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Transmission of thermal imaging by using infrared bundle based on silver halide solid solution

Transmission of thermal imaging by using infrared bundle based on silver halide solid solution

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Abstract. In this study, infrared bundle consisting of seven single fibres was manufactured. Experiences on transmission of the heated object thermal image was performed. The experimental data show that there is a fundamental possibility of thermal image transmission through the infrared bundle.

1. Introduction
Remote temperature detection of the heated objects by means crystalline infrared fibers based on silver halide solid solution [1] is a novel direction that opens up broad application prospects. It is primarily related with the properties of infrared fibers [2], in particular, with their wide spectral transmission from 2.5 to 25.0 μm, which corresponds to the temperature range from – 200 to + 1000 °C, according to Wien displacement law. Obtaining temperature distribution on a heated body surface using infrared bundle in real-time represent interest from both fundamental and practical point of view. Today, similar technology is implemented in endoscopes with fiber optics used in medicine for visual inspection of the internal cavities of the human body, biopsy, surgical and therapeutic influences on biological tissues by laser radiation, washing the cavity and filling it with air or liquid, injection of medicinal solutions, removal of tumors and foreign bodies, etc. [3]. Obtaining a thermal (infrared) image has several noticeable advantages, in contrast an endoscopic image in the visible range of the spectrum.
Thus, obtaining data on the temperature distribution in medicine will localize and assess the degree of any inflammatory process, including cancer, which will further contribute to the correct choice of treatment methods and simplify the procedure of exposure to the seat of infection. Using the infrared fiber optic cable in defectoscopy of power equipment and its components due to the temperature difference, it is possible to detect the presence of various kinds of damage and timely perform maintenance, thereby reducing the failure risk of the entire device. In addition, this equipment can be used for quality control of welds, measurement and analysis of thermal parameters inside pipelines and many other applications.

2. Experimental data
Infrared bundle consisting of seven crystalline fibres with $AgCl_{0.75}Br_{0.25}$ composition (length 150 mm, diameter 1.12 mm) were made for thermal imaging survey. Single optical fibres were packed by hexagonal type with compliance the straightness of their structure (Figure 1). The type of stacking we used provides stability of fibres in the bundle and has a small idle area, which 2.5 times less than in

square type stacking [4]. The final trimming of the bundle on two sides by a glassy cutter was carried out to create a plane-parallel surface of the thermal transfer image.

(a) **(b)**

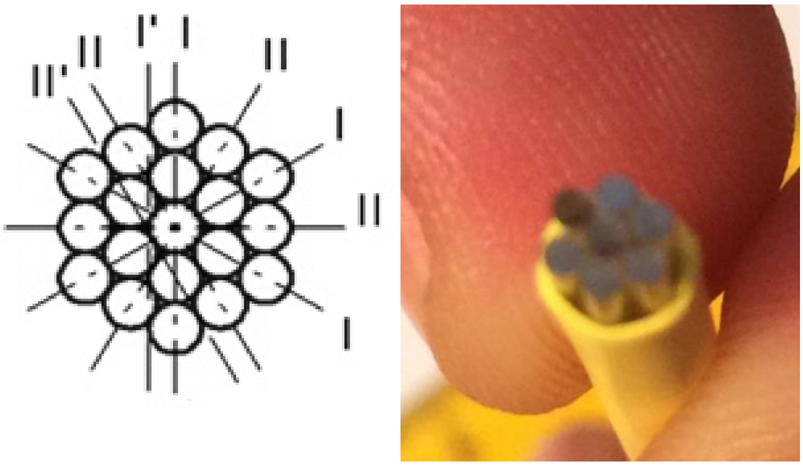

Figure 1(a, b). (a) Hexagonal type packaging of optical fibers **(b)** Imaging of the infrared bundle receiving end.

