This thesis entitled “Stability of viscous flow between cylindrical surfaces with radial heating” consists of six problems with different physical conditions. At the beginning of the thesis, in Introduction, few basic concepts related to the idea that dictates the need of studying the instability of flow between concentric circular cylinders and relevant literatures on the field of present study are presented.

The Chapters one to six are incorporated with problems with different physical considerations and the abstracts of these chapters are presented below:

CHAPTER-1

Title: Hydrodynamic stability of viscous flow through a curved porous channel with radial flow

Abstract: A linear stability analysis has been presented for the flow between two long concentric stationary porous cylinders driven by a constant azimuthal pressure gradient, when a radial flow through the permeable walls of the cylinders is present. The radial Reynolds number, based on the radial velocity at the inner cylinder and the inner radius, is varied from −100 to 30. The linearized stability equations form an eigenvalue problems which are solved using a numerical technique based on classical Runge-Kutta scheme combined with a shooting method, termed as unit disturbance method. It is observed that radially outward flow and strong inward flow have a stabilizing effect, while weak inward flow has a destabilizing effect on the stability. Profiles of the relative amplitude of the perturbed radial velocities show that radially
outward flow shifts the vortices toward the outer cylinder, while radially inward flow shifts the vortices toward the inner cylinder.

CHAPTER-2

Title: Stability of viscous flow driven by an azimuthal pressure gradient between two porous concentric cylinders with radial flow and a radial temperature gradient

Abstract: Effect of radial temperature gradient on the stability of viscous flow between two porous concentric circular cylinders driven by a constant azimuthal pressure gradient is studied, when a radial flow through the permeable walls of the cylinders is present. The radial Reynolds number $\beta$ based on the radial velocity at the inner cylinder and the inner radius $R_i$ is varied from $-130$ to $30$ and both positive and negative values of the parameter $N$ are taken, where $N$ depends on the temperature difference $T_2 - T_1$ between the outer and inner cylinders. The linearized stability equations form an eigenvalue problem, which are solved by using a classical Runge-Kutta scheme combined with a shooting method, termed unit disturbance method. It is found that for a given value of $N$, the radially outward flow ($\beta > 0$) has a stabilizing effect and the stabilization is more as the gap between the cylinders increases. But the inward throughflow ($\beta < 0$) has a destabilizing influence when $|\beta|$ increases up to a certain critical value and thereafter the throughflow is stabilizing with further increase in $|\beta|$. When the outer cylinder is kept at a lower temperature than the inner one ($N < 0$), the flow becomes more and more stable with increase in $|N|$. On the other hand for $N > 0$, the flow becomes more and more unstable with an increase in $N$. 
CHAPTER-3

Title: Stability of MHD Taylor-Couette flow with radial temperature gradient and constant heat flux at the outer cylinder

Abstract: An analysis is made of the linear stability of wide gap hydromagnetic (MHD) dissipative Couette flow between two rotating concentric circular cylinders in the presence of a constant axial magnetic field strength. A constant heat flux is applied at the outer cylinder and the inner cylinder is kept at a constant temperature. Both types of boundary conditions viz; perfectly electrically conducting and electrically nonconducting walls are examined. The three cases of $\mu < 0$ (counter-rotating), $\mu > 0$ (co-rotating ) and $\mu = 0$ (stationary outer cylinder) are considered. Assuming very small magnetic Prandtl number $P_m$, the wide-gap perturbation equations are derived and solved by a direct numerical procedure. It is found that for given values of the radius ratio $\eta$ and the heat flux parameter $N$, the critical Taylor number $T_c$ at the onset of instability increases with increase in Hartmann number $Q$ for both conducting and non-conducting walls thus establishing the stabilizing influence of the magnetic field. Further it is found that insulating walls are more destabilizing than the conducting walls. It is observed that for given values of $\eta$ and $Q$, the critical Taylor number $T_c$ decreases with increase in $N$. The analysis further reveals that for $\mu = 0$ and perfectly conducting walls, the critical wave number $a_c$ is not a monotonic function of $Q$ but first increases, reaches a maximum and then decreases with further increase in $Q$. It is also observed that while $a_c$ is a monotonic decreasing function of $\mu$ for $N = 0$, in the presence of heat flux ($N = 1$), $a_c$ has a maximum at a negative value of $\mu$ (counter-rotating cylinders).
CHAPTER-4

Title: Effect of radial temperature gradient and constant heat flux at the outer cylinder on the stability of narrow gap MHD Taylor-Couette flow.

