

# CONVECTIVE INSTABILITY IN NANOFUIDS UNDER VARIOUS CONFIGURATIONS

## ABSTRACT OF THESIS

Submitted to  
Babasaheb Bhimrao Ambedkar University  
(A Central University)

Lucknow

BABASAHEB  
BHIMRAO  
AMBEDKAR  
UNIVERSITY



•LUCKNOW•  
प्रज्ञा शील करुणा  
ESTABLISHED 1996

for the Award of the Degree of

**Doctor of Philosophy**

in

**MATHEMATICS**

Submitted By

**ISMAIL**

Enrollment No. 1439/20

Under the Supervision of

**Prof. B. S. BHADAURIA**

DEPARTMENT OF MATHEMATICS  
SCHOOL OF PHYSICAL & DECISION SCIENCE  
BABASAHEB BHIMRAO AMBEDKAR UNIVERSITY  
(A CENTRAL UNIVERSITY) (NAAC 'A++' ACCREDITED)  
VIDYA VIHAR, RAEBARELI ROAD, LUCKNOW - 226025  
UTTAR PRADESH, INDIA

2024

# CONVECTIVE INSTABILITY IN NANOFUIDS UNDER VARIOUS CONFIGURATIONS

## ABSTRACT OF THESIS

Submitted to  
Babasaheb Bhimrao Ambedkar University  
(A Central University)

Lucknow

BABASAHEB  
BHIMRAO  
AMBEDKAR  
UNIVERSITY



•LUCKNOW•  
प्रज्ञा शील करुणा  
ESTABLISHED 1996

for the Award of the Degree of

**Doctor of Philosophy**

in

**MATHEMATICS**

Submitted By

**ISMAIL**

Enrollment No. 1439/20

Under the Supervision of

**Prof. B. S. BHADAURIA**

DEPARTMENT OF MATHEMATICS  
SCHOOL OF PHYSICAL & DECISION SCIENCE  
BABASAHEB BHIMRAO AMBEDKAR UNIVERSITY  
(A CENTRAL UNIVERSITY) (NAAC 'A++' ACCREDITED)  
VIDYA VIHAR, RAEBARELI ROAD, LUCKNOW - 226025  
UTTAR PRADESH, INDIA

**2024**

# ABSTRACT

An advanced fluid known as “nanofluid” is one that was created by suspending nanoparticles in a base fluid. These nanoparticles typically have diameters between 1 and 100 nanometers. The nanoparticles can be formed of a variety of materials, including metals, metal oxides, carbon-based compounds, or polymers, and the base fluid can be a liquid like water, oil, ethylene glycol, or a gas. When used in a variety of applications, nanofluids are created to take use of the special characteristics of nanoparticles. Since we utilise various instrument forms on a regular basis, researchers are also interested in how nanofluid behaves in various enclosure forms. Choi, S. (1995) coined the term “nanofluids”.

When the system’s temperature ( $T$ ) exceeds a specific critical point, thermal instability occurs. Two horizontal, parallel plates that are indefinitely extended and are each filled with a fluid are considered to be ‘d’ distance apart in Fig. 1, The lower plate is warmer than the upper plate in terms of temperature. Heat transport occurs via conduction when the temperature across the boundaries is below the critical temperature ( $T_c$ ), and the system is considered to be *stable* when this occurs. When the temperature reaches the critical point, convection begins to take place, and the system is described as *marginally stable*. Beyond the critical temperature, fully developed convection cells can be seen, and term *unstable* is used to describe the system (Chandrasekhar, 1981).

