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MATHEMATICAL STUDY ON HEAT FLOW THROUGH NOZZLE BY DIFFERENTIAL EQUATIONS

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Abstract:

In various scientific fields, the thermal equation is of fundamental importance. Heat is an energy form which exists in every material. The temperature of an object changes, for example, with time and position inside the object. This equation can also be used to resolve science and engineering-related heat flow. We can use the numerical method to solve the problem of heat equation in science or engineering. The accuracy of numerical methods is more reliable than other methods. In this paper, a mathematical model for calculating limitation of heat transport of a nozzle is suggested and verified. Diagrammatic describe the estimates of different versions of the heat pipe winding structure and working fluid as a function of the heat transport limit on the operating temperature. It also tests the effect of these limits on the cooling capacity of the nozzle.

Key words: Differential equations, Heat flow, Numerical study

1.0 Introduction

In many scientific fields, the heat equation is important. It's the parabolic prototype partial mathematical differential equation. The diffusion equation, a more general version of the heat equation, arises in connection with a study of chemical diffusion and other related processes. It also defines the heat (or temperature variation) overtime distribution across the given area. Methods are relevant for numerical solution for partial differentially parabolic equations in areas such as molecular diffusion, heat transfer, analysis of the nuclear reactor and fluid flow. The differential equation is a differential equation that contains one or more unknown function variables. There are also two problems for discussing in the differential equation which are the ordinary differential equation depending on only one variable. Partial differential equations are important in several areas of science and engineering because more than one independent variable is often involved in physical problems. The applications of the subject are many and the types of equations are very different.

Statement of the Problem:

The heat equation in the heat flow is essentially always applied. Based on the problem, the problem must be correctly derived and the thermal equation model must be obtained under the borders and initial conditions. Therefore, the problem can be more than two variables, and a solution for the equation can be found, by using computer mathematical techniques both in business and in the real world. By using mathematical software we can solve this problems more rapidly and accurately it is not easy.

Objectives:

- To develop an understanding of the concept and application of the partial differential equation to derive the heat equation.
- To analyse the problem and solve the heat equation using numerical methods.
- To be able to implement numerical methods for the solution of heat equation arises in the science and engineering field

2.0 LITERATURE REVIEW

F. Khani, M. A. Raji [1] To calculate this type of compressible flow, the solution's mathematical characteristics are analysed. For the intent of this analysis, the flow model's solution and duct output functions are illustrated for various flows and heat flux values, as well as fluid parameter distribution along the duct for both subsonic and supersonic flows.
E. M. A. Mokheimer [2] The local wall temperature, air intake and outlet temperatures, pressure drop across the test section and air flow speed have been calculated and registered to determine and evaluate heating transfer capacity of the heated tube. At the aggregate mean mass temperature all fluid properties were determined and discussed. Average Nusselt figure was measured and discussed.
M. Y. Malik and A. Rafiq [3] Heat is transported using latent heat vaporization rather than a sensible heat or conduction where the heat pipe then operates under a near-inspiration. The work liquid works in a saturated thermodynamic state. This almost isothermal state provides the advantages of efficient heat transport, reduced total thermal transfers and saved weight.

3.0 Mathematical Formulation

A two-dimensional planar bucket shown in the picture Fluid density is constant. We consider a steady and frictionless flow. The pressure of stagnation is given at the inlet and the static stress is defined at the exit. With the backward grid, we record discrete momentum and press correction equations with the Basic algorithm and resolve unsure pressures at speed nodes. The continuousness of the simulated speed field can also be assessed and the error in the measured pressures and speed fields determined by comparing the same solution..

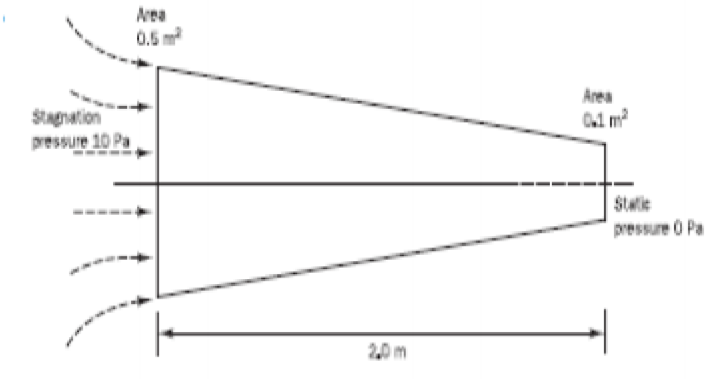

Fig : Geometry of planar 2D nozzle

The governing equations for steady, one-dimensional, incompressible, frictionless equations through the planar nozzle are as follows:

