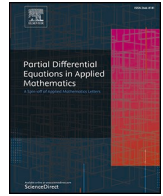




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A comprehensive review on the Dynamical behavior of heat and fluid flow mechanism: Thermal performance across different geometries

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ABSTRACT

The prominent novelty of current review is to exhibit the fluctuating and oscillatory convective heat transfer properties along various geometries with magnetic force, variable density, Prandtl number, buoyancy force and magnetic Prandtl number effects. The significance of present work is to illustrate a comprehensive review on transient convective heat transfer. Transient convective heat transfer plays an essential role in various technological and environmental applications, including climate control, structure safety, engines, thermal control, computer heating and cooling, and energy safety. The literature primarily focuses on steady temperature and velocity domains, with few studies exploring time-varying fluid flow in forced, natural, or mixed convective mechanisms with different methods. In current review, justification of results was performed by using oscillating stokes conditions directly in partial differential models. The similarity variables and stream functions are used in literature but in current review, the primitive variable transformation is used with implicit form of finite difference method and Gaussian elimination technique through FORTRAN and Tecplot-360 programming tools. The governing model is reduced into steady, real and imaginary form to explore steady and oscillating convective heat transmission. Transient flows have gained significance due to their ability to achieve large oscillating convective heat transfer rates. Compared with steady movement, oscillating flows exhibit higher velocity variations along the heated surface. Periodic flow produces an improved transient surface heat transmission rate than steady flow. Predicting and controlling transients in thermal exchangers requires a concept of transient forced convection heat transport. Transient convective thermal transmission solutions are important for ensuring the effectiveness and reliability of electrical components, nuclear and thermal power stations, heat-generating engines, steam turbines, condensation systems, catalytic converters, heat shielding for spacecraft, electrical devices, internal combustion engines, air conditioning and refrigerator components, cooling networks for batteries, generators, and transformers. It is found that the frequency of convective heat transport enhances through periodic and oscillating stokes variables. It was depicted that the higher amplitude in convective heat transfer was displayed for each choice of magnetic force parameter around two angles $\pi/4$ and π of circular magnetized surface. It was depicted that the maximum transient convective heat transmission was reported along vertical angle $\pi/2$ with buoyancy force, Prandtl and magnetic Prandtl values.

1. Introduction and literature

The novelty and significance of current review analysis is to show the importance of shear stress, heating rate and rate of mass distributions for unsteady/transient flow behavior of viscous fluid and nanofluid through

different prominent geometries. The theme of present review is to display the oscillatory frequency in heating rate and fluctuating behavior of nanoparticles. The transient and oscillatory fluid flow mechanism is very important in temperature oscillation techniques to estimate the thermal diffusivity of a fluid through different structures.

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The transmission of heat in the movement of unsteady/transient liquids has significance in the production methods of polymers, air conditioners, polyethylene strategies, extruding and the infusion issues, food, pharmaceuticals, rubber, rubber materials, alloys, petroleum-based products, fossil fuels, tooling, and technological textiles. Researchers have been interested in oscillating flow heat transmission for almost four decades due to significant improvements in the effectiveness of heat exchangers, MHD generators, nuclear reactors, aerodynamics, horizontal plate streams; finned tubes and twisted cylinders, and electronic devices. Unsteady behavior of heat transfer has prominent applications in heat exchangers, MHD generators, microchip, cooling devices of electro-mechanics, thermal power plants, transformer coils, batteries, spacecraft, missile technologies and many other industrial uses. Chawla¹ studied the laminar boundary layer on a magnetically charged surface as the electromagnetic field fluctuated around a steady non-zero mean. In the region of low frequencies, the phase-angles and amplitudes of skin-friction fluctuations initially grow before decreasing to their appropriate "skin-wave" levels. An approximately response was found for the average and oscillating velocity distributions in the boundary layer of a flat surface with a periodical source of turbulence around the leading edge in². Because the oscillating boundary layer is a significant fraction of the ordinary layer thickness and remains close to the surface. The oscillatory velocity behavior in boundary layer along the flat plate was displayed by using the Lin's linearization method. Ishigaki³ conducted analytical investigation on periodical-based properties of the laminar boundary layer around a 2-dimensional stagnating point, where the motion of the oncoming flow compared to the body fluctuates. The time-mean velocity distributions and skin friction were analyzed in comparison to the small-amplitude condition. It was noted that the time-mean heating rate decreases for small frequency and increases at high frequency along vertical plate using Lin's theory and method. Later, Ishigaki⁴ conducted an investigation on the heat wave characteristics around a 2-dimensional stagnant point with main-stream oscillations, expanding on the earlier velocity-field research. Mohanty⁵ examined how electromagnetic field fluctuations affected boundary layer movement over a magnetized plate. It was noticed that the surface current density was not affected by magnetic field variations along flat plate using Lighthill's technique. Dwyer and Mccroskey⁶ conducted physical and computational research on oscillating boundary-layer movement on a circular cylinder with a Reynolds value of 1.06×10^5 . The significant and strong asymptotic steady results were observed around circular cylinder by using unsteady components. Menendez and Ramaprian⁷ proposed a simple, effective, and reliable finite difference approach to solve fluctuating boundary layer problems for laminar and oscillating streams. The quasi-linearization method was used to handle

