Energy efficient methods of protecting buildings from cold air flows

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Abstract. In this work, we study new innovative methods for creating an additive temperature environment, study the influence of a new type of infrared devices such as air and air-thermal curtains on the living conditions and infiltration parameters of buildings and structures from penetrating cold air flows. For calculating these structures, the engineering and technical methods of V.M. Elterman was used, based on the methods of calculating heated air curtains of Soviet scientists V.V. Baturin, I.A. Shepelev, S.E. Butakov. Additionally, the method of calculating air curtains by M.E. Diskin was used. We studied the distribution of temperature fields in the gate area of the building, in which road transport is being repaired. The experiments showed that the best indoor microclimate is achieved by using dual-flow systems consisting of a heated air curtain and an air curtain. The study of thermoelectric systems showed that it is possible to recuperate about 500 watts of electrical energy in this case. Studies have shown that there are modern, innovative developments, use of which improves the microclimate in the rooms without spending additional energy resources.

1. Introduction
Creating comfortable conditions in rooms where, depending on the specifics of operation, the infiltration of cold air flows occurs is a complex engineering task. Usually, this problem is solved by installing heated air curtains, the energy costs of which, in some cases, are similar to the costs of heating the entire room. Energy efficiency of the entire building as well as the microclimate of the room depends on the right choice of measures to ensure the protection of open doorways from the infiltration of cold air streams [1-4].
Usage of heated air curtains creates a separation of two air environments with different temperatures. Experimental data show that the temperature gradient directly at the output grille can reach a 160°C. This allows to create thermoelectric systems to recuperate some amount of electricity, and thereby offset some energy costs used to operate the air-heat curtain [5]. Data on the temperature gradient were obtained in the study of heated air curtains used to heat trams and trolleybuses in the city of Irkutsk [6].

2. Materials and methods
Heated air curtains (HAC) are intended for the separation of air zones with different temperatures, while the operational efficiency is primarily assessed by the absence of influence of the zones on each other [7].
The foundations of the calculation methods of HAC were developed by Soviet scientists V.V. Baturin, I.A. Shepelev, S.E. Butakov, who formed the basis of the engineering technique of V.M. Elterman [8]. He considered the work of HAC as an additional resistance, reducing the amount of air passing through the opening, using the momentum theorem of P.N. Kamenev [9]. Subsequently, theoretical calculations were confirmed by experiments, but in underestimated rates [10].

An alternative method of calculating HAC was proposed by M.E. Diskin [11], arguing that if the curtain is rationally executed, only the air stream of the curtain passes through the opening. Even if part of the jet passes outside the opening, the temperature of the air passing through this opening will not be lower than the average temperature in that section of the jet that first contacts the opening enclosure [12].

Of particular interest, in our opinion, are the designs of dual-flow HAC, which have two separated air flows [13]. The first high-speed air flow without heating, carries out the primary barrier function. The second air stream is carried out by a heated air stream. In this case, two flows move parallel to each other, creating ideal conditions for the use of thermoelectric generators [14]. This design was made for a truck repair company. At the confluence of the two air streams, thermoelectric modules were installed, made according to the patent for the invention No. 2611562 [15]. Experiments was carried out using OWEN TPM138 device with a set of thermocouples for temperature and OWEN "ИМС-Ф1.Щ1" for voltage, current and power measurement.

3. Results

In the first experiment, at an external temperature of -12°C, the floor temperature was measured at a distance of 5 meters from the gate, with the air and heated air curtains turned off. It can be seen from the graph shown in Figure 1 that when the gate is opened, the temperature at the entrance decreases to negative values. The microclimate in the room is not satisfactory, which makes work impossible. It is necessary to heat the room to positive temperatures.

The second experiment was carried out with the heated air curtain turned on, the outlet air temperature was 60°C, and the air flow velocity was 8 m/s. The graph in Figure 2 shows that the favorable temperature at which the microclimate parameters pass into a satisfactory condition is already at a distance of 3-4 meters from the gate. Despite the fact that the total temperature in the room dropped by 3°C, it is possible to carry out repair work on vehicles without preliminary measures.

![Figure 1. Temperature distribution at the gate with air curtains turned off.](image)

In the third experiment, an air curtain with air intake from the upper part of the building was additionally included; the total height of the building is 7 meters. The velocity of the unheated airflow at the exit of the curtain was 10 m/s.
Figure 2. Temperature distribution at the gate with a working heated air curtain.

The graph shown in Figure 3 shows that there are no negative temperatures in the gate area and temperature in the main room have not changed. The value of the generated voltage from one module was 18 V at a load of 1 ohm, which corresponds to the generated power of 18 watts. Air curtain is powered by 180W engine. In this design, it is possible to install up to 25 thermoelectric modules, which are made in the form of additional screens. In conventional designs in heated air curtains these screens serve to distribute air flow to improve efficiency. The installation of thermoelectric generators does not impair the operation of the system of protecting openings from the infiltration of cold flows, but it can generate electrical energy up to 500 W at an external temperature of -12ºC, which blocks the need for electricity for the operation of the air curtain.

Figure 3. Temperature distribution at the gate with a working air and heated air curtains.

4. Conclusion
Studies have shown that the use of new innovative solutions in the design of systems for protecting openings from infiltrating cold flows helps to reliably protect rooms from temperature extremes, provide
favorable climatic conditions throughout the room, and reduce the recovery time of microclimate parameters when changing external meteorological conditions. Research in the field of creating thermoelectric systems showed that using the latest developments in this area, it becomes possible to implement energy-saving measures without attracting additional energy resources.

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