$$\frac{d}{dx}(\rho A u) = 0 \qquad (1)$$

$$\rho u A \frac{du}{dx} = -A \frac{dp}{dx} \qquad (2)$$

Discretised u-momentum equation the discretised form of momentum equation is

$$(\rho u A)_e u_e - (\rho u A)_w u_w = \frac{\Delta p}{\Delta x} \Delta V \qquad (3)$$

$$\text{where } \Delta p = p_w - p_e$$

This one-dimensional problem may be described as a discrete momentum equation as the coefficients can be derived from the Upwind Differentiation System.

$$a_W = D_w + \max(F_w, 0)$$
$$a_E = D_e + \max(0, -F_e)$$
$$a_P = a_W + a_E + (F_e - F_w)$$

Since the flow is frictionless, there is no viscous diffusion term in the governing equation, and hence Dw = De = 0. Fw and Fe are mass flow rates through the west and east face of the u-control volume. We compute the face velocities needed for Fw and Fe from averages of velocity values at nodes straddling the face and use the correct values of the west and east face area. At the start of the calculations we use the initial velocity field generated from the guessed mass flow rate. For subsequent iterations we use the corrected velocity obtained after solving the pressure correction equation.

General Information about the Heat Equation:

In a number of scientific fields, the heat equation is important. It is a partial differential parabolic prototype of the mathematical equation. The diffusion equation, a more general version of the heat equation, exists in connection with the study of chemical diffusion and other associated processes. It also defines the heat (or temperature variation) overtime distribution in a given area. For a function u, x and t variable, the equation for the heat equation is the following:

$$\frac{\partial u}{\partial t} = c \, \frac{\partial^2 u}{\partial x^2}$$

where c is a constant thermal conductivity with boundary conditions:

u(0,t) = 0, u(l,t) = 0,

initial condition : u(x,0) = f(x).

The heat equation is used to determine the change when the heat spreads over time. Over time, the change in the u function needs to be determined. The body's temperature may be reduced and the temperature in the box will equal after the last couple of times if a hot body is placed in a cool water box. A high principle that states that the maximum value of u is either earlier than the region in question or at the edge of the area concerned is an important feature of the heat equation. In general, this means the temperature is either from a source or earlier in time, because heat is permeating but not from nowhere. This depends on partial differential equations of parabolization.

4.0 CFD MODEL FOR HEAT TRANSFER IN NOZZLE

The CFD model of the nozzle and helix transmission of grids developed for analytical analysis is shown in Figure 2. This is the optimized grid following the study of grid independence in detail at Jayakumar et al . 2008. To coupl pressure velocity, a simple scheme has been employed. As a viscous model, the proposed standard k-β turbulence model is used. To mitigate the problems, the conclusions reached are: (1) the stream is expected to be incompressible; (2) the effects of radiation and normal convection have not been observed; and (3) the flow is expected to be continuous and instable for both the inlet nozzles and the helical ducts. Adiabatic wall boundary is present for nozzle wall and helical ducts. At 1500K, heat air passes across the nozzle with fluid fluids and the helical bandage in a reverse direction (water, kerosene, ethanol and nano-fluid (5% copper per volume), which translates heat as a counter-flow pin.

SOLVING HEAT EQUATION

There is no analytical solution to the most true mathematical problems. However, each of the problems has real answers. We may use other approaches such as graphical representation or numerical analysis to get these solutions. Numerical analysis is the mathematical method that also takes into consideration the exactness of an approximation. To complete a study of the physical situation, the solution in partial differential equations that arise in the scientific and technical problems is extremely important. Numerical values are also required in various intervals of variables in case of analytic solution to the partial differential equation. Numerical solution is therefore very useful and appropriate for a problem.