the periodical turbulent boundary layers. Helmy⁸ investigated the unsteady flow of electric-conductive viscous fluid motion along the non-conducting permeable plate and displayed the magnetic distributions for magnetic Prandtl number. By using similarity variables, harmonic terms and hyper-geometric functions, the analytical results were secured along non-conducting plate. Ashraf et al.⁹⁻¹⁰ investigated the influence of radiations on the oscillating hydro-magnetic natural convection movement of a dense, inflexible, electric-conducting fluid over a magnetically vertical plate with oscillating magnetization field and oscillating surface temperature. To explore the stability in transient convective heating rate and oscillating current density, finite difference method was used by applying Gaussian elimination approach. Some related geometries are given in Fig. 1.

The importance of this mechanism of transient heat transmission is well understood in technologies such as Stirling engines, cryogenic refrigerators, and pulsed-tube cry coolers. Additionally, improving the movement of heat using oscillating motions is critical in a wide range of chemical and mechanical industries that demand a small, productive system. Transient heat transfer effectiveness improves significantly due to the combination of increased transient heat convection and conduction caused by flow fluctuation in the context of temperature gradients. The prominent challenges in transient convective heat transport problems are described below.

- How oscillatory flow of viscous fluid and various nanoparticles influences the heating rate?
- How transient flow of viscous liquid enhances the oscillating frequency of heat transmission?
- How governing parameters affect the oscillating convective heat and current density?
- How mixed convection and thermal density parameter examines the transient heat rate?
- How Prandtl number, magnetic force, viscous dissipation and porous medium parameter shows maximum behavior of oscillatory heat transfer?
- How heat transfer increases along various angles of inclined surface?
- How different geometries affect the convective oscillatory heating rate?

Computational findings for periodical flow separation of convection-conduction along the outermost layer of a heated spherical with viscous dissipations were obtained by evaluating the mathematical models for movement using the implicit finite difference computational method.¹¹ The author¹² conducted a computerized simulation of the effect of transient shearing stresses on the frequency of thermal transport across

