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Experimental research on negative pressure wave signal of optical fiber and electronic sensor

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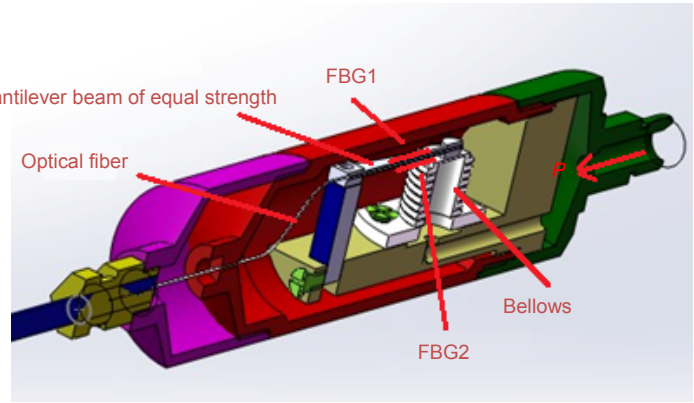

Structure model of optical fiber sensor.

Abstract: Negative pressure wave technique is an effective method for pipeline leak detection. However, the low sensitivity and poor locating accuracy seriously limit the applications of negative pressure wave in pipeline leakage detection. In order to obtain more accurate inflection point information of negative pressure wave and improve signal to noise ratio, the response time, static stability and anti-electromagnetic interference of the optical fiber sensor and the traditional electronic pressure sensor are analyzed.

In the 102.8 meters pipeline experimental platform, the optical fiber sensor and the electronic sensor are set in pairs, with distance of about 10 cm, to open the leakage valve and compare the response time of both sensors according to the negative pressure wave signal captured by the sensors. In the constant pressure state, collected pressure data after the signal is stable, recording the real-time pressure change and testing the long-term stability of the two sensors. In order to further verify the reliability of the data, the current output circuit of the electronic sensor is cascaded with 500 Ω resistors, and the voltage of the two ends of the resistor is real-time monitored using the oscilloscope to test the stability of the sensor output current. At the same time, water cycle in the whole pipeline is powered by a water pump, so there is 50 Hz frequency electromagnetic interference in the experimental environment, adjusting the internal pressure of the pipeline. After the pressure is stable, the pressure data of the two sensors are recorded, and comparative analyses to test the anti-electromagnetic interference performance are carried out.

Experimental results show that optical fiber sensor takes about 30 ms, and negative pressure wave signal of the leakage is acquired to the pressure signal resumes stable, which is far better than the electronic sensor with the time of 500 ms. In the static stability experiment, the pressure signal output of optical fiber sensor is stable, and the pressure fluctuation range is ± 0.001 MPa, which is far less than the electronic sensor's ± 0.006 MPa. In the electromagnetic interference experiment, with the influence of the water flow and the vibration of the pipeline, the pressure value of optical fiber sensor has a small fluctuation, and the fluctuation range is about ± 0.01 MPa. As to the electronic sensor, due to the sensitivity to electrical interference, the monitored pressure fluctuation range is ± 0.005 MPa, which is accompanied by pressure mutation point. Comprehensive evaluation analysis shows that the optical fiber sensor has excellent stability and electromagnetic interference resistant performance, and has wide application prospect in the fields of pipeline leakage monitoring, energy and chemical industry.

Keywords: negative pressure wave; optical fiber sensor; response time; stability

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