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RESEARCH OF FOCL PARAMETERS IN THE RANGE OF POSITIVE TEMPERATURES

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RESEARCH OF FOCL PARAMETERS IN THE RANGE OF POSITIVE TEMPERATURES

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Abstract. This article studies the parameters of fiber-optic communication lines (FOCL) in the temperature range. For research, a climatic unit has been developed that allows a wide temperature range for testing (from -90°C to + 90°C) and an experimental complex for investigating the stability of optical parameters of a fiber-optic cable with temperature changes in the range from + 18°C to + 76°C. A technology of sequential switching of optical fibers of a fiber-optic cable by means of welding is proposed, thanks to which the constructive problem of placing a long optical fiber in a limited volume of a heat chamber is solved. Measurement of changes in the attenuation of fiber-optic communication lines with a monotonic change in positive temperatures in the direction of increasing and decreasing temperature.

Keywords: optical fiber, attenuation, temperature, climate chamber, FOCL

Introduction

The rapid process of informatization of society was the main reason for the widespread use of fiber-optic transmission systems, which have the following advantages [1-4]:

- fiber-optic cables (FOC) are completely independent of electromagnetic interference, radio interference, lightning and high voltage surges;
- do not suffer from capacitive or inductive communication problems;
- there is no interference that can damage the signal;
- no need to license the use of radio frequency;
- low attenuation of the light signal in the fiber;
- galvanic isolation of network elements, etc.

A fiber-optic information transmission system is a complex of optical communication lines and devices that are designed to generate, transmit and process optical signals.

Fig.1 shows the generalized structure of a fiber-optic information transmission system (FOTS). In general, the FOTS includes: an optical transmitter (emitter) (1),converting an electrical signal into an optical; fiber-optic cable (2) - the medium through which the optical signal propagates; an optical receiver (detector) (3) that receives the optical signal and converts it back into an electrical signal; optical connectors (4), which are used to connect an optical fiber to an optical emitter, optical detector, connect optical fibers to each other [5-11].

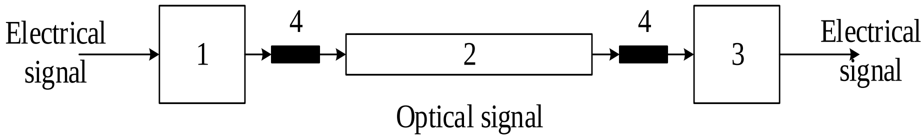

Fig.1. Generalized block diagram of a fiber-optic information transmission system

It is of great practical interest to study the performance of FOCs at positive temperatures and their positive changes.

Main part

To determine the dependence of the spectral characteristics and transmittance of optical fibers on temperature changes, both in the cable structure and in the open form, a special climatic chamber was developed and manufactured. A feature of this installation is that it can provide a wide test temperature range, namely, from - 90°C to + 90°C.

A wide range of temperature changes is achieved by the fact that not an electrical system is used to cool and heat the internal volume of the climatic chamber, but a special internal coil made of a copper tube, through which liquid nitrogen or superheated water vapor can be dosed.

To store liquid nitrogen and superheated water vapor, a Dewar vessel is used, which is a flask with double walls, from the space between which air is pumped out (Fig.2).

Fig.3 shows the external view, and Fig.4 shows the internal view of the climatic chamber. Fig.5 shows a general view of the air conditioner installation.

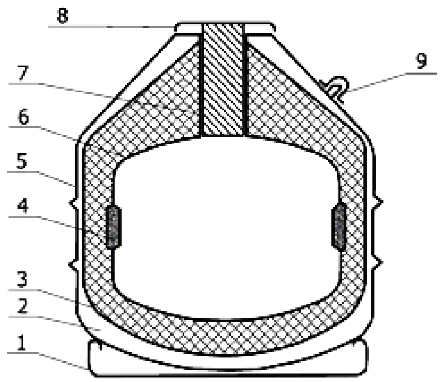

Fig.2. Dewar vessel diagram:
1- stand; 2 - evacuated cavity;
3 - thermal insulation;
4 - adsorbent; 5 - outer vessel;
6 - inner vessel; 7 - neck; 8 - cover;
9 - tube for evacuation

The principle of operation of the climatic chamber is as follows: a voltage of 12 V is supplied via an electric cable (16), which heats up two resistors located inside the cryogenic vessel and at its outlet.

The degree of heating is set using the knob (15) of the variable resistor. With slight heating, in the Dewar vessel, liquid nitrogen evaporates and an excess pressure arises, which, through a thermally insulated tube (10), distills the amount of liquid nitrogen required for cooling into the copper coil (8) of the climatic chamber.

