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Instability Analysis Study of the Jeffrey Nanofluid Flow through a Brinkman-Darcy Porous Medium

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Abstract

The analysis of thermal instability in a Brinkman-Darcy Jeffrey nanofluid flow through a porous medium is studied in this paper. The nanoparticles are immersed in the Jeffrey fluid so that the thermal conductivity of the system is maintained and high medium porosity is to be undertaken. Under the impact of the Jeffrey, nanoparticles and Brinkman-Darcy parameters, the momentum-balance equations of fluid flow are mutated. The dispersion relation for the Rayleigh number is derived by employing the normal mode analysis method and linear stability theory in terms of different parameters affecting the stability of the system. It is noticed that the Darcy-Brinkman number advances the convection while the Jeffrey parameter postpones the convection in a stationary mode. To verify the results numerically, graphs have been plotted by using Origin 6.1 software. Further, for the top-heavy nanoparticles distribution, oscillatory convection does not exist.

Keywords: Thermal convection, Rayleigh number, Jeffrey Model, porous medium, nanofluid.

1. Introduction

The instability of a non-Newtonian fluid has many applications in real-life problems as well as in various areas of modern technology and industry, viz. plastic production, polymer industry, paper and textile dyeing, food industry, geophysics, chemical and biological industry, etc. [1-9]. Motor oils, printing inks, egg white, wallpaper paste, toothpaste, soap solution, sauce, and biological fluids such as blood are some examples of non-Newtonian fluids. The Jeffrey fluid model [10] is one such kind of non-Newtonian fluid. He investigated some problems of an incompressible fluid that is heated from below, and now it is shown to be the best fluid model to describe the behaviour of physiological and industrial fluids [11-14].

Studying porous media has many applications in groundwater hydrology, Earth's molten core, and many others. Sandstone, limestone, human lungs, bile ducts and gall bladder with stones in the vessels are some examples of natural porous media. A simple Darcy model was used to initiate studies in a porous media. Later, the Darcy model was extended to the Brinkman-Darcy model due to its high porosity and was used in various industries for the

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Free Electrothermo-Convective Instability in a Dielectric Oldroydian Nanofluid Layer in a Porous Medium

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For the last few years, thermal instability of non-Newtonian nanofluids becomes a prominent field of research because it has various applications in automotive industries, energy-saving, nuclear reactors, transportation, electronics etc. and suspensions of nanoparticles are being developed in medical applications including cancer therapy. In this paper, a free electrothermo-convective instability in a dielectric nanofluid layer in a porous medium is studied. An Oldroyd's constitutive equation is used to describe the behaviour of nanofluid and for porous medium, the Darcy model is employed. The equation of conservation of momentum of fluid is stimulated due to the presence of an AC electric field, stress-relaxation parameter and strain-retardation parameter. The stability of the system is discussed in stationary and oscillatory convections for free–free boundaries. For the case stationary convection, it is found that the Oldroydian Nanofluid behaves like an ordinary nanofluid as the stationary Rayleigh number is independent of the stress-relaxation parameter, the strain-retardation parameter and Vadasz number. The effect of stress-relaxation-time parameter, strain-retardation-time parameter, Vadasz number, nanoparticles Rayleigh number, modified diffusivity ratio, medium porosity, Lewis number and electric Rayleigh number examined numerically and graphs have been plotted to analyse the stability of the system. It is observed that the electrical Rayleigh number has destabilizing influence whereas nanoparticles Rayleigh number, porosity and modified diffusivity ratio have stabilizing effect on the system. The oscillatory convection is possible for the values of the stress-relaxation parameter less than the strain-retardation parameter for both top-heavy/bottom-heavy distributions of nanoparticles.

KEYWORDS: Electrothermo-Convection, Nanofluid, Oldroydian Model, Porous Medium, Brownian Diffusion.

