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Adjustable range draw-wire type fiber Bragg grating displacement sensor

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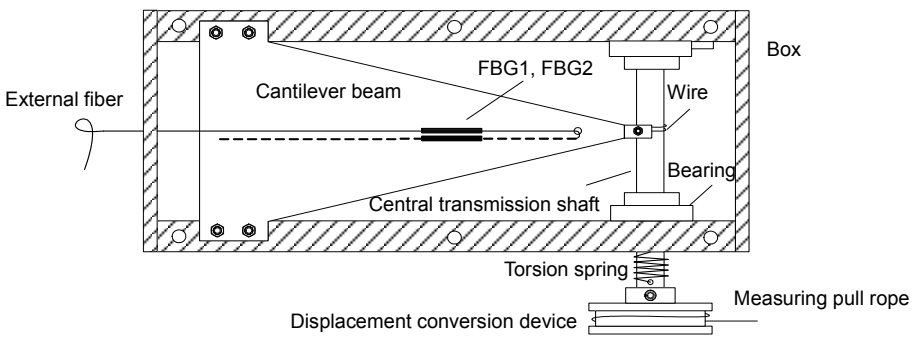

Fiber Bragg grating displacement sensor structure diagram.

Abstract: Displacement measurement technology is widely used and it is one of the most basic testing techniques. In order to solve the problem of displacement monitoring of health monitoring system in the complex electromagnetic environment, and realize the real-time monitoring of large mechanical and engineering structure health and safety conditions, a novel fiber Bragg grating displacement sensor based on the structure of the cantilever beam is designed in this paper. The fiber Bragg grating displacement sensor is mainly composed of cantilever beam, fiber Bragg grating, central transmission shaft, bearing, torsion spring and displacement conversion device. The main body of the sensor is encapsulated inside a box, and a smart displacement conversion device is specially designed outside the box, which is used to adjust the range of the sensor and realize the measurement in wide range. Two fiber gratings with different central wavelengths are symmetrically pasted on the both sides of the cantilever beam. When the free end of the cantilever beam is changed, the two fiber gratings are respectively subjected to tension and pressure, which leads to the drift of the gratings center wavelength to the opposite directions. Through demarcating the relationship between the two center wavelength difference and displacement, it is possible to realize the measurement of the displacement. At the same time, the influence of the temperature on the wavelength shift can be eliminated by central wavelength difference of the two gratings, and the problem of cross sensitivity between temperature and displacement is also solved. The sensor adopts draw-wire type displacement transmission mode, which makes the sensor installation location and measurement method more flexible. In addition, a smart device used to change the measuring range of the sensor is designed and it is also easy to be assembled and disassembled, so the whole sensor can be widely used. The displacement measurement system and temperature measurement system are set up to test the overall performance of the displacement sensor. The experimental results show that when the range is 60 mm, the average sensitivity of the displacement sensor is 47.7 pm/mm, the correlation coefficient is 0.998, the repeatability error is 2.83% FS and the hysteresis error is 1.02% FS. The temperature coefficients of FBG1 and FBG2 are 25.8 pm/℃ and 28.9 pm/℃, as well as the temperature coefficient of the sensor is -3.1 pm/℃. The structure of the double grating can achieve the effect of temperature compensation, reduce the temperature coefficient of the displacement sensor, and reduce the influence of the change of the environmental temperature on the displacement measurement. The displacement sensor is characterized by simple structure and adjustable range, which can meet the demands of displacement measurement under different environments.

Keywords: fiber Bragg grating (FBG); cantilever beam; displacement sensor; adjustable range
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