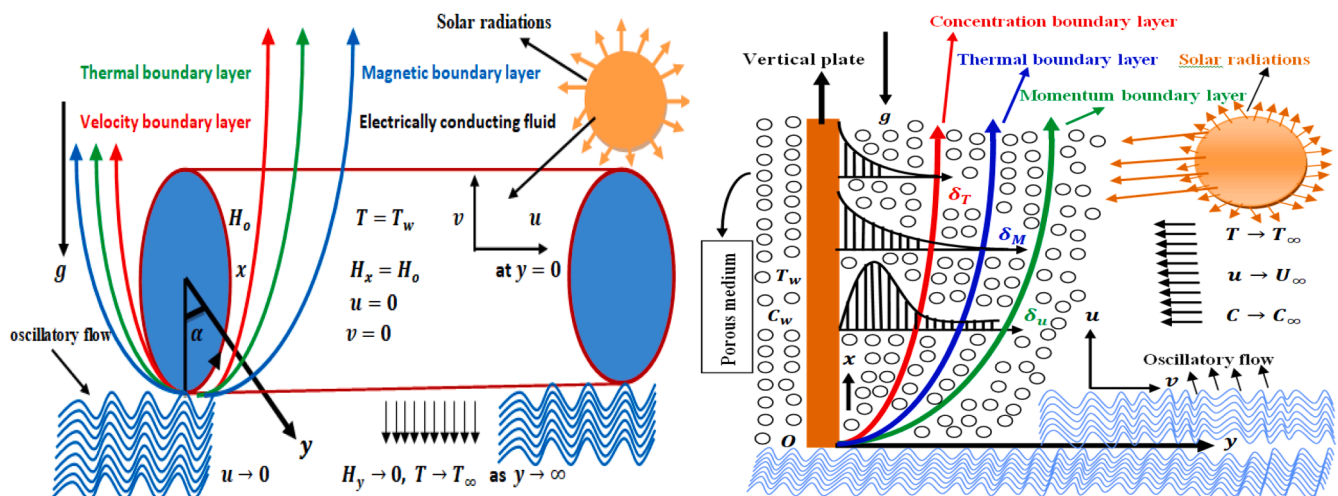


Fig. 1. Flow pattern along circular cylinder and vertical plate.

different places on the circumference of the sphere. By using Gaussian elimination technique with finite difference approach, the transient shear stress and transient heating rate along magnetized sphere was reported with prominent results.

In Fig. 2(a, b, c), Ullah et al.¹³⁻¹⁵ highlighted the importance of oscillating mixed convective stratification flow and thermal transfer properties at various points of a non-conducting stationary circular cylinder with MHD, variable density and thermal stratification effects. The fluctuations in magnetic flux and periodical heat transport were displayed with maximum amplitudes by using finite difference method with Gaussian elimination technique and oscillating stokes conditions. In Fig. 3(a, b, c), Ilyas and Ashraf¹⁶⁻¹⁸ emphasized the importance of periodical free/forced convection movement and heat transmission properties over the surface of a magnetically cone to estimate the oscillations, amplitudes and periodical patterns in magnetic flux. The steady profiles of velocity, magnetic field and temperature variations were used to estimate the oscillatory shear stress, oscillatory heating rate and oscillatory magnetic flux along magnetized cone. The investigation of oscillating nanofluid movements is important in a variety of programs, including food manufacturing, turbines, refrigeration, and chemical-based fluids. Oscillatory convective heat transfer have several usages in biology and industry, including blood circulation, foodstuff interaction, colors, polymerization responses, radioactive fuel liquids, and metallic liquids and ceramics. Unsteady viscous liquids have viscous qualities; examples include motor oil, vegetable oil, mineral oil, lubrication, and polymeric materials. These liquids have key roles in vehicles, electrical chemistry, plastic remedies, and biomechanics. Oscillating flows have an essential effect on the efficiency of heat transmission in various industries, including technological air conditioning, nuclear-powered reactors, transportation, micro-electro mechanical networks, radiators, chemical-based catalyst power plants, fiber and granular insulating material, compacted beds, crude oil storage tanks, radioactive waste sources, and medical devices.

Phase angles, fluctuations, amplitudes and transient sequence in heat transmission were investigated with the effect of a smaller gravitational force and MHD on fluctuating mixed convective-conductive fluid movement across a heated horizontally stationary cylinder in.¹⁹⁻²⁰ The magnetized and non-conducting circular cylinder was used to examine the fluctuating behavior of skin friction and fluctuating heating rate by applying finite difference method with transient stokes conditions and Gaussian elimination approach through FORTRAN and Tecplot-360 software. The implications of surface temperature, MHD, porous medium, buoyancy forces, and viscous dissipations on transient viscous fluid and nanofluid motion along vertical cone, stationary cylinder and plume has been illustrated in²¹⁻²³ to depict the transient convective heat and mass transmission. The plume and magnetized cone surface was used to sketch the oscillatory nanoparticle concentration, oscillatory mass rate, oscillatory heating rate and oscillatory skin friction by applying finite difference approach and Gaussian elimination technique.

Physical characteristics like temperature, velocity, and electromagnetic field profiles, as well as periodical shear stresses, transient heat transmission, and transient magnetic flux, have been represented for various governing variables in the thermal and water flow system in.²⁴⁻²⁵ The curved surface and magnetized vertical cone was used to analyze the transient convective heat transmission, reaction rate and mass rate by applying finite difference scheme. Khan et al.²⁶ designed a measurement of the oscillating thermal and magnetic flux of mixed convection flow across a straight, non-magnetic cylinder with viscosity and heat conductivity impact. The combined effects of variable viscosity and thermal conductivity with induced magnetic field were applied on electrical conducting water-based liquid to analyze the oscillatory current density and oscillatory heating rate. Khedher et al.²⁷ studied how heat sources and sinks and electromagnetic hydrodynamics affect the oscillation and periodical heat exchange and electrical density features of viscous fluids in a stationary cylinder. The impact of convective heat parameter, small gravitational forces, radiations, MHD, viscous dissipations and thermal viscosity on oscillating and transient heat and mass transport along the stretching, circular and inclined surface has been discussed in.²⁸⁻³⁰ The inclined plate, stretching cylinder and magnetized vertical plate was used to report the oscillatory shear stress, oscillatory mass rate and oscillatory heating rate with small gravitational and Lorentz forces.

