AND APPLICATION OF OPTICAL SENSORS

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Abstract

Recent developments in fibre optics (FOs) and the myriad benefits of light over electronic devices has improved optical sensor usefulness as well as application in different military, industrial and social fields. Examples are environment and atmospheric analysis, earth and space research, synthetic chemicals and biotechnology manufacturing, law enforcement, digital imaging, scanning, and printing. The ubiquity of photonic technology may push costs lower, cutting the price of lasers and optical fibres. Fiber optic sensors (FOSs) deliver a large range of benefits, like small size and longer lifespan, over conventional sensing devices. Electromagnetic interference immunity, multiplexing capability, and high sensitivity enable FOs the sensor technologies of use in a variety of areas, such as the medical and aerospace industries. Over traditional electrical and electronic sensors, FOSs display efficient and rigid sensing duties. The analysis as well as the most useful uses for optical sensors are discussed in this article.

Keywords: *Advantages, Application, Fibre Optics, Principle, Sensors, Detection, Electronics.*

I. INTRODUCTION

Over the last 25 years, the world of fibre optics has experienced immense development and improvement. By delivering better capacity, more efficient telecommunication connections with ever declining bandwidth rates, the fibre optic communication industry has practically revolutionised the telecommunications industry. The advantages of high volume output for element consumers and a true glass-built knowledge superhighway are brought on by this revolution. Developments of fibre optic sensor technology have become a major user of optoelectronic and fibre optic networking technologies. Fiber optic sensors (FOS) technology has been developed for numerous applications, including fibre optic gyroscopes; temperature, pressure and vibration sensors; and chemical probes, over the previous years. Compared to current methods, FOS has a range of benefits, such as improved flexibility and geometric mobility, which allows for random shapes [1].

In order to replace conventional sensors for acoustics, vibration, electric and magnetic field measurement, motion, rotation, temperature, friction, linear and angular location, strain, humidity, viscosity, chemical measurement and a range of other sensor applications, the capacity of fibre optic sensors has been improved. Because of their dielectric property, they could be used in high voltage, high temperature or corrosive environments; however, these sensors are compliant with communications networks and have the ability to perform remote sensing. Study in the sector has lately concentrated on the invention of novel substances with non-linear optical properties for significant future photonics uses. Conjugated semiconducting polymers that incorporate optical properties with the electronic properties of semiconductors are examples of these materials. In addition, the photo luminescent and electroluminescent characteristics of these conducting polymers make them desirable for optoelectronic applications [2].

In particular, the creation and eventual mass manufacturing of products to serve these companies has also been powered by fibre optic sensor technologies. The intrinsic benefits of fibre optic sensors, including their ability to be lightweight, very compact, inert, low attenuation and low power, electromagnetic interference (EMI) tolerance, high visibility, broad bandwidth and environmental robustness, have been extensively used to compensate for their main drawbacks of heavy price and lack of familiarity to the end consumer [3].

II. DISCUSSION

A. Optical Fiber Sensors Advantages Over Traditional Sensors: -

The developments in FOS system research and innovation have expanded their applications to diverse industrial areas, including the health, chemicals and telecommunications sectors. They are engineered to operate on a wide range of physical characteristics, such as temperature, chemical changes, electrical and magnetic fields, movements, strain, location, flow, pressure, motion, radiation, amount of liquid, strength of light, and colour. FOS proves stable and rigid sensing instruments over traditional electrical and electronic sensors for success in rugged conditions where they have difficulties. On the other hand, optical fibre sensors have a range of benefits over other types of sensors [4].