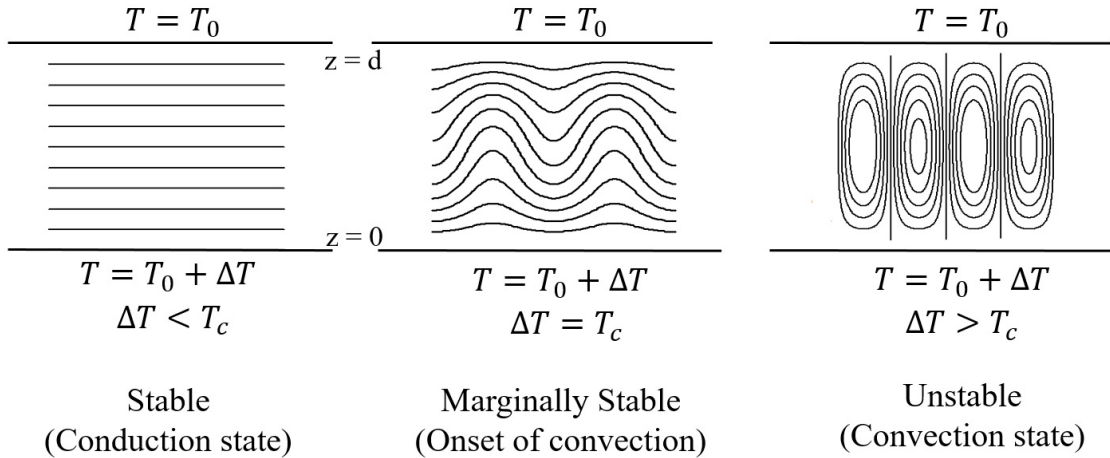


Figure 1: Thermal instability

Investigating the thermal instability of nanofluids is the goal of the thesis entitled “**CONVECTIVE INSTABILITY IN NANOFUIDS UNDER VARIOUS CONFIGURATIONS**”. In this thesis, primary objective is to investigate the onset of convection in various enclosures filled with nanofluid under the influence of gravity modulation, internal heating, rotation, magnetic field, thermal radiation, etc. The equations have been solved using the normal mode technique, Galerkin method, truncated Fourier series method, and Runge-Kutta-Fehlberg (RKF-45) method. The thesis comprises seven chapter, which are described as follows:

**Chapter 1** contains numerous fundamental definitions and concepts that are used throughout the entire thesis. The fundamental concept of nanofluids, their techniques of preparation, mathematical models, applications, porous media, various analytical and numerical methods utilised to solve the problems, literature review, etc. are all covered in this chapter.

In **Chapter 2**, the impact of rotation on thermal instability in a Hele-Shaw cell filled with Casson nanofluid is investigated by both linear and nonlinear analysis. The analysis has taken into account the free-free isothermal boundaries of the nanofluid model, which contains Brownian and thermophoresis diffusion. Both linear and nonlinear stability analyses have been presented in order to explore the start of convection and heat/mass transfer. It has been determined that the rotational effect

and the Casson parameter are essential to the mass and heat transport inside the system.

In the **Chapter 3**, Linear and nonlinear analysis has been used to study the Rivlin-Ericksen elastico-viscous nanofluid thermal instability with internal heating under three different types of gravity modulation in a horizontal layer of porous media. While nonlinear stability analysis is carried out using the truncated Fourier series method, linear stability analysis is carried out using the normal mode method. Convective motion in the system is advanced by internal heating, modified diffusivity ratio, and concentration Rayleigh number. However, Darcy number stabilize the system. Mathematica NDSolve and the Runge-Kutta-Fehlberg method (RKF-45) are two alternative approaches used to compare the behaviour of mass/heat transfer in the system. Day-night gravity modulation profile accelerates mass/heat transfer more fast than the other two types of gravity modulation profiles, when compared the gravity modulation profiles. The result of thermal Nusselt number, streamlines and isothermals of the fluid are also discussed.

In the **Chapter 4**, examines the impact of three different types of magnetic field modulation, namely, triangular-wave form, sine-wave form, and square-wave form on the instability of a porous medium saturated with a nanofluid ( $\text{Al}_2\text{O}_3 + \text{H}_2\text{O}$ ) with internal heating. Nonlinear stability analysis is carried out using the truncated Fourier series method, whereas linear stability analysis is carried out using the normal mode approach. Internal heating destabilises the system, whereas magnetic Chandrasekhar number and the Darcy number stabilise the system. Additionally, the effects of three alternative nanoparticle forms (spherical, brick-shaped, and cylindrical) on instability are examined. It is found that the system is most stable for spherical-shaped nanoparticles and least stable for brick-shaped nanoparticles. Mathematica NDSolve and the Runge-Kutta-Fehlberg method (RKF-45) are used to analyse the mass/heat transfer in the system. The heat/mass transfer in the system is greatly influenced by the internal heating and magnetic Chandrasekhar number. In contrast to other kinds of magnetic-field modulations, it is also noted that heat and mass transfer begin more quickly in the case of triangular waveforms.

