Optimization of Work of Ventilation System in the Building with “Warm Attic”

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Abstract. The article is devoted to the optimization of the ventilation system of a residential house with a warm attic. A new technical solution was proposed for the installation of an industrial fan in the space of a warm attic. The operation of such a system is provided by the phenomenon of ejection. The article presents the proposed method for calculating the ejection stream of an industrial fan. The advantages of this ventilation system were listed on the basis of the analysis. There is a table comparing the centrifugal exhaust fan with individual exhaust fans in the conclusion of the article.

1. Introduction
The paper analyzes the functioning of the ventilation system in a building with a "warm attic", reveals the shortcomings of its operation, propose and calculate new technical solutions for optimizing its operation, resource and energy saving.

The ventilation of residential buildings is provided in a natural way, without the use of machines, due to the gravitational pressure due to the difference in the temperatures of the external and internal air, and also under the influence of wind.

The inflow of outside air occurs through special valves installed in walls or window frames, and removal is carried out through the air intake devices installed in the rooms and further into the duct system, into the warm attic and the exhaust shaft (figure 1) [1].

At present, the use of a warm attic is widespread in construction. Also, since the introduction of this structural element in 1980, millions of square meters of housing have been built throughout the Russian Federation.

2. Relevance and main task
Warm attic as an energy-saving component is effective. It allows to exclude heat loss through the overlap of the last floor. But during the operation of buildings with a warm attic problems are identified, the solution of which is an important task.

Normative and recommendatory documents with the receipt and generalization of experience in designing and operating a warm attic have been amended and supplemented. This shows the urgency of solving problems with this constructive element.

The main task of the research task is to find technical solutions that will help solve the standard problems of buildings with a warm attic and optimize the operation of the ventilation system of these buildings.
3. Technical solutions
There are many ways to optimize the operation of building ventilation systems with a warm attic. The following technical solutions were adopted in this work:

- The applied exhaust channels of GOST 17079-88 have a large cross-sectional area. Aerodynamic calculation shows the possibility of reducing the cross-sections of the channel as a consequence of the higher available pressure compared to the pressure losses in the ventilation system.

- Air removed from the premises of the last floors of buildings using household fans will be removed by an industrial fan that also removes air from these rooms, but delivers it to the exhaust shaft. The jet ejects the air, which is removed by natural ventilation from the total volume of the attic and leaves the exhaust shaft (figure 2). This system allows a large amount of air to be ejected with a small flow rate, which can be controlled by changing the diameter of the nozzle creating the jet. Calculating the ejection jet is a difficult task. There are basic provisions for calculating this jet further in the article.
4. The procedure for calculating the jet

There are the following items for calculating the ejection jet:

a) For the proper operation of such a system, it is necessary to determine the critical sections of the jet \( X_1, X_2 \) according to formula [2]:

\[
X = \bar{X} \cdot m \cdot \sqrt{F_n},
\]

(1)

\( \bar{X} \), the relative distance from the air distributor to the considered section of the jet;
\( F_n \), the cross-sectional area of the shaft, m\(^2\).

The distance from the nozzle to the cutoff of the exhaust shaft must be at least the section \( X_1 \) and no more \( X_2 \).

b) Speed factor \( m \) for a compact jet is determined by the formula [2]:

\[
m = \frac{0.67}{\tan \alpha_{0.5V}}.
\]

(2)

\( \tan \alpha_{0.5V} \), the angle between the axis of the jet and the line joining the centre of the initial section of the jet to the point at which \( V=0.5V_x \).

c) Let us determine the air flow rate \( L_x \) in the sections of the jet \( X_1, X_2 \) according to formula [2]:

\[
L_x = \frac{2 \cdot x}{m \sqrt{F_0}}.
\]

(3)

\( F_0 \), the cross-sectional area of the air distributor, m\(^2\).

d) Ejected air flow \( L_{\text{Ejection}} \) determined by the formula:

\[
L_{\text{Ejection}} = L_x - L_0.
\]

(4)

5. Advantages of the adopted technical solution

In the scale of mass building optimization of the sections, of the channel, of the exhaust shaft and the use of an ejecting jet allows:

- to increase the usable area of the premises;
- to reduce the amount of materials for construction (concrete and reinforcement);
- to reduce transportation costs for the delivery of reinforced concrete products;
- to reduce the labor costs for the manufacture and installation of this design;
- to work natural ventilation without disturbance during blowing exhausts shaft;
- not to fall the precipitation into the "warm attic" through the exhausts shaft, which reduces the amount of moisture in it;
- to save energy at the work of ventilation equipment;
- not to create, because of the fan installed in the attic, resistance to the operation of natural ventilation (in contrast to household);
- to work natural ventilation during the warm period of the year;
- to increase available pressure due to air ejection;
- "Overturning traction" due to wind pressure does not occur.

| Table 1. Comparative table of energy consumption of ventilation equipment. |
|------------------|------------------|------------------|------------------|------------------|------------------|
| Fan Type        | Apartments        | Qty. for 1 apartment pcs. | Total | Flow rate (m\(^3\)/h) | Power 1 unit (W) | Total power (W)  |
| Household       | 4 fl. x 4 ap.    | 3                 | 48    | 2560             | 8.8              | 422              |
| Centrifugal     | 4 fl. x 4 ap.    | -                 | 1     | 2560             | 120              | 120              |

*a* Household and centrifugal fans with minimal energy consumption.
The technology with ejector jets can be used not only in new construction, but also in the reconstruction of constructed buildings, with a minimum capital cost that pays off with energy savings in the operation of ventilation equipment (Consumption is less than a minimum of 3.5 times, table 1).

6. Conclusion
A detailed analysis of the proposed method for optimizing the operation of the ventilation system of a residential building showed that the one is practically meaningful. The installation of an industrial centrifugal fan in the space of a warm attic allows solving many problems of the natural system of ventilation, as well as significantly reducing the consumed electric power.

In addition, this technical solution will allow you to select the optimal section of the ventilation unit. This will give a significant economic effect due to the increase in the useful area of the apartment and reducing the cost of ventilation units.

The resulted algorithm of calculation of an ejection stream will allow to make exact selection of the ventilating equipment for the accepted technical decision.

Reference
[1] Ministry of Regional Development of Russia 2012 TR AVOK-5.2-2012 Technical recommendations on the organization of air exchange in apartments of residential buildings (Moscow: AVOK) p 26 [In Russ]
[2] Shumilov R N 2000 Theoretical foundations of ventilation Aerodynamics: Tutorial 2nd ed Revised and add (Ekaterinburg: USTU) p 92 [In Russ]
[3] GOST 17079-88 Reinforced concrete ventilation blocks Technical conditions (Moscow: Standardinform) p 8 [In Russ]
[4] Ministry of Regional Development of Russia 2012 SP 60.13330.2012 Heating, ventilation and air conditioning (Moscow: FCS) p 76 [In Russ]
[5] Recommendations for the design of reinforced concrete roofs with a warm attic for residential buildings of different heights. Approved prot. OJSC "TsNIIIEP Housing" dated October 25 1979 No 34 (Moscow: TsNIIIEP) p 13 [In Russ]
[6] GOST 17079-88 Residential and public buildings Indoor microclimate parameters (Moscow: Gosstroy of Russia, GUP TsPP) p 14 [In Russ]
[7] Ministry of Regional Development of Russia 2001 SANPiN 2.1.2.1002-00 Sanitary and epidemiological requirements for residential buildings and premises (Moscow: Gosstroy of Russia) p 15 [In Russ]
[8] Grimitlin M I 2004 Indoor air distribution (SPb.: ABOK North-West) p 37 [In Russ]