Visualization of Unsteady Natural Convection along Vertical Cylinder with Heat Transfer using GUI

Dr.Syeda Asma Kauser
Associate professor, Department of mathematics
Anwarul Uloom College, New Mallepally, Hyderabad.
asmaxlnc1@gmail.com

Dr. Syed Salahuddin
Professor, Department of mathematics
Anwarul Uloom College, New Mallepally, Hyderabad
syedsalah1069@gmail.com

ABSTRACT

The transient natural convection flow over a vertical cylinder under combined buoyancy effect of heat transfer is presented numerically. The velocity and temperature profiles, local and average skin-friction and Nusselt number are shown graphically. The solution is visualized in the GUI of MATLAB. This GUI is an easily adaptable interface for users even when they are unfamiliar with MATLAB.

LITERATURE SURVEY

The problem of heat transfer in natural convection over vertical cylinders has wide range of applications in the field of science and technology. Several steady state analyses for a vertical cylinder are found in the literature. Bottemanne (1972) studied the combined effect of heat and mass transfer in the steady laminar boundary layer of a vertical cylinder placed in still air. Gebhart and Pera (1971) analysed the steady combined buoyancy effects on vertical natural convection flows. Minkowycz and Sparrow (1974) used local non-similarity method to obtain the steady boundary layer velocity and temperature profiles for isothermal cylinder placed in air.

The GUI in MATLAB contains a variety of attributes such as numeric text boxes, buttons, sliders, menu bars, lamps, and axes which can execute any type of computation and show the result in the form of tables or as plots. GUI is developed to visualize the solution of the one-dimensional Burgers' equation which is a crucial equation in fluid dynamics, and MATLAB's GUI provides a powerful interface to analyze its solution.

PROBLEM STATEMENT

A vertical cylinder of radius r which is situated in an otherwise quiescent environment having temperature T01 is considered. The surface of the cylinder is maintained at a uniform temperature T0w. The radial coordinate r is measured from the axis of the cylinder. The axial coordinate x is measured vertically upward with the origin located at the leading edge of the cylinder. With Boussinesq's approximation and above assumptions, the transient natural convection boundary layer equations are considered in cylindrical coordinates.

$$\frac{\partial(UR)}{\partial X}+\frac{\partial(VR)}{\partial R}=0 \quad (1)$$

$$\frac{\partial U}{\partial t}+U\frac{\partial U}{\partial X}+V\frac{\partial U}{\partial R}=GrT+\frac{1}{R}\frac{\partial U}{\partial R}+\frac{\partial^2 U}{\partial R^2} \quad (2)$$

$$\frac{\partial T}{\partial t}+U\frac{\partial T}{\partial X}+V\frac{\partial T}{\partial R}=\frac{1}{Pr}\left(\frac{1}{R}\frac{\partial T}{\partial R}+\frac{\partial^2 T}{\partial R^2}\right) \quad (3)$$

where *Gr* denotes the Grashof number, which is the ratio between thermal to viscous forces and *Pr* denote the Prandtl number which is the ratio of viscous to thermal diffusion forces.

SOLUTION METHODOLOGY

The above non-dimensional non-linear governing equations (1)–(3) have been are unsteady and coupled equations. They are solved using an implicit finite difference method of Crank–Nicolson type. In order to ensure the accuracy of the results, the paper has adopted a rigorous approach by comparing the numerical solutions obtained through Crank-Nicolson with the results available in the literature. The results are shown as graphs in terms of the velocity and temperature profiles.

References

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3. Minkowycz WJ; Sparrow EM (1974) Local nonsimilar solutions for natural convection on vertical cylinder. J Heat Trans 96: 178-183.