1. Enable small sensor sizes
2. Non-electrical machines
3. Provide exposure to certain environmental factors
4. Small cable sizes and weights needed
5. Allow remote sensing
6. Enable entry to areas usually unavailable

7. Communication is often not needed,
8. Immune to interference with radio frequencies (RFI) and electromagnetic interference (EMI)
9. May not contaminate the soil and are not exposed to corrosion.
10. Offer high sensitivity, dynamic range, and resolution
11. Data transmission mechanisms can be configured

B. **Fiber Optic Sensor Principles: -**

1. The total configuration of an optical fibre sensor device comprises primarily of four source, fibre optic, transducer and detector elements. The amplitude, phase, colour (spectral signal), and state of polarisation are the optical variables which can be amplified in FOS systems. The strategies of optical manipulation of the sensors include the following [5][6]:
2. Intensity-modulated sensors: Sensors can sense the variance of the light intensity that is equal to the upsetting environment. Transmission, reflection, and micro bending comprise the principles associated with pressure modulation. A reflective or transmissive target may be inserted into the fibre for this. Absorption, absorption, fluorescence, and polarisation are other processes that can be used independently or in combination with the three main principles. Usually, intensity modulated sensors need more light to operate than phase modulated sensors; they use large core multimode fibres or bundles of fibres as a result.
3. Phase-modulated sensors: In a system known as an interferometer, the phase of light in a sensing fibre is contrasted to a reference fibre. A coherent laser light source and two single-mode fibres are used in these sensors. The light is broken into the reference and sensing fibres and is pumped. If the light is exposed to the upsetting environment in the sensing fibre, a phase change happens between them. The interferometer senses the phase change. Far more precise as compared to intensity-modulated sensors are phase modulated sensors. The colour change is related to the adjustments in optical signal absorption, propagation, reflection or luminescence, while the polarisation is linked to the birefringence of the pressure.

C. **Optical Sensor Types: -**

Fibre optical sensors are sensor which could operate in rugged conditions where there are problems with traditional electronic and electric sensors. Different physical features such as friction, location, strain, chemical reactions, electric and magnetic effects, flow, vibrations, degree of illumination, radiation, and colour can be sensed [7][8].

1. Chemical sensors, remote spectroscopy and degradation of groundwater and soil.
2. Temperature sensors; the largest sensors currently available, ranging from -40 to 1000 degree Celsius.
3. Strain sensors; technology for fibre Bragg gratings (FBG), detecting as little as 9 micro strain.

4. Biomedical sensors; simultaneous measurement of spectroscopic biomedical sensors, CO2, O2 and PH, laser dopplerimetry flow control,
5. Electrical and magnetic sensors; they are almost all hybrid, enticing intrinsic dielectric nature, less susceptible to electromagnetic interference, small size and safer.
6. Rotation sensor; two kinds of ring laser gyroscope (RLG) and fibre optic gyroscope, based on the sagnac effect (FOG).
7. Pressure sensors; high performance (polarisation based sensors) based on piezo resistive or movable diaphragm technique; working pressure varies from 0-70,000 torr.
8. Simple sensors depend on the shift in retro reflectance due to a proximal mirror surface, often referred to as liquid level sensors, as one of the first optoelectronic sensors to be created.

D. **Optical Fiber Sensing Applications: -**

1. Optical sensing is known to be the ideal alternative for extreme environmental environments and long distance sensing in applications where traditional electrical sensors such as foil strain gauges, thermocouples and vibrating wires have proved unreliable or impossible to use due to those conditions. Nonconductive, electrically neutral, resistant to electromagnetic interference (EMI), mediated noise, sensor measurements over very long distances (10+ km), daisy chain multiple sensors on a single fibre are among the characteristics and advantages of fibre Bragg grating (FBG) optical sensing. To ease installation and minimise weight, large and lightweight systems may take advantage of the distributed single fibre architecture. The fiber's nonconductive and noncorrosive design supports outdoor and commercial applications where there could be dangerous gases and voltages. The immunity to EMI also reduces the need for costly and frequently demanding signal conditioning appropriate for measurements near noisy sources like power transformers. Many applications in fields like electricity, civil infrastructure, and transportation surveillance may benefits from FBG optical sensing.
2. Medical field: Optical-chemical and biochemical sensing is being widely investigated around the world, and a growing range of applications are being found in the fields of industry, environmental monitoring, medicine, biomedicine, and chemical composition. Absorption and fluorescence are the key physical phenomenon exploited for optical chemical detection, while chemical luminescence, Raman scattering, and plasmon resonance have been utilized. Health-care is probably the area of application that appears to get the most scope for future growth. For many purposes, optical biosensors are seeking ever-increasing opportunities in diverse aspects of healthcare.
3. Energy field: FBG optical sensing has special characteristics that make it ideal for applications that are typically challenging. The monitoring of electrical power generation, producing, transmitting and transforming systems poses many problems that can be solved with FBG optical sensing. If it is a windmill requiring a lightweight solution or an EMI-resistant hydroelectric turbine, optical sensing has special