Mathematical construction

Let us presuppose the steady laminar nanofluid flow between two horizontal plates situated at a distance y ¼ 0 and y ¼ h respectively

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0, \tag{1}$$

$$\rho_{nf}\left(u\frac{\partial u}{\partial x} + v\frac{\partial u}{\partial y}\right) = -\frac{\partial p}{\partial x} + \mu_{nf}\left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2}\right), \tag{2}$$

$$\rho_{nf}\left(u\frac{\partial v}{\partial x} + v\frac{\partial v}{\partial y}\right) = -\frac{\partial p}{\partial y} + \mu_{nf}\left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2}\right), \tag{3}$$

$$(\rho C_p)_{nf}\left(u\frac{\partial T}{\partial x} + v\frac{\partial T}{\partial y}\right) = \kappa_{nf}\left(\frac{\partial^2 T}{\partial x^2} + \frac{\partial^2 T}{\partial y^2}\right) + \mu_{nf}\left(2\left[\left(\frac{\partial u}{\partial x}\right)^2 + \left(\frac{\partial v}{\partial y}\right)^2\right] + \left(\frac{\partial u}{\partial y} + \frac{\partial v}{\partial x}\right)^2\right) - \frac{\partial q_r}{\partial y}, \tag{4}$$

Where u; v are the fluid portion of velocity, p corresponds to the changed nanofluid pressure, T to the temperature of nanofluid, qnf to the fluid density, lnf to the dynamic viscosity of fluid, jnf to the thermal conductivity of nanofluid, qCp nf to the specific heat of Nanoplasms, qr to the radiative heat flux.

Graphic dependencies of the mathematical model:

On the basis of the mathematical model verification with the measurement of nozzle efficiency, certain essential dependencies and geometric parameters of the capillary structure of the hot tube are obtained. Awareness of the findings may be used to further refine applications for sintered wick heat tubing construction. The diagrams show heat flow dependencies and maximum heat flow range of the nozzles with working conditions. In the various mathematical model equations, heat transfer structure limits for wick nozzle.

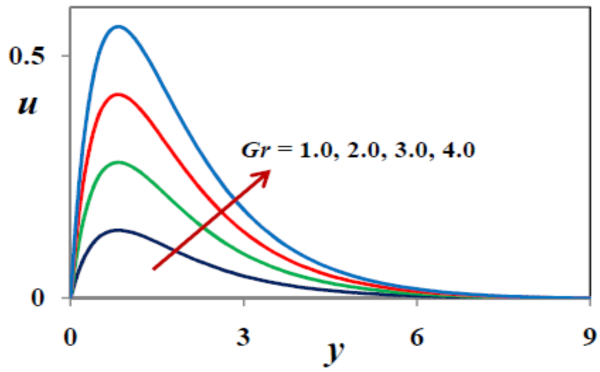

Fig. 1. Influence of *Gr* on velocity in fluid fow

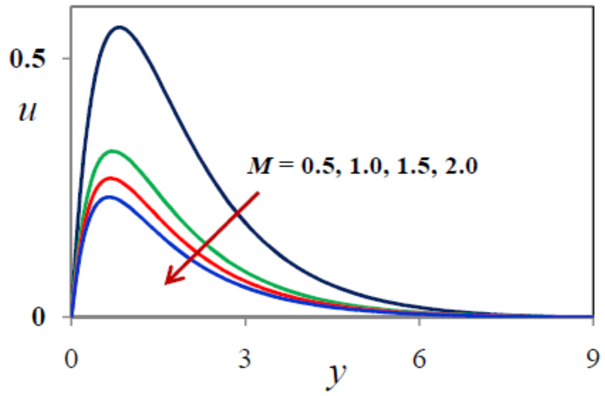

Fig. 2. Influence of *M* on velocity profiles

Fig. Shows Temperature actions for various varietal Prandtl values. The rise in the variety Prandtl has been shown to result in lower thermal physical phenomena and typically lower average physical temperatures intervals. The reasoning is that smaller Pr Ar values remind us of an increase in the fluid's thermal conductivity and therefore heat will disperse from the heated surface for higher Pr values earlier. For this reason, the thermal physical phenomenon in Prandtl is more thick in a smaller variety because the rate of transfer of heat is decreased