1. INTRODUCTION

Nanofluids is a mixture of a regular fluid, with a very small amount of suspended metallic or metallic oxide nanoparticles or nanotubes of typical dimension up to the range of about 100 nanometers which was first coined by Choi.[1] Due to the enhanced thermal conductivity of nanofluids, they are considered great coolants. These enhanced properties suggested an extensive potential of nanofluids for device miniaturization and process strengthening which could influence on many industrial sectors including chemical processing, transportation, electronics, medical, energy-saving, and food processing etc.[2] The abnormal increase in the thermal conductivity and viscosity of nanofluids were explained by (Buongiorno;[3] Vadasz[4,5]). The main focus of Buongiorno[3] was on heat transfer enhancement of nanofluids in convective situations. He derived the conservation equations of mass, momentum, and heat transport in a non-homogeneous equilibrium model of nanofluids.

The thermal instability nanofluid in a porous medium has been a topic of interest due to its various applications in fields of food and chemical process, petroleum industry, bio-mechanics and geophysical problems and thus has been studied by different authors.[6–13] Porous media heat transfer problems have several engineering applications, such as geothermal energy recovery, crude oil extraction, groundwater pollution, thermal energy storage etc. Nanofluid has now various commercial applications in thermal energy technologies, R and D centers, geothermal systems etc. Dispersion of nanoparticles in engine oils, automatic transmission fluids, coolants, lubricants, and other synthetic high-temperature heat transfer fluids found in the conventional truck, thermal systems-radiators, engines, heating, ventilation and air-conditioning (HVAC)-have inherently poor heat transfer properties could be

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Impact of rotation on thermal instability of Darcy–Brinkman porous layer filled with a Jeffrey nanofluid

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ABSTRACT
The novelty of this research lies in its investigation of the initiation of thermal instability within a Darcy–Brinkman porous layer containing a Jeffrey nanofluid under the influence of rotation. While non-Newtonian fluids complex flow patterns and heat transfer enhancements due to thermal gradients are known, this study addresses a specific and previously unexplored aspect, the impact of rotation on Darcy–Brinkman porous layer containing a Jeffrey nanofluid. When a fluid is subjected to rotation, it can induce additional forces and flow patterns within the fluid. The linear stability theory and normal mode analysis method are used to analyze the stability of the system analytically and are computed numerically using the software Mathematica version 11.3. The investigation focuses on understanding the influence of various factors, namely, the Taylor number, the Lewis number, the Jeffrey parameter, the modified diffusivity ratio, nanoparticles Rayleigh number, the Darcy–Brinkman number, and medium porosity on the onset of thermal instability in the physical system. This novel perspective can contribute to a deeper understanding of heat transfer processes in non-Newtonian fluids and has potential applications in improving the efficiency of industrial systems, such as cooling systems, heat exchangers, and microfluidic devices where efficient heat transfer is crucial for performance improvement.

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KEYWORDS
Darcy–Brinkman; Jeffrey model; nanofluid; porous medium; Rayleigh number

1. Introduction

The practical applications of thermal instability in non-Newtonian fluids have a broad scope and address various real-world challenges. These applications are relevant across multiple fields of modern technology and industries, including the manufacturing of plastics, polymer industries, dyeing of papers and textiles, food processing, geophysics, as well as chemical and biological sectors [1–5]. Non-Newtonian fluids encompass a diverse range of substances, such as engine oils, printing inks, egg white, wallpaper paste, toothpaste, soap solution, sauce, and various biological liquids like blood [6–9].

The Jeffrey fluid model, originally introduced by Jeffreys [10], represents a significant class of non-Newtonian fluids. Jeffrey's investigations into incompressible fluids heated from below led to the recognition of the Jeffrey model as the most suitable fluid model for characterizing the

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Effect of variable gravity on thermal convection in Jeffrey nanofluid: Darcy-Brinkman model

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ABSTRACT
The subject under consideration in this research has various geophysical and astrophysical applications. Specifically, we investigate the impact of variable gravity on the onset of thermal instability within a layer of Jeffrey nanofluid confined in a Darcy-Brinkman porous medium. The solution of the fluid layer, which is positioned between two free-free boundaries, is determined using a linear stability analysis employing the normal mode technique. The Rayleigh number on the onset of convection is derived by using the Galerkin method. For stationary convection, the effects of different variable gravity parameters on the Jeffrey parameter, Darcy-Brinkman number, Lewis number, moderated diffusivity ratio, porosity of porous media and nanoparticle Rayleigh number are analyzed and presented graphically. The choices of using Jeffrey nanofluid as the base fluid for the study add novelty. Non-Newtonian fluids encompass a diverse range of substances, such as engine oils, oil extraction, wallpaper paste, and various biological liquids like blood etc.

