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## A MATHEMATICAL MODEL FOR CONVECTIVE AND NONLINEAR HEAT TRANSFER IN MULTI-VARIABLE, MULTI-COMPONENT MEDIA

***Annotation.*** *The focus is on the mathematical modeling of convective and nonlinear heat transfer in multicomponent media, and the analysis of heat dissipation in a complex process is of great importance in various scientific, engineering and technical fields. The reason is that it helps to better control heat transfer, thermodynamic systems and technological processes. Computational methods and algorithms have been developed for the study. Modeling develops a description of physical processes in the form of mathematical models. The high-precision calculation results obtained as a result of the research are of significant scientific importance in the construction and energy sectors. The program code is written in the Python programming language and the process is modeled.*

***Keywords:*** *Heat dissipation, temperature and heat, initial condition, two components, differential equation, boundary condition, iterative method.*

## KO'P O'ZGARUVCHAN, KO'P KOMPONENTLI MUHITDA KONVEKTIV VA CHIZIQLI BO'LMAGAN ISSIQLIK UZATISHNING MATEMATIK MODELI

***Annotatsiya.*** *Ko'p komponentli muhitda konvektiv va chiziqli bo'lmagan issiqlik uzatishning matematik modeliga qaratilgan bo"lib, murakkab jarayonda issiqlik tarqalishini tahlil qilish turli xil ilmiy, muhandislik va texnik sohalarda muhim ahamiyatga ega. sababi issiqlik almashinuvi, termodinamik tizimlar va texnologik jarayonlarni yaxshiroq nazorat qilishga yordam beradi. Tadqiqot uchun hisoblash usullari va algoritmlari ishlab chiqilgan. Modellashtirish fizik jarayonlar tavsifini matematik modellar shaklida ishlab chiqadi. Tadqiqotlar natijasida olingan yuqori aniqlikdagi hisoblash natijalari qurilish va energetic-ka sohalarida muhim ilmiy ahamiyatga ega. Dastur kodi Python dasturlash tilida tuzilgan va jarayon modellashtirilgan.*

***Kalit so'zlar:*** *issiqlik tarqalishi, harorat va issiqlik, dastlabki holat, ikki komponentli, differensial tenglama, chegaraviy shart, iterativ usul.*

## МАТЕМАТИЧЕСКАЯ МОДЕЛЬ КОНВЕКТИВНОГО И НЕЛИНЕЙНОГО ТЕПЛООБМЕНА В МНОГОПАРАМЕТРИЧЕСКИХ, МНОГОКОМПОНЕНТНЫХ СРЕДАХ

***Аннотация.*** *Основное внимание уделено математическому моделированию конвективного и нелинейного теплообмена в многокомпонентных средах, а анализ теплоотдачи в сложном процессе имеет большое значение в различных научных, инженерных и технических областях. Причина в том, что это помогает лучше управлять теплопередачей, термодинамическими системами и технологическими процессами. Для исследования разработаны вычислительные методы и алгоритмы. Моделирование развивает описание физических процессов в виде математических моделей. Полученные в результате исследования высокоточные результаты расчетов имеют важное научное значение в строительной и энергетической отраслях. Программный код написан на языке программирования Python, а процесс смоделирован.*

***Ключевые слова:*** *тепловыделение, температура и тепло, начальное условие, двухкомпонентное, дифференциальное уравнение, граничное условие, итерационный метод.*

**Introduction.** The topic of modeling heat propagation processes with different components in two-dimensional fields. is a scientific and technical research aimed at the in-depth analysis of heat transfer. This topic includes the mathematical description and study of how thermal energy is distributed through one or more components within various geometric areas. (1) We get a numerical solution from Eq. [1;8 p.]. It is very important in solving physical phenomenon and differential equation. The initial and boundary conditions are defined using the auto model, the next step is to determine the discretization scheme by obtaining an optimal solution. the last solution serves as a solution to the dynamic increase-decrease visualization of the system [4;9 p.].

