Remote fiber optic sensor for monitoring the radiological situation

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Abstract. The necessity of remote monitoring the radiological situation in the different areas of nuclear power plants, adjacent territories, etc. is sustained. One of the most important conditions for this control is the duration of the system work (for ten or more years) without human intervention (only in a special case). It is noted that a feature of this environmental monitoring for the presence of radiation is the ability to transmit information over long distance in real time without distortion. And constant receipt of information about the value of the exposure dose in the sensor area is also important. In a case of using the system of a large number of sensors, there are no problems information processing, because it is contained in the optical signal. The design of the fiber optic communication line with using the fiber optic sensor is proposed. The measurement limits of the exposure dose of radiation are marked. The results of experimental researches of various fibers for using in these sensors are presented. The method of radiation control with their use is determined.

1. Introduction

Environmental situation in the world is one of the most discussed and actual topics [1-12]. Scientific and technological progress led to the appearance of large number of negative factors, which influence on the natural environment [11-23]. These factors mostly connect with human activities and barbaric attitude to nature [17-19, 22-34]. But there is one factor, which always increases in its volume on planet. This factor is radioactive pollution [8, 11, 23, 35-40]. People require more and more energy for their activities every year [1, 2, 4, 5, 20-23, 38-45]. Nuclear power plants (NPP) are one of the main energy sources, which provides required powers at any time [9, 11, 39, 40, 46]. Also, NPP are the source of radioactive emissions to the atmosphere, which are inevitable during their work [9, 11, 39, 40, 46]. Also, the number of industrial and scientific facilities, which work with using radioactive materials, increase in the world. Despite the creation of protecting structures and ceilings around such facilities, risk of the radioactive materials leaking into soil and water has increased. Control of radiation by different methods [11, 39-49] allows to detect it at the final formation stage. In this case the efficiency measures to prevent the consequences of radioactive pollution is reduced. It is not always possible to control it by people (fig. 1).
Moreover, it is not always possible to transfer the information about the radioactive territory state to distance. So, this is the reason, why the development of systems for remote control of the radiological situation at any time is extremely actual.

2. Research methodology and instruments
Nowadays the most effective device for controlling the radiation state of territory and facilities is multifunctional dosimeter MKS-AT1117M (fig.2).

It is difficult to integrate this device into the remote automatic radiation control system. In some cases, this device operation will depend on the temperature and humidity of the environment, in which it is located. It is also difficult to integrate another simple dosimeter into the automatic control systems for cases, when it requires to control situation on the long distance. The disadvantages of all electronics include its low resistance to the large doses of radiation influence. After such influences it functions don’t recover nothing works. Therefore, it is extremely important to endure electronic systems of devices out of the influence zone of powerful radioactive radiation.
For such purposes are best suited sensors for controlling radiological situation based on the optical fiber. Nowadays developed fiber optic sensors, which are based on the measurement changes in the laser radiation polarization under the γ-radiation influence. Such devices can register rather weak changes of the exponential radiation dose (a decrease in the laser radiation power by 0.05 dB). But, in the case of high doses, optical fiber sensors stop their work, because fiber is very sensitive to the γ-radiation influence (the optical fiber accumulates it). The relaxation processes without interventions can take $10^6$ s and more, even in the case of small exposure doses of radiation. If the optical fiber is exposed to a high dose of radiation, it can’t recover to the initial state (the structure will be destroyed). So, this is the reason, why fiber optic sensors for controlling radiological situation need to be improved.

3. **Results of experimental studies and discussion.**

We have previously carried out research of the possibility of controlling the relaxation process in the optical fiber. It allowed to develop the method of the fiber optic communication lines recovery after γ-radiation influence [38, 39]. During sensors development it is necessary to find an optimal solution between its sensitivity to changes in exposure dose of radiation, resistance to powerful radiation influence and possibility to recover the optical fiber transparency.

Previously researches [38, 39] allowed to propose, as a sensor, a bundle of the optical fiber 100 m long with SiO$_2$ – GeO$_2$ core with various alloying. The sensor parameters are required to check when exposure dose of radiation will change from 0.1 to 1000 G. For optical transparency of the optical fiber, we use the additional laser radiation with wavelength $\lambda = 1310$ nm. The results of measurement of the radiation-induced losses level in sensor when exposure dose of radiation will change are showed at the fig.3.

![Figure 3](image)

**Figure 3.** Dependence of the radiation-induced losses $\alpha_s$ with exposure dose $D_R$ at a wavelength $\lambda = 1550$ nm for a single-mode fiber with a SiO$_2$ – GeO$_2$ core at a $T = 294.2$ K. Charts 1, 2, 3 и 4 correspond to different alloying in %: 1.5; 4.0; 10.0 и 20.0.

Analysis of the results shows, that this optical fiber sensitivity is in direct proportion to the alloying percentage. It allows to register the changes of small values of the exposure dose and fix decrease of the laser radiation power at the output of the fiber optic communication line by 0.2 dB.

The obtained results confirm the work reliability of the developed sensor for controlling exposure dose of radiation in remote mode with using the method of device recovery.
4. Conclusion

Analysis of the obtained results on the change of losses in the optical fiber from the change of exposure dose confirm the possibility of using the developed sensor for environmental monitoring of radiological situation.

Highly sensitivity of sensor allows to control the background radiation changes near the radiation hazardous facilities and industries, and also in agricultural areas, where can fall the radioactive fallouts.

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