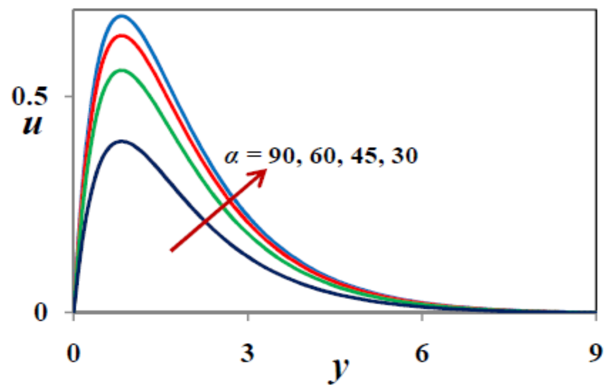

Fig. 3. Influence of α on velocity profiles

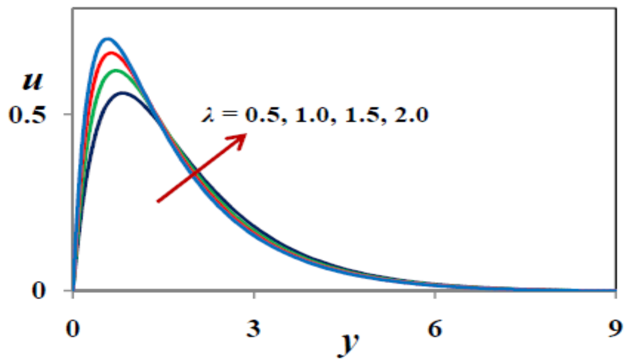

Fig. 4. Influence of λ on velocity profiles

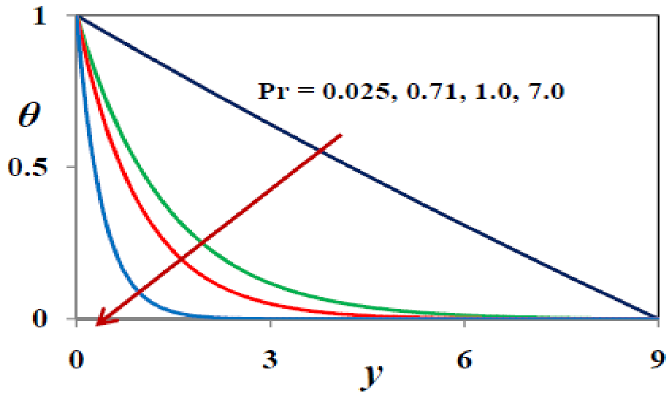

Fig. 5. Influence of Pr on temperature

Above graphs were examined the combined effect of thermal transfer and inclination angles on the instable fluid flow along a vertical plate. The fluid velocity decreases from this study with increasing fluid parameter. The effect of speed profiles, although for the Grashof number the opposite behavior is found. The angle of inclination parameter tends to delay fluid motion across the boundaries.

Conclusion:

Graphic requirements indicate which thermal transmission limitations are most essential to the overall nozzle 's performance. The limits rely generally on the parameters of the nozzle and the wick structure and the thermophysical properties of the working fluid. Viscous limitation and sonic limitation are the highest values. These restrictions reach so high values that they can be overlooked in many cases. They affect the output of heat pipes close to the freezing temperatures of the working fluid at low temperature. Dose limitation, capillary limitation and boiling limitation are the critical limits to the performance of the dome.

REFERENCES:

1. F. Khani, M. A. Raji, and H. H. Nejad, “Analytical solutions and efficiency of the nonlinear fin problem with temperature-dependent thermal conductivity and heat transfer coefficient,” Communications in Nonlinear Science and Numerical Simulation, vol. 14, no. 8, pp. 3327–3338, 2009.
2. E. M. A. Mokheimer, “Heat transfer from extended surfaces subject to variable heat transfer coefficient,” Heat and Mass Transfer, vol. 39, no. 2, pp. 131–138, 2003.
3. M. Y. Malik and A. Rafiq, “Two-dimensional fin with convective base condition,” Nonlinear Analysis: Real World Applications, vol. 11, no. 1, pp. 147–154, 2010.
4. Y. Xia and A. M. Jacobi, “An exact solution to steady heat conduction in a two-dimensional slab on a one-dimensional fin: application to frosted heat exchangers,” International Journal of Heat and Mass Transfer, vol. 47, no. 14–16, pp. 3317–3326, 2004.
5. Aziz and H. Nguyen, “Two-dimensional performance of convecting-radiating fins of different profile shapes,” Wärme und Stoffübertragung, vol. 28, no. 8, pp. 481–487, 1993.
6. L. T. Chen, “Two-dimensional fin efficiency with combined heat and mass transfer between water-wetted fin surface and moving moist airstream,” International Journal of Heat and Fluid Flow, vol. 12, no. 1, pp. 71–76, 1991.