**Main part:** the equation is commonly used to describe heat transfer, substance diffusion, or hydrodynamic processes.

$$\frac{\partial u}{\partial t}=\frac{\partial}{\partial x}\left(s_1(t,x,y,u)\frac{\partial}{\partial x}\right)+\frac{\partial}{\partial y}\left(s_2(t,x,y,u)\frac{\partial}{\partial y}\right)-v_1\frac{\partial u}{\partial x}-v_2\frac{\partial u}{\partial y} \quad (1)$$

$u=u(t,x,y)$ - heat temperature or substance concentration. $s_1(t,x,y,u)$ and $s_2(t,x,y,u)$ - diffusion coefficients. $v_1$ , $v_2$ - constants.

We find solutions of a special appearance using the auto model method. In this case, we normalize the parameters and find the functions of the automodel. [6-10]

Normalization of space and time dimension:

$$\xi=\frac{x}{L},\quad \eta=\frac{y}{L},\quad \tau=\frac{t}{T},\quad u=u_0\cdot U(\tau,\xi,\eta),$$

$L$ - distance measure, $T$ - measure of time, $u_0$ - initial characteristic value.

When we normalize:

$$\frac{\partial u}{\partial \tau}=\frac{\partial}{\partial \xi}\left(S_1(T,\xi,\eta,U)\frac{\partial U}{\partial \xi}\right)+\frac{\partial}{\partial \eta}\left(S_2(T,\xi,\eta,U)\frac{\partial U}{\partial \eta}\right)-V_1\frac{\partial U}{\partial \xi}-V_2\frac{\partial U}{\partial \eta}$$

In this $V_1=\frac{v_1}{L^2/T}$, $V_2=\frac{v_2}{L^2/T}$, $S_1=\frac{s_1T}{L}$, $S_2=\frac{s_2T}{L}$.

An automodel of a function: $U(\tau,\xi,\eta)=f(\zeta)$, $\zeta=\alpha\xi+\beta\eta-\gamma\tau$, $\alpha,\beta,\gamma$ - car model parameters. Calculation of derivatives from a function:

$$\frac{\partial U}{\partial \tau}=-\gamma f'(\zeta),$$

$$\frac{\partial U}{\partial \xi}=\alpha f'(\zeta),\quad \frac{\partial U}{\partial \eta}=\beta f'(\zeta),$$

$$\frac{\partial^2 U}{\partial \xi^2}=\alpha^2 f''(\zeta),\quad \frac{\partial^2 U}{\partial \eta^2}=\beta^2 f''(\zeta).$$

Let's substitute the normalized equation:

$$\frac{\partial U}{\partial \tau}=\frac{\partial}{\partial \xi}\left(S_1\frac{\partial U}{\partial \xi}\right)+\frac{\partial}{\partial \eta}\left(S_2\frac{\partial U}{\partial \eta}\right)-V_1\frac{\partial U}{\partial \xi}-V_2\frac{\partial U}{\partial \eta}$$

Let's place the automodel function:

$$-\gamma f'(\zeta)=\frac{\partial}{\partial \xi}(S_1\alpha f'(\zeta))+\frac{\partial}{\partial \eta}(S_2\alpha f'(\zeta))-V_1\alpha f'(\zeta)-V_2\beta f'(\zeta)$$

We calculate the derivative of diffusion from the simplified equation:

$$\frac{\partial}{\partial \xi}(S_1\alpha f'(\zeta))=\alpha^2 S_1 f''(\zeta)+\alpha\frac{\partial S_1}{\partial \xi}f'(\zeta),$$

$$\frac{\partial}{\partial \eta}(S_2\beta f'(\zeta))=\beta^2 S_2 f''(\zeta)+\beta\frac{\partial S_2}{\partial \eta}f'(\zeta).$$