characteristics that best fit these typically demanding applications. Using optical fibre sensors, partial discharge detector optical fibre sensors are being investigated for use in the detection of partial discharges in electrical transformers. To avoid insulation breakdown and catastrophic failures, it is important to recognise these leakage. For instance, because of long copper lead wires, measuring the structural stability of a wind turbine blade with electrical sensors will often result in noisy measurements. With optical sensors, with little additional weight to the framework, precise and noise-free strain measurements on wind turbine blades are feasible. In addition, the nonconductive and dispersed design of optical fibres, including pipeline tracking and downhole monitoring, is well suited for many utilizes in gas and oil technologies. Wind turbine blade tracking, pipeline monitoring, power line monitoring, offshore platform monitoring and downhole monitoring are energy FOS system applications.

4. Civil field: Electrical sensor-based structural health control systems often pose major environmental challenges. The addition of numerous cables, a lightning grounding device, occasional external calibration, and the likely repair of corroded and/or degraded sensors would entail an electrical control system. Those downfalls are all removed with an optical sensing approach. The ability to chain multiple sensors on a single fibre daisy chain significantly decreases the system's weight and complexity. In addition, optical fibre does not corrode or conduct like copper wire, which enhances resilience and decreases the chance of lightning damage. These characteristics, combined with the fact that no calibration is needed for optical sensors and NI interrogators, dramatically reduce the amount of maintenance required. Broad building surveillance, bridge and path monitoring, airport landing strip load monitoring and dam monitoring are applications of civil FOS systems**.**
5. Transportation field: Monitoring devices are constantly implemented to ensure the proper service of aircraft, railways, vehicles, and more, in order to ensure passenger safety. However, the installation of an electrical monitoring device can be greatly challenged by weight, scale and harsh environmental conditions. By offering lightweight distributed sensor measurements that are resistant to corrosion, high voltage, and EMI-induced noise, FBG optical sensors mitigate these difficulties. This sensing systems may even be installed reliably for decades without any maintenance due to the durability and ease of implementation of FBG optical sensors and the lack of need for external calibration, which is particularly useful for long-term railway and ship hull monitoring. The ability to provide multiple sensors on a single, very thin fibre decreases the monitoring system's weight significantly, which is particularly useful in aircraft components. Transport FOS software uses include train tracking, monitoring of fuel tanks, monitoring of aeroplane wings, and monitoring of ship hulls [9][10].

III. CONCLUSION

Recently, developments in fibre optics-based technologies and applications have advanced quite quickly. Optical fibre, as a physical medium, is susceptible to multiple disruptions at all times. It thus encounters variation in size and form and optical changes (refractive index, mode conversion) to a greater or lesser degree, depending on the nature and severity of the disturbance. It is important to be accurate at all times for communication applications and to reduce different impacts on transmitted signals. In the other hand, the response to external influence is purposefully improved in fibre optic detection, so that the resultant change in optical radiation could be used as an indicator of external disruption. As light is defined by amplitude (intensity), phase, frequency and polarisation, there can be a difference in any some or all of these variables. In the sensing point, the fibre serves as a modulator, while in contact, the signal going through a fibre is already modulated. It also acts as a transducer that transforms the measurement into a corresponding optical radiation shift.

There are many benefits of FOSs, such as EMI independence, broad bandwidth, compactness, geometric simplicity and economy. Indeed, as opposed to other forms of sensors, dielectric structure, passive, and high sensitivity. Fibers that have been specially prepared can survive extreme temperatures and other harsh conditions. A fibre segment can be used as a sensor gauge in telemetry and remote sensing applications, whereas a long stretch of the same or another fibre can transfer the sensed information to a remote station. It is also possible to instal dispersed and array sensors that span vast systems and geographical locations.

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