Abstract: A linear stability analysis has been presented for hydromagnetic dissipative Couette flow, a viscous electrically conducting fluid between rotating concentric cylinders in the presence of a uniform axial magnetic field and constant heat flux at the outer cylinder. The narrow gap equations with respect to axisymmetric disturbances are derived and solved by a direct numerical procedure. Both types of boundary conditions, conducting and non-conducting walls are considered. A parametric study covering on the basis of $\mu$, the ratio of the angular velocity of the outer cylinder to that of inner cylinder, $Q$, the Hartmann number which represents the strength of the axial magnetic field, and $N$, the ratio of the Rayleigh number and Taylor number representing the supply of heat to the outer cylinder at constant rate is presented. The three cases of $\mu < 0$ (counter rotating), $\mu > 0$ (co-rotating) and $\mu = 0$ (stationary outer cylinder) are considered wherein the magnetic Prandtl number is assumed to be small. Results show that the stability characteristics depend mainly on the conductivity on the cylinders and not on the heat supplied to the outer cylinder. As a departure from earlier results corresponding to isothermal as well as hydromagnetic flow, it is found that the critical wave number is strictly a monotonic decreasing function of $Q$ for conducting walls. Also, the presence of constant heat flux leads to a fall in the critical wave number for counter rotating cylinders, which states that for large values of $-\mu$, there occur transition from axisymmetric to non-axisymmetric disturbance whether the flow is hydrodynamic or hydromagnetic and this transition from axisymmetric to non-axisymmetric disturbance occur earlier as the strength of the magnetic field increases.
CHAPTER-5

Title: Effect of Prandtl number on the stability of curved channel flow between concentric circular cylinders.

Abstract: Effects of radial temperature gradient and Prandtl number on the stability of viscous flow between two concentric circular cylinders driven by a constant azimuthal pressure gradient is studied. The critical values of wave number and Dean number are presented in tables and shown graphically for various values of radius ratio in the range $0.1 \leq \eta \leq 0.95$, Prandtl number $Pr = 0.71, 3.5, 4.35$ and $7.0$; and the parameter $N$ is varied from $-2$ to $2$, where $N$ depends on the temperature difference $(T_2 - T_1)$ between the outer and inner cylinders. When the outer cylinder is kept at a lower temperature than the inner one i.e., for negative radial temperature gradient ($N < 0$), the flow becomes more and more stabilized with increase in $|N|$ and the stabilization is more stronger as the gap widens. On the other hand for $N > 0$, the flow becomes more and more unstable with increase in $N$. The results reveal that increasing the Prandtl number profoundly stabilizes the flow for $N < 0$.

CHAPTER-6

Title: Stability of narrow gap Taylor-Dean flow with radial heating: stationary critical modes.

Abstract: A linear stability analysis for Taylor-Dean flow, a viscous flow between concentric cylinders with a pressure gradient acting in the azimuthal direction keeping the cylinders at different temperatures, when the inner cylinder is rotating and outer one is stationary has been implemented. The analysis is made under the assumption
that the gap spacing between the cylinders is small compared to the mean radius (small gap approximation). A parametric study covering wide ranges of $\beta$, a parameter characterizing the ratio of representative pumping and rotation velocities and $N$, the parameter characterizing the direction of temperature gradient ($T_2-T_1$) is conducted, where $T_1$ and $T_2$ are the temperatures of the inner and outer cylinders respectively. The most stable state is always accompanied by keeping the inner cylinder is at higher temperature than the outer one. In the isothermal case ($N = 0$), the flow is most stable near a critical value of $\beta^* = -3.667$, at which the critical wave number ($a_c$) jumps discontinuously and the discontinuity of $a_c$ corresponds to the fact that the neutral curve consists of two separated branches occurs precisely at $\beta^*$, where there exists an oscillatory axisymmetric mode of approximately equal stability. Emphasis is given to the occurrence of critical stability for the onset of instability by finding the intersection of the two neutral curves for the inner and outer part in a range of values of the radial temperature gradient $-1.25 < N < 0.25$. We point out the existence of such critical point of stability $(a^*, T^*) = (8.377, 110376)$ where the two neutral curves intersect and disappearance of oscillatory mode when $N = -1.0$.

An appendix is included at the end of the thesis. Here, we have explained the way of implementing the Harris and Reid method used for computing the critical wave number and Taylor number (Dean number). For better presentation of the algorithm, we have considered the system of equations mentioned in CHAPTER 2. A complete and elaborate explanation of the algorithm is presented for the benefit of the readers.