When we generalize, we get the following equation:

$$-\gamma f'(\zeta)=(\alpha^2 S_1+\beta^2 S_2)f''(\zeta)+(\alpha\frac{\partial S_1}{\partial \xi}+\beta\frac{\partial S_2}{\partial \eta}-V_1\alpha-V_2\beta)f'(\zeta).$$

$f'(\zeta)$ and $f''(\zeta)$ we separate: $(\alpha^2 S_1+\beta^2 S_2)f''(\zeta)+(\alpha\frac{\partial S_1}{\partial \xi}+\beta\frac{\partial S_2}{\partial \eta}-V_1\alpha-V_2\beta+\gamma)f'(\zeta)=0.$

$f(\zeta)$- an ordinary differential equation is solved to determine. $S_1 = S_1(\tau,\xi,\eta,f(\zeta)),\quad S_2 = S_2(\tau,\xi,\eta,f(\zeta))$ - diffusion coefficient, $V_1$ and $V_2$ - constants depending on the external flow, $\alpha,\beta,\gamma$ - car model parameter.

The first-order derivative in the coefficients:

$$\alpha\frac{\partial S_1}{\partial\xi}+\beta\frac{\partial S_2}{\partial\xi}-V_1\alpha-V_2\beta+\gamma.$$

Simplifying the equation for $S_1 = S_2 = const$ let's say: $(\alpha^2 S_1+\beta^2 S_2)f''(\zeta)+(-V_1\alpha-V_2\beta+\gamma)f'(\zeta)=0.$ ordinary differential equation will have the following form: [7-10]

$Af''(\zeta)+Bf'(\zeta)=0.$ Here: $A=\alpha^2 S_1+\beta^2 S_2,\quad B=-V_1\alpha-V_2\alpha+\gamma.$

The equation is normal when we state: $f''(\zeta)+\frac{B}{A}f'(\zeta)=0.$ Here: $\mu=-\frac{B}{A},$

The following results from this: $f''(\zeta)-\mu f'(\zeta)=0.$

linear equation by first-order derivative: $f'(\zeta)=C_1 e^{\mu\zeta}$, $C_1$ - constant.

When we integrate a linear equation: $f(\zeta)=\frac{C_1}{\mu}e^{\mu\zeta}+C_2,$

The automodel function is generally found as follows:

$$U(\tau,\xi,\eta)=f(\zeta)=\frac{C_1}{\mu}e^{\mu(\alpha\xi+\beta\eta-\gamma\tau)}+C_2.$$

$\mu=-\frac{B}{A}$ - the rate of propagation of the car model in space and time.

$C_1, C_2$ - constants in initial and boundary conditions.

A prerequisite for a car model: $U(0,\xi,\eta)=\varphi(\xi,\eta),$

Initial value of the car model $\varphi(\xi,\eta)$ is equal to $\tau=0$ when. $\varphi(\xi,\eta)=\frac{C_1}{\mu}e^{\mu(\alpha\xi+\beta\eta)}+C_2.$

Boundary conditions $\xi\to\infty,\eta\to\infty$

When we simplify the automodel function:

$$U(0,\xi,\eta)=\varphi(\xi,\eta)=\frac{C_1}{\mu}e^{\mu(\alpha\xi+\beta\eta)}.$$

$C_1$ if we find $C_1=\mu\cdot\varphi(\xi,\eta)\cdot e^{-\mu(\alpha\xi+\beta\eta)}.$

auto model function: $U(\tau,\xi,\eta)=\varphi(\xi,\eta)\cdot e^{-\mu\gamma\tau}.$

We prepare the differential equation for the iterative method by discretizing it:

$$\frac{\partial u}{\partial t}=\frac{\partial}{\partial x}\left(s_1(t,x,y,u)\frac{\partial}{\partial x}\right)+\frac{\partial}{\partial y}\left(s_2(t,x,y,u)\frac{\partial}{\partial y}\right)-v_1\frac{\partial u}{\partial x}-v_2\frac{\partial u}{\partial y}$$