In the **Chapter 5**, Effect of rotation on heat transfer in a micropolar nanofluid saturated porous material has been studied. Analysing nonlinear stability use the truncated Fourier series method, and analysing linear stability employs the normal mode method. The system is stabilised by the micropolar parameter, rotation, and the coupling coefficient between the vorticity and spin effects. In contrast, the Lewis number, porosity parameter, and nanoparticle Rayleigh number accelerate the onset of convective motion within the system. A major contribution in heat and mass transport in the system is performed by the rotation parameter, micropolar parameter, Prandtl number, and the coefficient of coupling between vorticity and spin effect. Runge-Kutta-Fehlberg method (RKF-45) and Mathematica NDSolve are two alternative methods used to analyse mass/heat transfer in the system.

In the **Chapter 6**, both nonlinear and linear analysis, has been examined doing effects of three different types of magnetic-field modulation on the instability of micropolar nanofluid filled within Hele-Shaw cells, nonlinear stability analysis used truncated Fourier series method, and linear stability analysis employs normal mode method. The system is stabilised by the micropolar parameter, magnetic Chandrasekhar number, Hele-Shaw number, and the coefficient of coupling between vorticity and spin effect. As opposed to that, the beginning of convective motion within the system is accelerated by the nanoparticle Rayleigh number. The system's heat/mass transport is significantly influenced by the Hele-Shaw number, micropolar parameter, magnetic Prandtl number, and magnetic Chandrasekhar number. The Runge-Kutta-Fehlberg method (RKF-45) and Mathematica NDSolve are used to examine the system's heat and mass transport. On, comparing the magnetic-field modulations result, has been found that heat and mass transmission begin sooner in the case of triangular wave forms.

In the **Chapter 7**, investigated the thermal instability of Tri-hybrid Casson nanofluid in four different enclosures using both linear and nonlinear analysis with thermal radiation saturated porous material. While nonlinear stability analysis is carried out using the truncated Fourier series method, linear stability analysis is carried out using the normal mode methodology. The system is stabilised by the porous parameter,

thermal radiation, and porosity. On the other hand, the Casson parameter advance the initiation of convective motion in the system.. Mathematica NDSolve and the Runge-Kutta-Fehlberg method (RKF-45) are two alternative approaches used to understand the behaviour of mass/heat transfer in the system. On comparing the result of different enclosures, the tall enclosures has quicker onset of convection than the square and shallow enclosure. The tall enclosure accelerates mass/heat transfer more quickly than the square and shallow enclosure.

At last the thesis is concluded with the possible future scopes of the present work.

### **Published**

1. **Ismail**, B.S.Bhadauria and Anurag Srivastava, Effect of Rotation on Thermal Instability under Hele-Shaw Cell Saturated by Casson Nanofluid, ***International Journal of Modern Physics b***(Published).
2. **Ismail**, B.S.Bhadauria, Effect of three types of gravity modulation on Rivlin Ericksen nanofluid saturated in porous medium with internal heating, ***Journal of Nanofluids***(Published).
3. **Ismail**, B.S.Bhadauria, Awanish Kumar and Anurag Srivastava, Effect of Three Types of Magnetic-Field Modulation and Different Shapes of Nanoparticles on the Instability of Nanofluid ( $\text{Al}_2\text{O}_3 + \text{H}_2\text{O}$ ) Saturated Porous Medium with Internal Heating, ***Journal of Nanofluids*** (Published).
4. **Ismail**, B.S.Bhadauria, Effect of Thermal Instability on Heat Transfer of Micropolar Nanofluid Saturated in Porous Medium with Rotation, ***Numerical Heat Transfer, Part B***(Published).
5. **Ismail**, B.S.Bhadauria and Anurag Srivastava, Effect of three types of magnetic-field modulation on the instability of heat transfer in micropolar nanofluid filled within Hele-Shaw cell, ***Numerical Heat Transfer, Part A***(Published).
6. **Ismail**, B.S.Bhadauria, Anish Kumar, Sawan Rawat and Moh Yaseen, Thermal instability of Tri-hybrid Casson nanofluid with thermal radiation saturated

porous medium in different enclosures, *Chinese Journal of Physics*(Published).

## References

Choi, S. (1995). Enhancing thermal conductivity of fluids with nanoparticles. In: Signier, D.A., Wang, H.P. (eds.) Development and Applications of Non-Newtonian flows, *ASME FED*, vol. 231/*MD vol. 66*, 99-105.

Chandrasekhar, S. (1981). *Hydrodynamic and hydromagnetic stability (International Series of Monographs on Physics)* (Dover). Dover Publications.