The experimental setup for investigation of the thermal image transfer possibility through infrared bundle was constructed. The infrared bundle *(3)* in a protective fluoropolymer shell was fixed in a holder and placed vertically. The thermal imager *(1)* NEC 7102WV was placed above the top end of the bundle. Along the perimeter of the bundle upper end to eliminate the influence of ambient light, there was a protective screen *(2)*. Under the lower end of the infrared bundle at a fixed distance x = 1 mm was Peltier's element *(4)*, which worked as a heat source. The change in the value of the voltage supplied to the element by means of a DC *(5)* source allowed to change the surface temperature. Preliminary thermal imaging survey (without details 2 and 3) showed that the temperature distribution on the upper surface of the Peltier's element at different degrees of heating was uniform (surface temperature variation of less than 0.5 K).

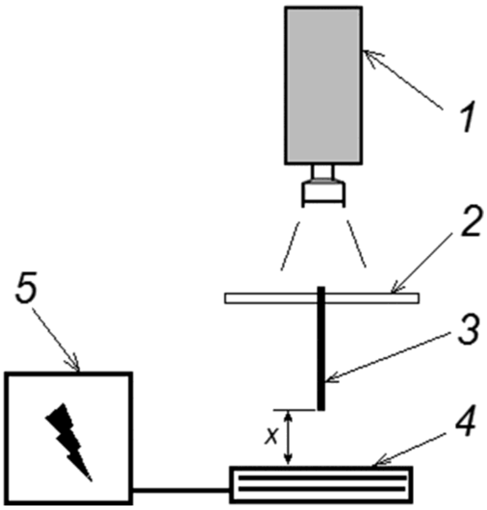

Figure 2. Scheme of the experimental setup.

The procedure of the experiment was the following. As soon as the temperature of the upper surface of the Peltier's element (hereinafter the sample temperature) reached a constant value, it was placed under the lower end of the infrared bundle. At the same time, the thermal imager lens was focused on the upper end of the bundle. Experiments showed that immediately after the appearance of the heated surface under the lower end of the infrared bundle, the thermal imager recorded an instantaneous change in the thermal image on the upper end.
As the observation object we used a copper wire with diameter three times smaller than the diameter of the single fiber (approximately 300 μm) which was wound on surface of the Peltier's element horizontally and vertically. The Peltier's element was the source of thermal radiation. The heating of the cooper wire was made at the expense of heat conductivity that is due to the thermal contact resistance did not allow the object to reach the temperature of the source during the observation time. The temperature of the thermal radiation source was equal to 80 °C in all experiments. That was done to maintain equable and constant heating for a long time, which was a primary condition for the experiment. The obtained thermal imaging (Figure 3) clearly show the temperature difference of the object and source. This indicates a good degree of visualization.