$x$ and $y$ divide into equally spaced parts: $x_i=i\Delta x,\quad y_i=i\Delta y,\quad i,j=0,1,2,.....$

An expression is generated: $u^n_{i,j}\approx u(t_n,x_i,y_j).$

1. We express the first-order derivative in terms of time: $\frac{\partial u}{\partial\tau}\approx\frac{u^{n+1}_{i,j}-u^n_{i,j}}{\Delta t}.$
2. First order derivative: $\frac{\partial u}{\partial x}\approx\frac{u^n_{i+1,j}-u^n_{i-1,j}}{2\Delta x},\quad \frac{\partial u}{\partial y}\approx\frac{u^n_{i,j+1}-u^n_{i,j-1}}{2\Delta y}.$
3. Second-order derivative: $\frac{\partial^2 u}{\partial x^2}\approx\frac{u^n_{i+1,j}-2u^n_{i,j}+u^n_{i-1,j}}{\Delta x^2},$
$\frac{\partial^2 u}{\partial y^2}\approx\frac{u^n_{i,j+1}-2u^n_{i,j}+u^n_{i,j-1}}{\Delta y^2}.$

We substitute discrete expressions for derivatives of differential equations:

$$\frac{u_{i,j}^{n+1}-u_{i,j}^{n}}{\Delta t}=\frac{1}{\Delta x^2}\left[s_{1,i+1/2}(u_{i+1,j}^{n}-u_{i,j}^{n})-s_{1,i-1/2}(u_{i,j}^{n}-u_{i-1,j}^{n})\right]+\frac{1}{\Delta y^2}\left[s_{2,j+1/2}(u_{i,j+1}^{n}-u_{i,j}^{n})-s_{2,j-1/2}(u_{i,j}^{n}-u_{i,j-1}^{n})\right]$$

$$-v_1\frac{u_{i+1,j}^{n}-u_{i-1,j}^{n}}{2\Delta x}-v_2\frac{u_{i,j+1}^{n}-u_{i,j-1}^{n}}{2\Delta y}.$$

We write the discrete equation in iterative form:

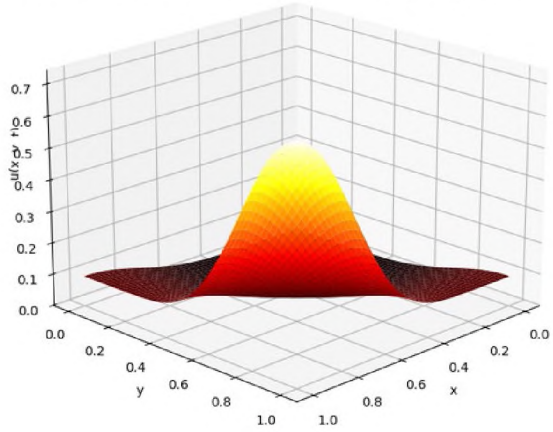
$$u_{i,j}^{n+1}=u_{i,j}^{n}+\Delta t\cdot\left[\begin{array}{l}\frac{1}{\Delta x^2}(s_{1,i+1/2}(u_{i+1,j}^{n}-u_{i,j}^{n})-s_{1,i-1/2}(u_{i,j}^{n}-u_{i-1,j}^{n}))+\frac{1}{\Delta y^2}(s_{2,j+1/2}(u_{i,j+1}^{n}-u_{i,j}^{n})-s_{2,j-1/2}(u_{i,j}^{n}-u_{i,j-1}^{n}))\\ -v_1\frac{u_{i+1,j}^{n}-u_{i-1,j}^{n}}{2\Delta x}-v_2\frac{u_{i,j+1}^{n}-u_{i,j-1}^{n}}{2\Delta y}\end{array}\right]$$