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KEYWORDS
Darcy-Brinkman model; Galerkin technique; Jeffrey nanofluid; porous medium; variable gravity

1. Introduction

Thermal instability problems have attracted significant interest during the last few decades because of their importance in various applications such as geophysics, soil sciences, ground water hydrology, astrophysics, food processing, oceanography, limnology and engineering etc. By examining various forms of fluids, several researchers have looked at issues with thermal instability. Chandrasekhar [1] provided a thorough explanation of how a Newtonian fluid might become thermally unstable under various hydrodynamic and hydromagnetic assumptions. Ranganathan and Viskanta [2] studied boundary-layer flow with mixed convection along a vertical surface embedded in a porous medium while Thermal instability occurring in a heat-generating porous bed with a horizontally layered fluid studied by Poulikakos [3]. Nguyen et al. [4] investigated double-diffusive convection in anisotropic porous media with layered structure.

Ingham et al. [5] as well as Nield et al. [6–8] provided a helpful review of the instability issues in a porous media.

The word "nanofluid" was initially defined by Choi [9]. Nanofluids consist of suspended nano-sized particles which are generally made up of metals, metal oxides and metal carbides. Recent work on nanofluids by taking into account of nanoparticles aggregation are done by Shah et al. [10–12], Awan et al. [13–15], Ali et al. [16,17] and Akbar et al. [18]. Convection of nanofluids was scrutinized by Buongiorno in [19] and Buongiorno's model has attracted great interest in the recent years. Buongiorno's model was later studied by the experts [20–35]. Later, Rana [36] and Rana and Gautam [37] looked into the thermal instability of Jeffrey nanofluid. A Maxwellian

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THERMAL CONVECTIVE INSTABILITY IN A JEFFREY NANOFLUID SATURATING A POROUS MEDIUM: RIGID-RIGID AND RIGID-FREE BOUNDARY CONDITIONS

TERMIČKA NESTABILNOST KONVEKCIJE KOD POROZNE SREDINE ZASIĆENE JEFFREY NANOFLUIDOM: GRANIČNI USLOVI SU KRUTO-KRUTO I KRUTO-SLOBODNO

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Keywords
- nanofluid
- Jeffrey model
- Rayleigh number
- porous medium
- convection

Abstract

In this paper, the onset of stationary convection in a porous layer saturated with a thermally unstable Jeffery nanofluid is considered. The behaviour of the nanofluid is described by using a Jeffrey fluid model and the porous layer is assumed to adhere to Darcy's law. The momentum-balance equations for the fluid are modified by the Jeffrey parameter and nanoparticles. Linear stability analysis, the normal modes analysis, and Galerkin type weighted residual method (GWRM) techniques are used to calculate the dispersion relation for the Rayleigh number in terms of various parameters for rigid-rigid and rigid-free boundaries. The effects of the Rayleigh number of nanoparticles, Lewis number, modified diffusivity ratio, Jeffrey parameter, and porosity are investigated analytically and graphically.

Ključne reči
- nanofluid
- Jeffrey model
- Rejlejev broj
- porozna sredina
- konvekcija

Izvod

U ovom radu se razmatra uslov za stacionarnu konvekciju u poroznom sloju, koji je zasićen termički nestabilnim Jeffrey nanofluidom. Ponašanje nanofluida se opisuje primenom modela Jeffrey fluida, a porozni sloj se tretira prema zakonu Darcy-ja. Ravnotežne momentne jednačine za fluid se modifikuju Jeffrey parametrom i nanočesticama. Primenjene su metode: analiza linearne stabilnosti, analiza u normalnom modu, analiza težinskim ostatkom tipa Galerkin (GWRM), za proračun relacije disperzije za Rejlejev broj, u uslovima različitih parametara za granice kruto-kruto i kruto-slobodno. Uticaj Rejlejevog broja nanočestica, Lewis-ovog broja, modifikovanog odnosa difuznosti, Jeffrey-ovog parametra i poroznost su istraženi analitički i grafički.