Additional fine adjustment of the liquid nitrogen supply is carried out using two valve knobs (13 and 14) for supplying and adjusting nitrogen. Liquid nitrogen flows through a spiral wound copper coil (8), cooling the climatic chamber to the required temperature, the exhaust gas is discharged through the outlet pipe (12). The fan (5) (Fig.2) ensures efficient heat exchange inside the climatic chamber.

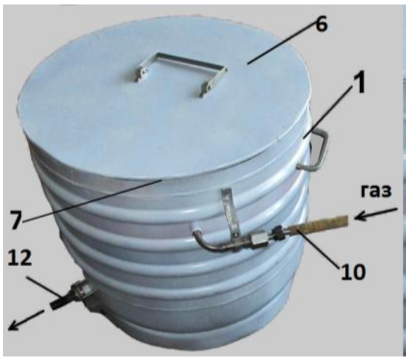

Fig.4. External view of the climatic chamber: 1 - the outer casing of the climatic chamber; 6 – cover of the outer casing of the climatic chamber; 7-layer special insulator of the climate chamber cover; 10 - thermally insulated tube; 12 - outlet branch pipe

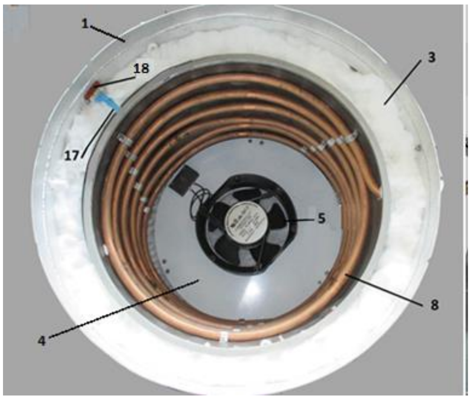

Fig.3. Internal view of the climatic chamber (top view): 1 - external casing of the climatic chamber; 3- mineral wool; 4- bottom of the inner case of the climatic chamber; 5-fan; 8 - copper coil; 17 - electric multicore cable; 18 - electrical connector

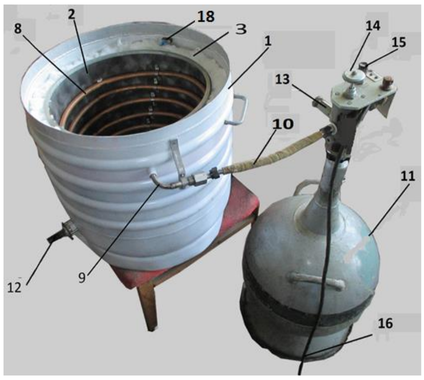

Fig.5. General view of the climatic unit: 1 - the outer casing of the climatic chamber; 2 –inner body of the climatic chamber; 3 - thermal insulating mineral wool; 8 - copper coil; 10- thermally insulated tube; 11 - Dewar vessel; 12 - outlet branch pipe; 13, 14 - taps for supply and regulation of liquid nitrogen; 15 - handle of a variable resistor for regulating nitrogen evaporation; 16 - electric cable; 18 - electrical connector

For testing in the plus temperature range, in a thermally insulated tube (10) superheated steam is supplied from the steam generator, which can provide heating of the internal volume of the climatic chamber up to + 90°C.

To study the characteristics of the optical parameters of a fiber-optic cable when the ambient temperature changes in the range from + 18°C to + 76°C, an experimental complex was developed, shown in Fig.6.

A fiber-optic cable with a single-mode fiber, 24-fiber, wavelength 1550 nm, standard G.652 (manufactured in China) was used for research [12-20].

During the research, the task arose to place at least 1000 meters fibers in a limited volume of the heat chamber, since the rigidity, large overall dimensions of the cable allowed only 50 meters cable inside the volume of the heat chamber.

This technical problem was solved by switching optical fibers of a multicore optical cable (Fig.7) [12-15].

The first end of the fiber-optic cable is connected, in addition to the light guides for input and output of laser radiation (3a), (3b), with an external cassette (17a), where twenty-two ends of the optical fiber are spliced into eleven loops.

Fig.6. Photo of an experimental complex for studying the optical parameters of a fiber-optic cable with a change in temperature:
1 - a metal body of a heat chamber with a heater; 2 - removable heat chamber cover; 3 - fiber-optic multicore cable; 4 - electric heater (1 kW); 5 - vessel for generating steam (in the case of cooling, a Dewar vessel is used); 6 - Wavetek MTS 5200 reflectometer

From the second end of the cable, radiation is introduced into an internal cassette (17b), consisting of twenty-four ends of an optical fiber welded in twelve loops (Fig.7). The welding locations are indicated in Fig.7 with the number (19) and the designation “X”.

