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Temperature Distribution of High Temperature Protective Clothing Based on Partial Differential Equation

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Abstract. *This paper discusses the heat transfer problems in the design of special clothing for high temperature operation. A unified partial differential equation model is established according to the laws of thermodynamics for the variation of the temperature of four layers with different materials. Because the four layers of media are different, the decision variables are divided into four layers, that is, four for loops are built in the code for splicing, and the finite difference method of classical explicit format is used to solve the partial differential equations. The classical display is used in the solution process. The finite difference method of the format finally obtains the temperature distribution of each layer.*

Keywords: *High temperature protective clothing, Partial differential equation, Finite difference method*

1. Introduction

Since the 1970s, breakthroughs have been made in individual cooling systems, and various types of protective clothing have emerged in an endless stream, making the application of high-temperature protective clothing very extensive, from aerospace to marine, military, mining, steelmaking and other fields. The research on high-temperature protective clothing helps to improve the comfort of the workers, improve the working efficiency of the workers, and reduce the damage to the physiological and biochemical functions and behaviors of the human body. The research on high-temperature protective clothing is of particular importance to China's national defense field and industries related to national economy and people's livelihood.

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2. Heat conduction equilibrium analysis

According to the laws of thermodynamics, there are three main ways of heat conduction between objects: heat conduction, heat convection and heat radiation. According to the definition of three ways, it can be first determined that the heat conduction between objects is mainly heat conduction. Considering the temperature change with time in a uniform medium and during conduction, it can be concluded that the heat conduction is carried out in an unsteady state in the four-layer material, and the equilibrium temperature at the equilibrium state is 48.08 °C.

According to the analysis of the heat conduction mechanism, this paper first solves the temperature change of the four layers of materials in the heat transfer process of each layer. In this process, some thermodynamic equation models need to be established, as follows:

The density equation for each layer of material is:

$$\rho=\frac{m}{V}$$

The thermal conductivity of each layer of material k, thermal conductivity: the heat per unit section, length of material directly under unit temperature difference and unit time. The unit of thermal conductivity is watts per meter Kelvin. Import and export net heat: set the initial heat to be Q, then consider this situation, we establish a one-dimensional coordinate system (Figure 1), then import the heat into Qx, you can get the import and export net value (Q is:

$$\Delta Q = Q_x - Q_{x+dx} = \frac{\partial q}{\partial x} dx * dt$$

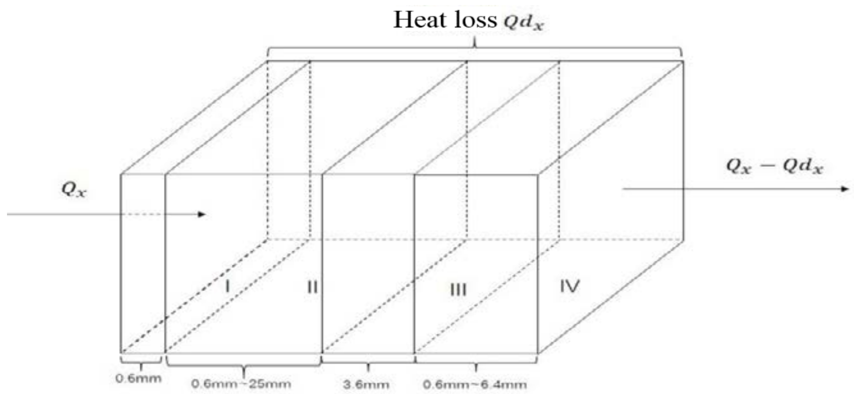

Figure. 1 Heat loss one-dimensional graph

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Internal heat source heat: The heat emitted by the material itself during heat transfer. The increase in thermodynamic energy: The formula for increasing the thermodynamic energy of an object during the time defined by thermodynamics is:

$$\Delta U = mcdT = \rho * c * \frac{\partial T}{\partial t} * dx * dt$$

From the above formula, the following partial differential equation can be obtained:

$$\rho * c * \frac{\partial T}{\partial t} = \frac{\partial}{\partial x} * (\lambda * \frac{\partial T}{\partial x}) + \Phi$$

Then the function of the temperature distribution in each layer can be established as:

$$T = f(x,t)$$

According to this equation, it is obvious that the temperature distribution of each layer can be obtained by changing the attribute value parameters in each layer.

3. Partial differential equations

Since the established partial differential equation model has many parameters and complicated calculations, it can be solved by Matlab software. For the solution of partial differential equations, we use the "finite difference method".

The finite difference method is also called the difference method. It is a numerical solution that solves the problem of partial differential (or ordinary differential) equations and equations by using difference equations to approximate differential equations and approximating differential equations by difference equations. Compiling and running in Matlab yields a three-dimensional image of the temperature distribution shown in Figure 2 with respect to time distance (material thickness) and derives the temperature distribution.

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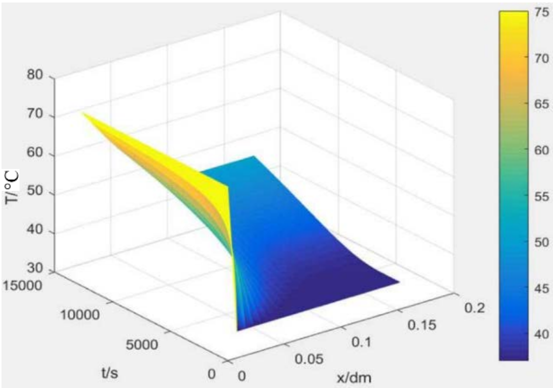

Figure. 2 Three-dimensional image of temperature distribution with respect to time, distance (material thickness)

4. Conclusion

In this paper, an unsteady aperiodic heat conduction model is established by the laws of thermodynamics, and the model is given in the form of partial differential equations, making the problem more operable. In the process of solving the differential equations, considering that the RBM collocation method solves the differential equations by the basis function, the stereo image cannot be given. Therefore, the finite difference method is used to make the conduction process of heat in the medium in the space by using the grid. The abstract heat transfer process is embodied in a more intuitive three-dimensional view. Based on the differential equation model established by some research institutes in the heat conduction process, we can use the model in the study of radioactivity and conduction in some fields of physics, chemistry, etc., such as the production of space suits, diver clothes during diving. Insulation issues, etc.

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