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SAVING OF HEATING IN A HOUSE BY MEANS OF OPTIMUM GEOMETRICAL PARAMETERS AND MATERIALS. ENERGY SAVING HOUSE PROJECT

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Abstract. The work contains the results of research of heating problems in houses and loss of warmth through various constructions and materials. We conducted experiments with cubic, spherical, arch constructions and various heat-insulating materials. In total, we made nine models, with amount of heat calculated for them. We presented the results of temperature decrease and increase on time, carried out with the help of thermal camera Testo 881-2 with spectral range 8-14 mcn.

1 Introduction

Climate in all territory of the Sakha Republic (Yakutia) is sharply continental. Temperature drop reaches 100^0C, from -60^0C to $+40^0$C on average, a cold period of winter lasts for nearly 4 months. Therefore, the problems of preservation and saving of heat in a house are vital and are very acute. The article aim is research and design of the energy saving house of various geometrical forms and materials. In other words, creation of optimum warm conditions in house for life under such severe conditions. The hypothesis is the thought that the optimum geometrical size and forms of the house reduce heat loss from internal part of the house. Practical importance is minimization of heat loss of thermal resources, such as gas, oil, coal and electricity. The idea and the basic points of the research work are stated in the 1, 4, 5, 7 articles.

2 Experimental installation and methods of research

We carried out a lot of experiments to check the hypothesis: models of hemispheres from polystyrene, basalt and wood were prepared. Volume of a hemispherical house calculated by the formula:

$$\mathrm{U} = \frac{\pi\, \mathrm{d}^3}{12} = 0{,}2423\ \mathrm{m}^3\ ; \quad \mathrm{d} = 0{,}21\ \mathrm{m}; \quad \mathrm{S} = 2\pi \mathrm{r}^2 = 0.0692\mathrm{m}^2. \qquad (1)$$

Parameters of arch model calculated by formula:

$$\mathrm{U} = \frac{\pi \mathrm{r}^2 \mathrm{l}}{2} = 0{,}2423\mathrm{m}^3; \quad \mathrm{r} = 0{,}105\ \mathrm{m}; \ \mathrm{l} = 0{,}14\mathrm{m}; \quad \mathrm{S} = \pi \mathrm{rl} = 0.0791\mathrm{m}^2. \qquad (2)$$

The size of cubic models from polystyrene, basalt and wood:

$$\mathrm{U} = \mathrm{a}^3 = 0{,}2423 m^3; \quad a = \sqrt[3]{U} = 0{,}13\ m. \qquad (3)$$

Where:
U – volume of model,
D – diameter of model,
R – radius of model,
L – length of model

We carried out experiments of temperature loss measurement in regular intervals of time. The experiments showed an interesting fact, that heat loss really depends on the house external form. We analyze heat loss by the measured temperature through the wall of three models of house: cubic, arch (half of cylinder) and hemispherical.

In order to convince that loss of heat really depends on form and material, we carried out an extra experiment of temperature fluctuation, not only of decrease, but also increase by means of the filament lamp. We used thermal camera Testo 881-2 with spectral range 8-14 mcn for this purpose.

Thermal camera Testo 881-2 displays potentially problematic parts, such as thermal bridges and constructional defects of a building. The thermal camera also visualizes defects of insulating material or bad isolation. Thanks to its ability to distinguish

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even a small difference of temperature through heat sensitivity <110 мК, testo 881-2 visualizes defects of isolation of the building and, as a result, spots of heat loss. So, it is possible to make purposeful diagnosis of construction quality and take necessary measures for elimination of building defects.

Figure 1. Testo 881-2.

3 Results of experiment

A comparative analysis, based on the first experiment results, is on the figure 2.