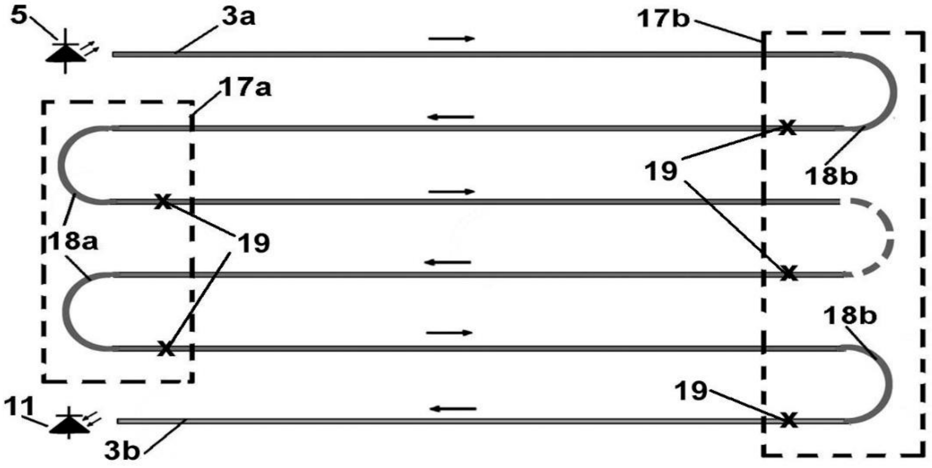

Fig.7. Schematic diagram of switching single-mode optical fibers of a multicore optical cable: 3a - lead-in end of the fiber-optic fiber; 3b - Lead-out end of optical fiber; 5 - emitting laser; 17a - external cassette; 17b - inner cassette; 18a, b - loops of optical fiber with splice points; 19 - optical fiber splice points

Thanks to this fiber switching technology, radiation passes through all twenty-four lengths of optical fiber inside the cable and returns to the lead-in end of the fiber-optic fiber (3a) (Fig.7).

Due to the serial switching of 24 optical fibers, respectively, in the cassettes (17a) and (17b), the laser radiation passes along an optical path equal to 2370 meters (24 x 98.75 m = 2370 m). The area exposed to temperature is 1200 meters (24 x 50 m = 1200 m).

Thus, it is possible to observe the effect of temperature (both positive and negative) on an optical fiber with a total length of 1200 meters, instead of 50 meters limited by the length of the overall and rigid cable. There are 12 welding sections (points) inside the chamber.

With the help of an experimental complex for research (Fig.6), full-scale measurements of the optical kilometric attenuation of a fiber-optic cable were carried out with a change in temperature, namely, with a monotonic increase in temperature +18°C, +35°C, + 46°C, +56°C, +66°C, +76°C and respectively +66°C, +56°C, +46°C and +25°C with a corresponding decrease in the temperature of the optical cable are given. Tables 1 and 2, Fig.8 and Fig.9 show the results of measurements of the value of the dependence of the kilometric attenuation on the temperature change of the fiber-optic cable at temperatures of +18°C and +35°C, respectively.

Table 1

Dependence of kilometric attenuation on the temperature change of a fiber-optic cable at a temperature of + 18°C

Plot №	Distance from the end A, m	Distance from the end B, m	Attenuation at + 18°C, dB			Δα, dB
			End A	End B	(A + B) / 2	
1	168	2202	-0.949	1.604	0.328	0.000
2	354	2016	-0.756	1,326	0.285	0.000
3	539	1835	1,478	-0.043	0.718	0.000
4	721	1646	1.120	-0.689	0.216	0.000
5	908	1462	1,460	-0.624	0.418	0.000
6	**1094**	**1276**	**3.808**	**5.120**	**4.464**	**0.000**
7	1276	1094	2.031	-1,160	0.436	0.000
8	1462	908	1,662	-0.553	0.555	0.000
9	1646	721	0.763	0.362	0.563	0.000
10	1835	539	-0.259	0.852	0.297	0.000
11	2016	354	0.048	1.229	0.639	0.000
12	2202	168	2.463	-1.929	0.267	0.000

Table 2

Dependence of kilometric attenuation on the temperature change of a fiber-optic cable at a temperature of + 35°C