INTRODUCTION

Non-Newtonian fluids are extensively utilised in many different industries and have significant applications in many different branches of science and technology, including the production of plastics, the polymer industry, textile and paper dyeing, food processing, geophysics, the chemical and biological industries. Examples of non-Newtonian fluids include engine oil, soap solutions, sauces, foam, paints, lubricants, and biological fluids like blood. The modelling of non-Newtonian fluids has produced a number of constitutive relations due to the importance of non-Newtonian fluids in contemporary technology and industry. The Jeffrey non-Newtonian fluid model is one of these constitutive relations. A linear model called the Jeffrey fluid model substitutes time derivatives for convective derivatives. Jeffrey /4/ investigated the stability of a fluid layer that had been heated from below. He came up with a numerical solution to a few issues with the stability of a layer in a compressible fluid as temperature rises. Chandrasekhar /3/ has provided a thorough literature assessment on thermal instability in a Newtonian fluid. The Jeffrey fluid model has been researched by numerous researchers and as a result, it is today regarded as the best fluid model to represent the behaviour of physiological and industrial fluids, /1, 5, 10-13, 16/.

The flow of a fluid through a homogenous and isotropic porous medium is governed by Darcy's law that states that the usual viscous term in the momentum-balance equations is replaced by the resistance term, where the viscosity is the medium permeability, is the Jeffrey parameter and is the Darcian (filter) velocity of the Jeffrey fluid. The study of flow in porous layers has many real-world applications, including flow in molten earth cores, oil reservoirs, tires, ropes, cushions, chairs, and sand beds. Examples of naturally porous materials include sandstones, limestone, human lungs, bile ducts and gallbladders containing blood vessel stones. The convective flow in a porous material was researched by Lapwood /7/. The Rayleigh's instability of a thermal boundary layer in a flow through a porous media was explored by Wooding /21/. They discovered that the layer is stable under certain conditions, including a critical positive Rayleigh number for the system and a limited wave number for the critical neutral disturbance. Nield and Bejan /9/ worked on the problem of thermal convection in a porous medium.

The Buongiorno /2/ model-based investigation of hydrodynamic thermal convection issues in porous and non-porous

IMPACT OF POSITIVE INDUSTRIAL RELATIONS ON THE PERFORMANCE OF LABOUR IN THE PHARMACEUTICAL INDUSTRY IN INDIA

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ABSTRACT

The pharmaceutical industry in India stands as a cornerstone of the nation's economy, marked by its significant growth and global presence. Within this industry, the performance of labour is pivotal, necessitating a nuanced understanding of the role of industrial relations in shaping productivity and efficiency. This research delves into the impact of positive industrial relations on labour performance within the Indian pharmaceutical sector. By analysing various facets such as employee satisfaction, organizational culture, and labour-management collaboration, this paper elucidates how fostering constructive industrial relations can amplify labour productivity and contribute to the overall success of the industry. The study draws on extensive literature review and empirical evidence, offering insights and recommendations for industry stakeholders.

Keywords: Industrial Relations, Labour Performance, Pharmaceutical Industry, India, Employee Satisfaction, Organizational Culture

INTRODUCTION

Industrial relations refer to the interactions between employers, employees, and relevant stakeholders within an organizational context. This encompasses various aspects such as employment contracts, collective bargaining, dispute resolution, and workforce management practices. In the pharmaceutical industry, effective industrial relations are crucial for ensuring compliance with regulatory standards, fostering innovation, and maintaining a skilled workforce. The pharmaceutical industry in India has witnessed remarkable growth, emerging as a global leader in the production and export of pharmaceutical products. Amidst this growth trajectory, the performance of labour stands as a critical determinant of the industry's success. Industrial relations, encompassing the dynamics between employers and employees, play a pivotal role in shaping labour performance. This paper aims to explore the impact of positive industrial relations on labour performance within the Indian pharmaceutical industry, offering insights into the mechanisms through which constructive relations contribute to enhanced productivity and efficiency. The pharmaceutical industry stands at the intersection of scientific innovation, regulatory scrutiny, and commercial competitiveness. Within this dynamic landscape, industrial relations play a pivotal role in shaping organizational dynamics, employee engagement, and overall performance. This paper provides a comprehensive analysis of industrial relations within the pharmaceutical industry, examining the key factors influencing labour-management interactions, regulatory compliance, and workforce dynamics.