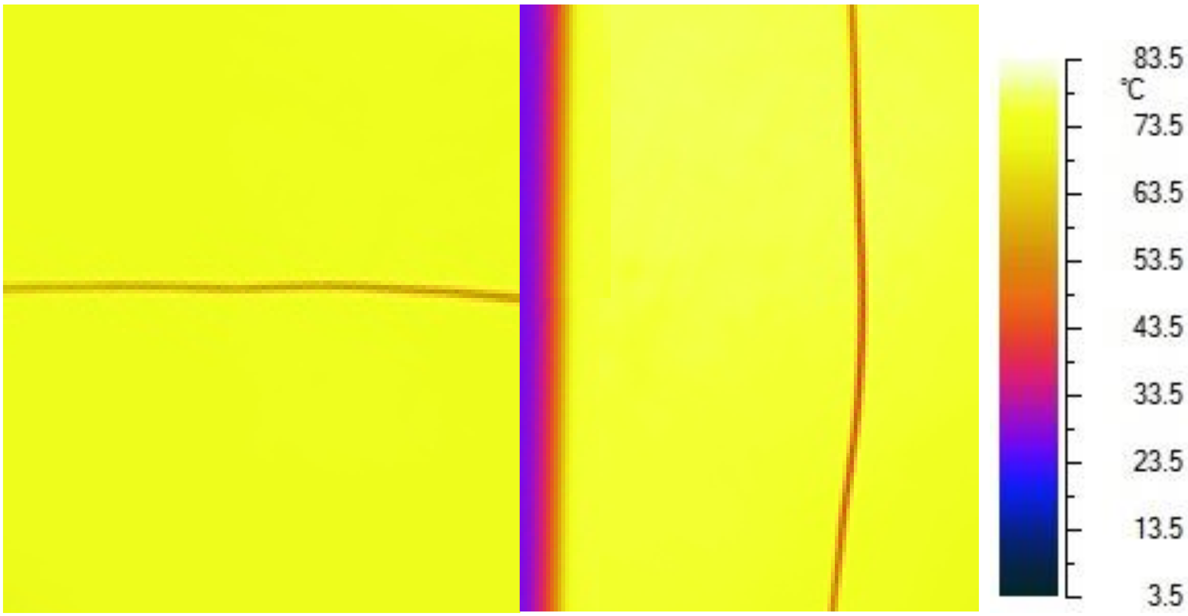

Figure 3. Thermal imaging of the cooper wire.

The infrared bundle was placed perpendicularly relative to the surface of the thermal radiation source and it moved left-right and up-down with the vertical and horizontal location of the wire respectively. Testo-882 thermal imager in real time recorded the temperature changes of the single fibers. The temperature of the cooper wire was significantly different from the Peltier's element temperature, which allowed to easily capture its temperature field through the infrared bundle. The thermal images of the infrared bundle receiving end with the vertical location of the object are shown in figure 4a, with the horizontal location - in figure 4b.

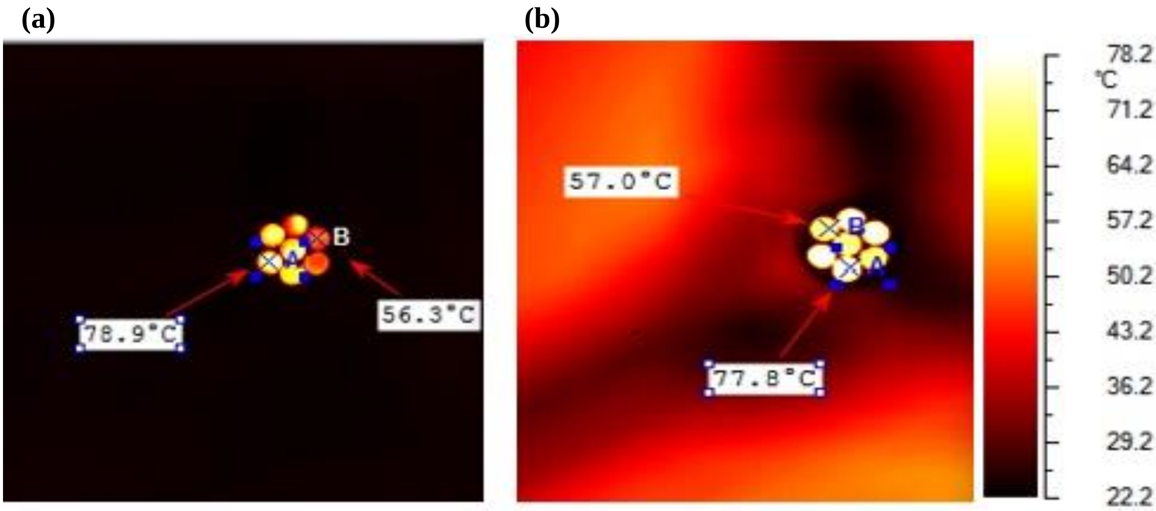

Figure 4(a, b). (a) Thermal imaging of the infrared bundle end with vertical location of the object **(b)** Thermal imaging of the infrared bundle end with horizontal location of the object.

3. Conclusion

Thus, the obtained data show that there is a fundamental possibility of thermal image transmission through the infrared bundle consisting from single fibres based on silver halide solid solutions. The results of the experiments reveal that such a small bundle is not capable of transmitting clear thermal picture of the object, and can only record the temperature likewise a single fiber. A solution to this problem is to increase resolution of infrared bundle due to increase in the number of single fibres in the structure, as well as reducing their diameter. Therefore, the manufacture of fiber bundle, and further investigation of thermal images transmission requires additional scientific and engineering research.

Acknowledgments

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