Plot №	Distance from the end A, m	Distance from the end B, m	Attenuation at + 35°C, dB			Δα, dB
			End A	End B	(A + B) / 2	
1	168	2202	-0.787	1,600	0.407	0.079
2	354	2016	-0.370	1,346	0.488	0.203
3	539	1835	1.122	0.092	0.607	-0.111
4	721	1646	1,621	-0.913	0.354	0.139
5	908	1462	1.998	-0.338	0.830	0.412
6	**1094**	**1276**	**2.984**	**5,220**	**4.102**	**-0.362**
7	1276	1094	1,894	-1.344	0.275	-0.161
8	1462	908	1,841	-0.907	0.467	-0.088
9	1646	721	-0.223	0.370	0.074	-0.489
10	1835	539	-0.404	0.928	0.262	-0.035
11	2016	354	0.567	1.075	0.821	0.183
12	2202	168	3.394	-1.882	0.756	0.489

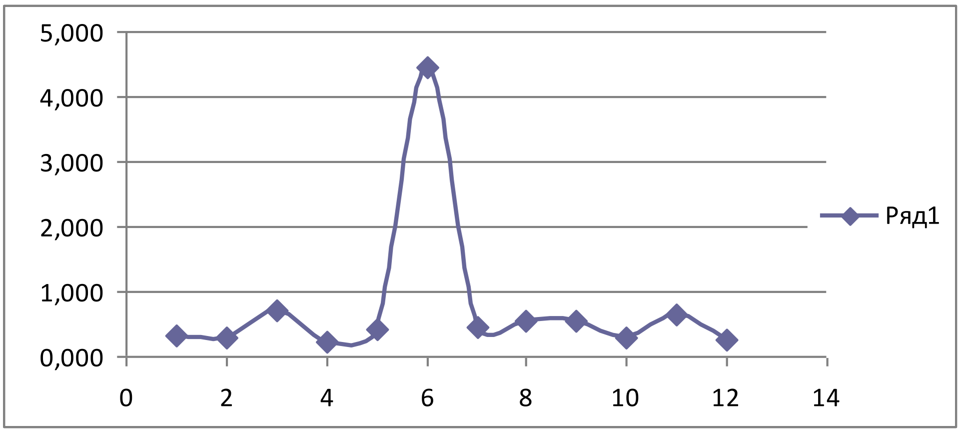

Fig.8. The graph of the attenuation dependence for twelve investigated sections of the OF at a temperature of + 18°C

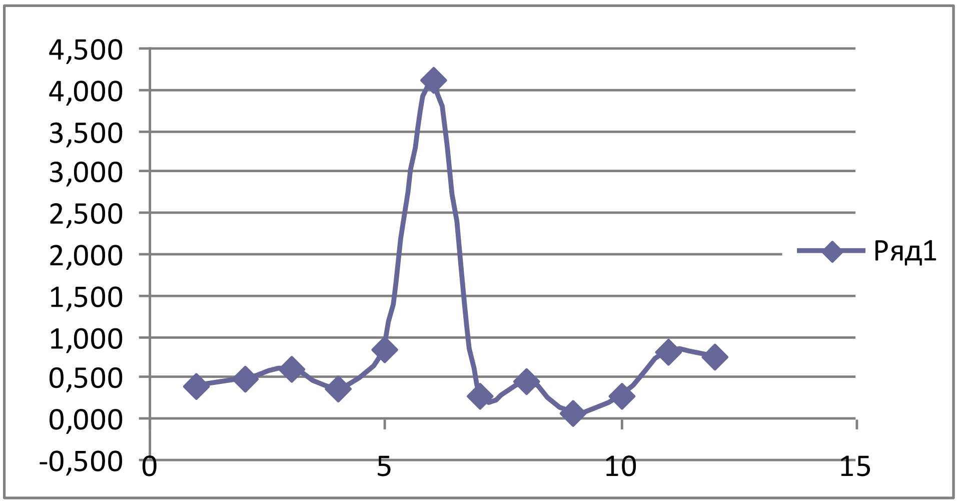

Fig.9. The graph of the attenuation dependence for twelve investigated sections of the OM at a temperature of + 35°C (temperature rise)

Fig.8 and Fig.9 clearly show the difference between the attenuation coefficient of the sixth section from the remaining eleven sections: 4.464 dB per kilometer, for the fifth and seventh sections, respectively, 0.418 and 0.436 dB per kilometer (in Fig. 8 and Fig. 9 by the *x*-axis is the number of the spliced optical fiber section; the *y*-axis is the optical attenuation in dB/km).

Conclusion

It should be concluded that in the case of multiple splice points, different sections of the optical fiber can have different temperature dependence of optical attenuation. Obviously, the fiber itself, for the same cable, cannot have different temperature sensitivity. Consequently, different temperature "behavior" of different sections is associated precisely with the micro-sections of the fiber, where the welding operation was performed [1-14].

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