DEFINISANJE TERMIČKOG PROCESA U ZIDU ESKIMSKOG IGLOA, UZ POMOĆ TEORIJSKIH I NUMERIČKIH METODA

DEFINING THE THERMAL PROCESS IN THE WALL OF THE ESKIMO IGLOO, WITH THE HELP OF THEORETICAL AND NUMERICAL METHODS

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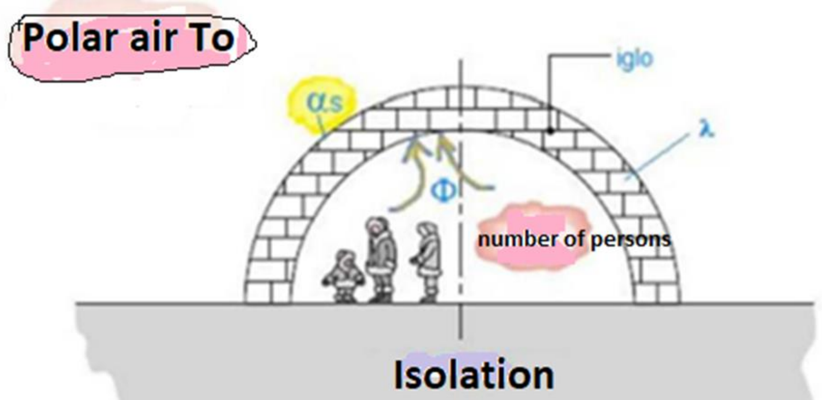
Abstract: In nature and everyday practice, there are quite frequent examples of heat propagation. For the last half century, the phenomena of heat and matter transfer have taken a fundamental role in thermal energy, thermotechnics and process technology, so the development of apparatus and devices in these areas of human activity cannot be imagined without knowing the essence of this process. Heat propagation in space is a very complex process which in generally contains three different ways (mechanisms) of propagation: convection, conduction and radiation. Heat and matter processes play an important role in many industrial processes. Therefore, there is a need to manage these processes and a desire to quantitatively predict the outcome of these processes (theoretical and experimental). Methods of classical mathematics that are used in solving the system of differential equations which manage the processes of heat and matter propagation manage to solve a very small number of simplified practical problems. However, the development of numerical methods allows a mathematical model to be solved for any practical problem, numerically. This paper theoretically and numerically investigates the thermal process in the Eskimo igloo wall, which is made of compact snow blocks with a heat transfer coefficient of 0.25W / (mK) in the form of a hemisphere with an inner radius of 2m and a wall thickness of 1m. In addition, the temperature has been determined for every 10 cm of wall thickness, as well as on boundary surfaces. The obtained results are presented in tables and diagrams.

Key words: Thermal process, temperature, wall thickness, igloo, heat distribution



Picture 1: Appearance of the igloo and mechanisms of heat propagation

Specifically, the igloo considered here is hemispherical in shape with an inner radius of 2m and a wall thickness of 1m. It is made of compact blocks of snow with a heat conduction coefficient of 0.25 W/(mK). It is assumed that the coefficient of heat transfer from the outer surface of the igloo to the polar air at a temperature of -40°C is 20 W/(m^2 K). The floor of the igloo is adiabatically insulated. It is accepted that the heat release according to one Eskimo is qv=115 W/mK.

The heat flux in the igloo takes place from the people to the walls, through the walls and then to the outside air. First, the people present radiate heat to the wall, and a part of the heat is transferred to the indoor air by convection, then air transfers that heat to the inside of the wall. After that, the heat is conducted through the wall by conduction, and after that it is transferred to the surrounding air by convection.