In Table 1, the effect of buoyancy force, Prandtl and magnetic Prandtl on amplitude of transient heat transfer is derived by.³¹ The oscillating, transient, phase angle and amplitude behavior of conducting and viscous fluid motion of heat and mass transport along the heating plate, stationary magnetic and non-magnetic cylinder has been studied in³²⁻³⁴ with small gravitations and stratification impact. To illustrate the maximum oscillations and amplitude in convective heat and mass transport, the impact of solar radiations, joule heating, heat generation, and surface heat flux on classical fluid and nanofluid through various geometries has been investigated in.³⁵⁻³⁹ El-Zahar et al.⁴⁰ produced wave fluctuations by concentration nanoparticles across an inclined surface with low gravity force. Li et al.⁴¹⁻⁴⁴ reported the radiating polarized movement of Maxwell nanofluid, which was created by expanding the surface. The temperature domain exhibits a rising pattern with heat Biot and Dufour coefficients. Higher Maxwell variables have an opposing influence on the distribution of the flow. The heating characteristics of Eyring Powell substance in the presence of dust nanoparticles were investigated. It was discovered that the knowledge of peristalsis in the framework of Ree-Eyring fluids has the ability to impact a variety of scientific and healthcare uses. Additionally, for both suction and injection impacts, porous factors improve flow rate while decreasing heat transmission and drag pressures. Later, Li et al.⁴⁵⁻⁴⁸ investigated Lie similarity substitutions for turbulent flow in a thin film influenced by its internal temperature and radiant heat. The fluid temperature and velocity characteristics were displayed by creating homotopic techniques to the given mathematical models.

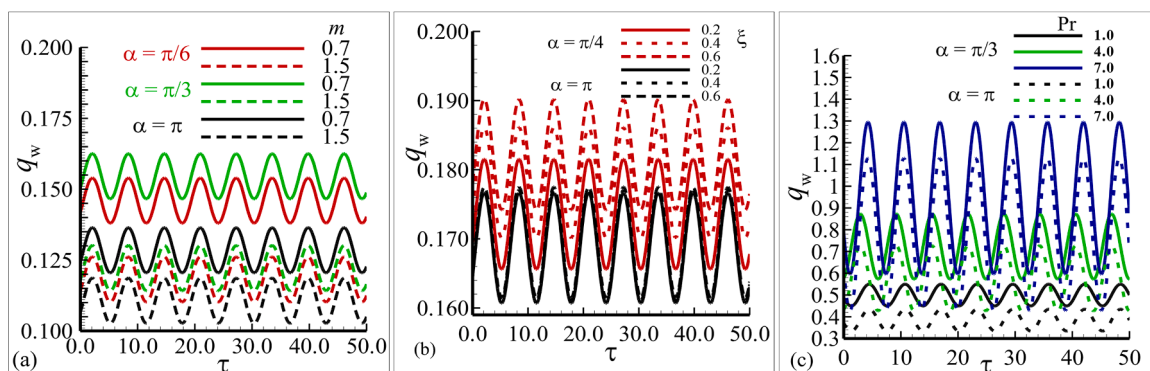


Fig. 2. (a, b, c) Effect of variable density, magnetic force and Prandtl number on transient heat transfer.