REVIEW OF LITERATURE

Industrial relations in the pharmaceutical industry are crucial for fostering a collaborative and productive work environment amidst the complex landscape of research, development, and regulatory compliance. Industry 4.0 has revolutionized pharmaceutical manufacturing by integrating AI, IoT, robots, cloud computing, and big data analytics. These technologies have simplified production processes, improved medical diagnosis, and led to self-sufficient industries. They have resulted in personalized products, improved vaccine quality, and reduced pollution. Industry 4.0 bridges the gap between real and virtual worlds, reducing study work and establishing a sustainable pharmaceutical supply chain **(Sharma et al., 2023)**. The pharmaceutical firms in India have been confronted with several obstacles on a variety of fronts. As a result of the medication price control order, which regulates the pricing of pharmaceuticals in the domestic market, there is a significant amount of pressure on

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AN IMPLICATION OF CHANGING RURAL STRUCTURE ON EMPLOYMENT AND GROWTH IN INDIA

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ABSTRACT

Villages are the lifeline of India as 65% of country's population lives in the rural areas. Rural economy contributes 25-30 per cent to the GDP. Rural development focuses on creating economic opportunities in rural areas through initiatives such as skill development, agricultural innovation, and the promotion of rural industries. By generating income and employment opportunities, rural development plays a crucial role in reducing poverty and promoting sustainable livelihoods. The use of digital tools and communication technologies can enhance productivity, promote financial inclusion and bridge the information gap between rural and urban areas. Sustainable and inclusive rural development not only benefits the rural population but also contributes to the overall socio-economic development of a nation.

1. Introduction

Employment generation is the cornerstone of the economic development of any nation. India is a country of villages and majority of the population of rural India still depends mainly on agricultural work for their livelihood. Presently, emphasis is being laid on setting up of public utility facilities in rural areas along with the development of transport facilities, electrification, housing roads and connectivity routes, have made it easier for rural people to get suitable employment at the local level. At the village level, Increase in economic activities is in turn increasing the rate of economic growth and thereby reducing the poverty level in the rural sector.

One of the objective or priorities of the Modi Government are to remove the imbalance between urban and rural India and the dream of five trillion economies cannot be achieved without including villages. As per the Census 2011, India's total population is 121.02 crore, of which 68.84 per cent (83.31 crores) live in the rural areas and only 31.16 per cent (37.71 crores) in the urban area (Registrar General & Census Commissioner, 2012).

(3)

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WOMEN EMPOWERMENT THROUGH SELF HELP GROUPS IN HIMACHAL PRADESH

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ABSTRACT

Development of a nation is very much dependent on the development of rural people. Today, the real problem faced by every developing country like India is the poverty. Nearly half of the available human resource in India is women. Majority of them are living in rural areas and most of them are illiterates and are below poverty line. Besides this in comparison to urban women, rural women have limited access to all kinds of resources such as education, transportation, training, financial support, availability of current information etc. but have more hidden talents, which have to be bought in to light. Hence, there is need to change their capacity to work by giving them the necessary trainings on income generating activities, bringing their talents into light, supporting them with financial facilities, giving them marketing knowledge, current information etc. which helps in increasing knowledge, enriching their skills and improve their economic status.

1. Introduction

Poverty and unemployment are the major problems of any underdeveloped countries, to which India is no exception. Poverty has been a pervasive problem in India. Around one-third of our people do not have the basic resources for survival. Most of the poor people live in villages, which have an extremely thin presence of financial institutions and Government machinery. The battle against poverty, therefore, needs to be fought, harnessing the local resources following an appropriate methodology. Lack of basic resources hits the women directly, and through her, her present and future progeny **(Ponnarasi, 2011)**[1].