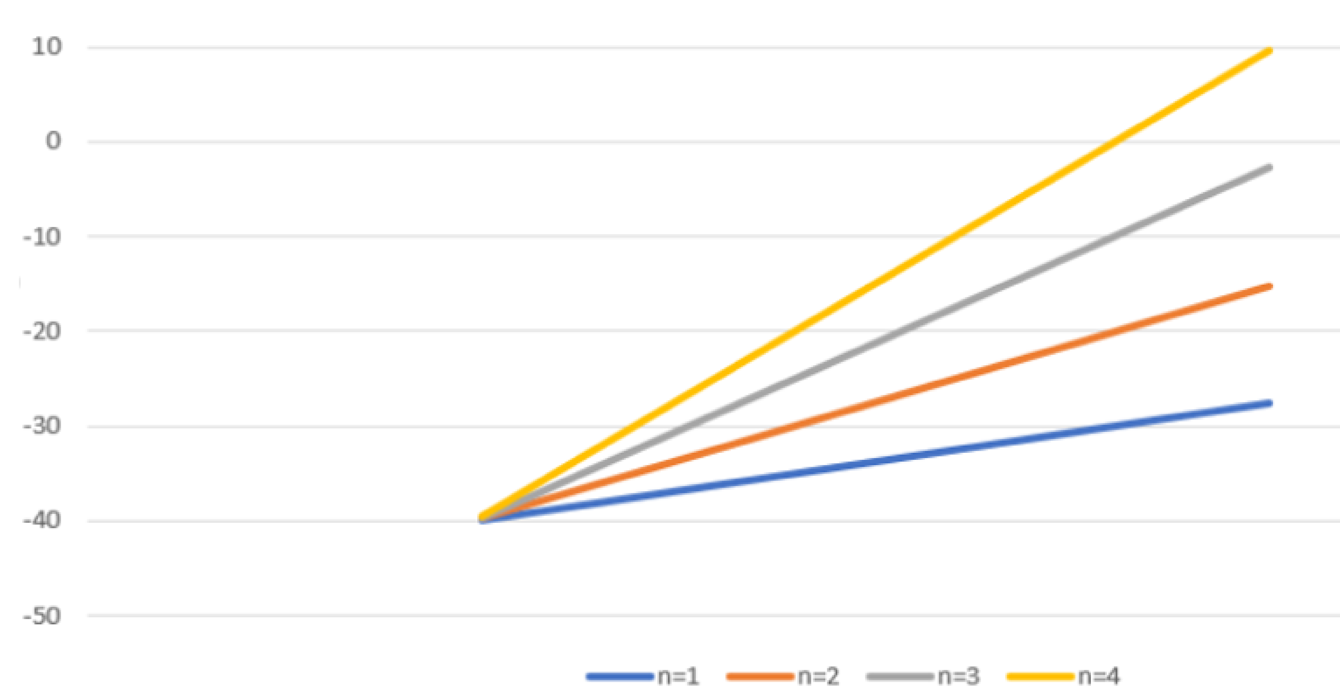
The temperature in the igloo depends on the number of people in it, so at a critical number of people the ice will melt on the inside of the wall. Ice blocks are considered to be isotropic and homogeneous, the volume expansion of the body due to temperature change is negligible. [1]

In this paper, the thermal process in the wall of the Eskimo igloo, which is made of compact blocks of snow with a heat conduction coefficient of 0.25W/(mK) in the form of a hemisphere with an inner radius of 2m and a wall thickness of 1m, was theoretically and numerically investigated. The temperatures at the interface were also determined. for every 10 cm of wall thickness and on border surfaces. The obtained results are presented in tabular and diagram form.