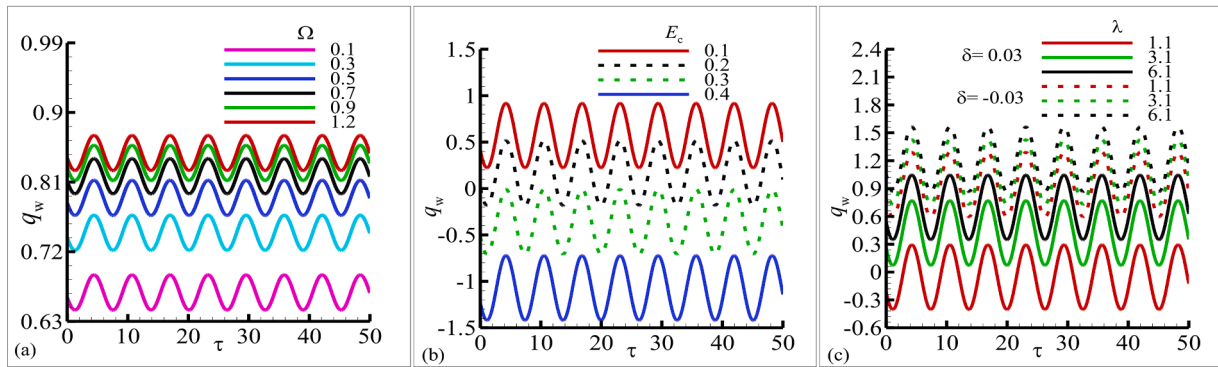


Fig. 3. (a, b, c) Effect of porosity, Eckert number and buoyancy force on transient heat transfer.

Table 1

Effect of buoyancy force, Prandtl and magnetic Prandtl on amplitude of transient heat transfer.

α	A_t		A_t		A_t	
	$\lambda = 0.5$	$\lambda = 1.1$	Pr= 0.5	Pr= 1.0	$\gamma = 0.5$	$\gamma = 1.5$
$\pi/6$	1.2997	1.3939	3.1616	2.5048	1.1595	1.5474
$\pi/4$	1.3388	1.4781	3.9610	3.0536	1.2496	1.6282
$\pi/2$	1.3849	1.5759	4.8364	3.6600	1.3533	1.7226
$3\pi/4$	1.3702	1.5448	4.5634	3.4704	1.3204	1.6925
$5\pi/6$	1.3056	1.4067	3.2873	2.5908	1.1733	1.5597
π	1.2272	1.2355	1.4174	1.3440	0.9867	1.3969

2. Conclusion

Transient convective heat transfer is clearly appropriate for use in actual energy transmission operations, as it has the ability to improve heat transmission in a wide range of conventional and manufacturing processes. Engineers have the potential to build extremely portable and efficient temperature transfer systems. The current paper provides an overview of prior work for distinct fluctuating turbulent flow rates and heat transmission for various thermal and fluid properties. The effects of several parameters along different geometries and thermophysical properties of thermal fluid, thermal boundary conditions and types of transient convective heat transfer are investigated. Previous studies showed that the transient convection heat transfer have many parametric implications of surface temperature, magnetohydrodynamics, porous medium, buoyancy forces, and viscous dissipations, and nano-fluid motion along vertical cone, stationary cylinder and plume. Physical characteristics like temperature, velocity, and electromagnetic field profiles, as well as periodical shear stresses, transient heat transmission, and transient magnetic flux, have been represented for various governing variables in the thermal and water flow systems. The oscillating, transient, phase angle and amplitude behavior of conducting and viscous fluid motion of heat and mass transport along the heating plate, stationary magnetic and non-magnetic cylinder has been reported. To illustrate the maximum oscillations and amplitude in convective heat and mass transport, the impact of solar radiations, joule heating, heat generation, and surface heat flux on classical fluid and nanofluid through various geometries by different authors has been investigated. The main key findings are discussed below.

- Significant oscillating sequence in convective heat transmission was reported for each value of variable density parameter along each angle $\pi/6$, $\pi/3$ and π of inclined surface.
- It was depicted that the higher amplitude in convective heat transfer was displayed for each choice of magnetic force parameter around two angles $\pi/4$ and π of circular magnetized surface.

- Small layer of oscillating convective heat transfer was noted for lower Prandtl value but maximum fluctuating heat transmission was sketched for higher Prandtl values along vertical surface.
- The minimum oscillations in heat rate were observed for each porous medium parameter but significant amplitude and oscillation in convective heat transfer was displayed for Eckert factor and mixed convection factor.
- It was depicted that the maximum transient convective heat transmission was reported along vertical angle $\pi/2$ with buoyancy force, Prandtl and magnetic Prandtl values.

Author contributions

All authors have equal work. All authors have read and agreed to the published version of the manuscript

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Declaration of competing interest

There is no conflict of interest in the data used in this study.

Data Availability

Data will be made available on request.

Acknowledgments

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