For smooth and overall development of the nation, it is necessary to stimulate the banking system at micro level so that banking services can be insured easily accessible to the vast sections of disadvantaged and low income groups at affordable cost in a fair and transparent manner. The financial sector reforms in India with financial inclusion emerging as a major

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STRESS MANAGEMENT: A STRATEGY WITH REFERENCE TO HAPPINESS

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1. Introduction

Stress is a normal human reaction that happens to everyone. In fact, the human body is designed to experience stress and react to it. When you experience changes or challenges (stressors), your body produces physical and mental responses. Stress is the way human beings react both physically and mentally to changes, events, and situations in their lives. People experience stress in different ways and for different reasons. The reaction is based on your perception of an event or situation. If you view a situation negatively, you will likely feel distressed—overwhelmed, oppressed, or out of control. Distress is the more familiar form of stress. The other form, eustress, results from a "positive" view of an event or situation, which is why it is also called "good stress."

Emotional wellbeing is the foundation of happiness. Each one of us experiences multiple emotions in our daily lives. According to experts, negative emotions lead to stress. This can be because of bad interaction with someone or some unpleasant situation, too much work, or even due to too much of everyday hassles like being stuck in long traffic jams. Negative emotions can impact both mental and physical health of people and so it is important to manage these emotions. But how can one deal with negative emotions like stress, ego and fear.

Stress Is the Ratio of Emotional Pressure and Inner Resilience

Each one of us responds to situations differently due to the difference in the coping powers. Something that is stressful for person may not be a matter of concern for someone else. For example, for a child the reason for stress could exams, for a professional it could be a target, in a relationship it could be getting along with the other person. A lot of these pressures are not in our control. It is important to note that the intensity of stress can differ with respect to our attitude towards it. We must learn to be more resilient because how much inner resilience or coping power we can have, is in our control.

6.7 (iii) Citations

6.7

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Fluid Mechanics Nanofluid Convection in porous media

FOLLOWING

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Effect of variable gravity on thermal convection in Jeffrey nanofluid: Darcy-Brinkman model PL Sharma, D Bains, GC Rana Numerical Heat Transfer, Part B: Fundamentals 85 (6), 776-790	18	2024
On thermal convection in rotating Casson nanofluid permeated with suspended particles in a Darcy-Brinkman porous medium PL Sharma, D Bains, GC Rana Journal of Porous Media 27	1	2024
Effect of variable gravity on thermal convection in rotating Jeffrey nanofluid: Darcy-Brinkman model D Bains, PL Sharma, GC Rana Special Topics & Reviews in Porous Media: An International Journal 15, 25	3	2024
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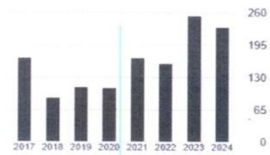

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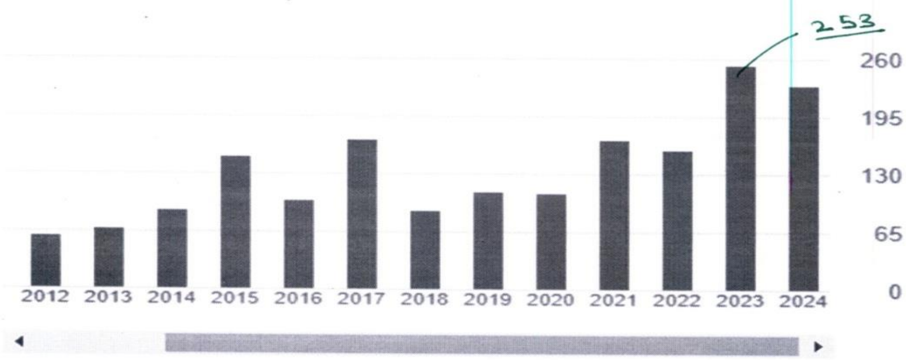

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