Results by mathematical model

Table 1 Distribution of temperatures by wall thickness

n- number of people	T_{P2}- temperature of the outer surface of the wall [°C]	T_{P1}- temperature of the inner surface of the wall [°C]
1	-39, 89 [°C]	-27,57[°C]
2	-39,79[°C]	-15,17[°C]
3	-39,69[°C]	-2,76[°C]
4	-39,59[°C]	9,64[°C]



Picture 2: Distribution of temperatures by wall thickness

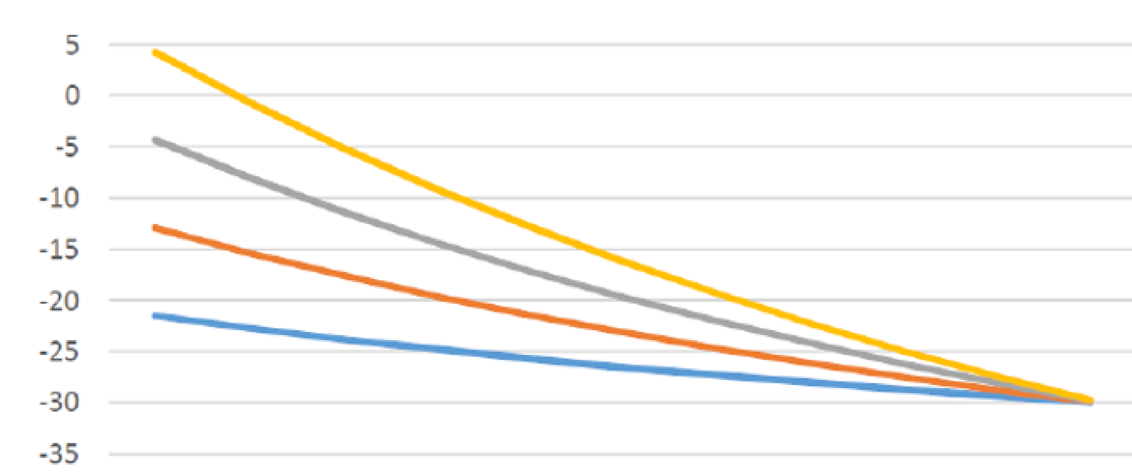
Numerical solution of the given problem

To solve this problem numerically, the method of control volumes and control differences was used. [1]

Those two methods gave the following results, which are presented in tabular and diagram form.

Table 2: Distribution of temperatures by wall thickness obtained by numerical methods

Radius Wall	Temperature for n=1	Wall temperature for n=2	Wall temperature for n=3	Wall temperature for n=4
2	-21,41 [°C]	-12,8 [°C]	-4,2[°C]	4[°C]
2,1	-22,70[°C]	-15,88[°C]	-7,79[°C]	-0,78[°C]
2,2	-23,43[°C]	-17,132[°C]	-11,30[°C]	-5,73[°C]
2,3	-24,91[°C]	-19,83[°C]	-14,74[°C]	-9,27[°C]
2,4	-25,2[°C]	-21,62[°C]	-17,05[°C]	-12,942[°C]
2,5	-26,81[°C]	-23,60[°C]	-19,59[°C]	-16,79[°C]
2,6	-27,61[°C]	-24,18[°C]	-21,06[°C]	-19,42[°C]
2,7	-28,42[°C]	-26,88[°C]	-24,68[°C]	-22,24[°C]
2,8	-29,93[°C]	-27,91[°C]	-26,13[°C]	-24,17[°C]
2,9	-30,70[°C]	-28,43[°C]	-28,84[°C]	-27,13[°C]
3	-31,41[°C]	-29,88[°C]	-29,88[°C]	-29,24[°C]



Picture 3: Temperature distribution for the numerical solution

Conclusion

The described thermal problem of determining the temperature distribution of the temperature in the igloo was first solved by an analytical method, where the temperatures on the inner wall and the critical number of people from the point of view of melting the ice on the inner wall were determined. The critical number of people is 4, which means that a maximum of three people can stay in the igloo without melting it.

The used numerical methods are the finite volume method and the finite difference method. The wall was divided into 10 different volumes (depending on the radius). Four cases were solved depending on the number of people. The sys-tem was predetermined, so it was solved in one pass. For both methods, the values obtained by calculation were tabulated, and corresponding diagrams were drawn.The numerical solution gives more accurate results considering that it also in-cludes errors, which can be seen in the diagram.

Literature

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