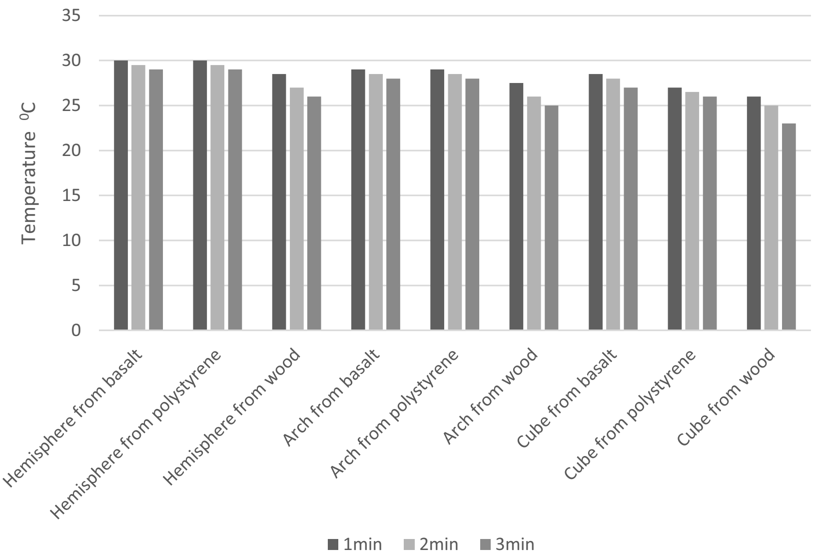


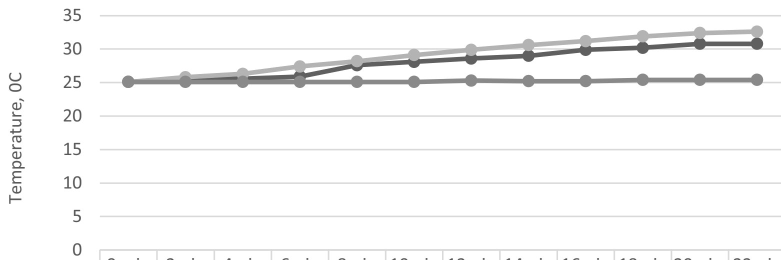
Figure 2. Total figure of various models' heat loss on time.

We calculated heat loss using these data by Fourier's formula, which is on table 1.

Table 1. Calculation of heat loss for various models.

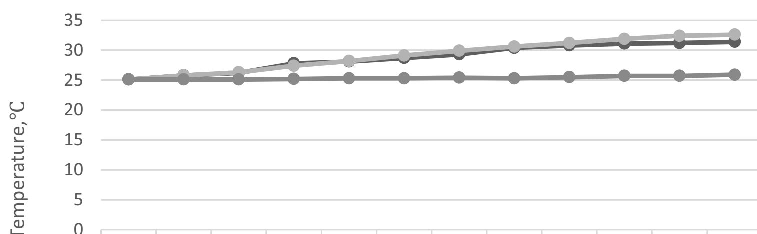
№	Model	Temperature inside the model, ^0C	Temperature of the environment, ^0C	Heat loss, Q, J
1	Hemisphere of basalt	30	- 46	-214,575
2	Arch of basalt	29,5		-243,659
3	Cube from basalt	29,25		-259,432
4	Hemisphere of polystyrene	29,25		-220,886
5	Arch of polystyrene	28,75		-250,826
6	Cube of polystyrene	28		-264,401
7	Hemisphere of wood	30		-2249,554
8	Arch of wood	29,5		-2554,297
9	Cube of wood	28,5		-2701,296

Extra experiment of temperature fluctuation showed that the greatest temperature increase is recorded in hemisphere of basalt.



	0 min	2min	4min	6min	8min	10min	12min	14min	16min	18min	20min	22min
Arch from polystyrene	25,1	25,6	25,6	25,9	27,6	28,1	28,6	29	29,9	30,2	30,8	30,8
Hemisphere from basalt	25,1	25,8	26,3	27,4	28,2	29,1	29,9	30,6	31,2	31,9	32,4	32,6
Cube from wood	25,1	25,1	25,1	25,1	25,1	25,1	25,3	25,2	25,2	25,4	25,4	25,4

Figure 3. Increase of temperature at models of houses of various constructions.



	0min	2min	4min	6min	8min	10min	12min	14min	16min	18min	20min	22min
Hemisphere from polystyrene	25,1	25,8	26,2	27,8	28,1	28,7	29,3	30,4	30,8	31,1	31,2	31,4
Hemisphere from basalt	25,1	25,8	26,3	27,4	28,2	29,1	29,9	30,6	31,2	31,9	32,4	32,6
Hemisphere from wood	25,1	25,1	25,1	25,2	25,3	25,3	25,4	25,3	25,5	25,7	25,7	25,9

Figure 4. Increase of temperature in hemispherical model of house.

Results of experiments showed that the minimum heat loss is observed at hemispherical model, and maximum heat loss – at cubic model, given the equal real volume of models. The second important point of work is the choice of heat-insulating material. We measured temperature increase and decrease with the time, for the models of wood (arch, hemisphere, cube), from polystyrene (arch, hemisphere, cube), from basalt (arch, hemisphere, cube). Based on the achieved results, we designed the model with hemispherical form (we used polysterene concrete as a carrier). We made comparative analysis of prime cost of spherical and cubic model, warmed by "SakhaBazalt", which showed that hemispherical house of polysterene concrete, warmed by "SakhaBazalt", would cost 224 351 rubles fewer than the cubic house of wood, warmed by "SakhaBazalt", given equal volume.

4 Conclusion

Heat loss in form of thermal stream can be minimized by reduction of radiation surface area (for example, model of hemispherical house). Nowadays, given the increased price of energy resources, the problem of heat insulation is especially sharp. It is necessary to reduce heat loss because of the walls' thermal conductivity, using modern heat-insulating materials and building houses with optimum geometrical parameters. It is also possible to apply additional technologies on automation and energy saving such as:

- Use lighting with motion sensors and illumination;
- Use automated systems of heating;
- Use solar collectors, thermal pumps;
- Use heating floor;
- Use automated valve for ventilation.

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