**In initial conditions:** $n=0$ at $u_{i,j}^{0}=\varphi(x_i,y_i)$,

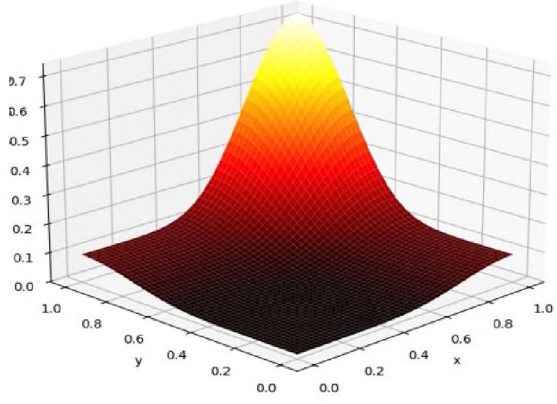
In boundary conditions:

1. Neumann condition: $\frac{\partial u}{\partial n}=0$.
2. Dirichlet condition: $u=const$.

**Analysis and results.** After solving the equation and creating a program in the python programming language, the following solution was obtained in the online google colab program




**The first case.**




**The second case**.

**Conclusion.** The mathematical model of convective and nonlinear heat transfer in a multi-component environment allows you to monitor and control the temperature distribution for each component. Graphs are drawn for each component that show how the temperature changes in time and space. This model helps to analyze how the heat distribution changes over time. There is a heat dissipation model for each component. The heat exchange between the components is different. The graphs show the heat dissipation in parabolic shapes for each component. Modeling algorithms allow you to analyze the performance of each component separately. This method is solved using numerical methods that help to obtain exact solutions and analyze heat dissipation in a new environment by changing the parameters. Modeling provides a useful tool for scientific research by monitoring and controlling multi-component thermal diffusion processes in multi-dimensional domains. These software models allow solving problems

in technological processes, environmental studies, engineering systems, and many others, and the results obtained help to better understand and control heat dissipation.

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## ON COMPLEX HYPERPLANES IN $\mathbb{C}^n$ SPACE AND THEIR PROJECTIONS IN REAL SPACE


***Annotation.*** *This article studies the projections of complex hyperplanes in the real space of $\mathbb{C}^n$. In particular, it proves a theorem stating that for any $m \le n$ dimensional real plane taken from the space $\mathbb{R}^n \subset \mathbb{C}^n$, there exists a unique $m$-dimensional complex plane that contains it.*



***Key words****: real space, complex space, real plane, complex hyperplane.*



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## $\mathbb{C}^n$ FAZODAGI KOMPLEKS GIPERTEKISLIKLAR VA ULARNING HAQIQIY FAZODAGI PROYEKSIYALARI HAQIDA


***Annotatsiya.*** *Ushbu maqolada $\mathbb{C}^n$ fazodagi kompleks gipertekisliklarning haqiqiy fazodagi proyeksiyalari o'rganilgan bo'lib, xususan, $\mathbb{R}^n \subset \mathbb{C}^n$ fazodan olingan ixtiyoriy $m \le n$ o'lchovli haqiqiy tekislikni o'z ichiga oluvchi yagona $m$ o'lchovli kompleks tekislik mavjudligi haqidagi teorema isbotlangan.*



***Kalit so'zlar:*** *haqiqiy fazo, kompleks fazo, haqiqiy tekislik, kompleks gipertekislik.*



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## О КОМПЛЕКСНЫХ ГИПЕРПЛОСКОСТЯХ В $\mathbb{C}^n$ ПРОСТРАНСТВЕ И ИХ ПРОЕКЦИЯХ В РЕАЛЬНОМ ПРОСТРАНСТВЕ


***Аннотация.*** *В данной статье исследуются проекции комплексных гиперплоскостей в вещественном пространстве $\mathbb{C}^n$. В частности, доказывается теорема, утверждающая, что для любой $m \le n$ мерной вещественной плоскости, взятой из пространства $\mathbb{R}^n \subset \mathbb{C}^n$, существует единственная $m$-мерная комплексная плоскость, содержащая её.*