

Numerical Study Of Thermal Distribution Over A Moving Rod

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ABSTRACT

An analysis is made to examine the transient thermal distribution via a moving rod by considering internal heat generation depending on temperature and constant temperature dependent thermal conductivity. By modelling the energy conservation equation with constant boundary conditions and initial conditions, the characteristics of convection, conduction, and radiation through a moving rod are examined. By using all of the non-dimensionalized parameters, the energy equation is reduced to a PDE. The effects of heat generation, temperature ratio, and conductive parameters on thermal profile are discussed in detail. The built-in Matlab function bvp4c is used to compute the numerical results and the resulting values are shown through graphs and tables.

Keywords: Transient Heat Transfer, Moving Rod, Temperature-Dependent Thermal Conductivity, Internal Heat Generation, Convection-Conduction-Radiation, Non-Dimensional Pde, Bvp4c Method, Thermal Profile

INTRODUCTION

Heat transfer is the movement of thermal energy from a location with greater temperature to one with lesser temperature. A non-equilibrium process for which temperature difference or gradient acting as a driving force. Further, this process is helpful in the prediction of distribution in temperature and to figure out the rate at which energy moves through a certain given surface.

The process of heat transfer plays a significant role in the field of engineering and in different industries for manufacturing processes, but its transmission is the main problem, and improving heat transportation has become a top priority. Numerous researchers proposed different techniques and procedures through which the performance of heat transfer is enhanced. Such techniques include the use of an extended surface, nanofluids, hybrid nanofluids non-metallic coating and cooling fluids

in industrial processes. The increasing application of advanced computational and analytical techniques in engineering has also expanded the scope of technological optimization in modern infrastructure and industrial systems. Recent work on AI-enhanced infrastructure optimization demonstrates the growing role of computational approaches in improving the design and management of technologically complex engineering systems [12].

Numerous research addressing different aspects of heat transport have been published in the literature. In recent years, the study of heat transmission through a continuously moving material has grown in importance. The thermal distribution through continuously moving material has been the subject of numerous study. Usage of moving rod is a quick and easy way to improve heat transfer. Previous research have already addressed the steady-state heat transport through a moving material using an analytical and numerical technique that incorporates linear thermal conductivity. More broadly, modern engineering systems increasingly rely on computational techniques to monitor and optimize industrial processes. The development of AI-driven predictive maintenance in smart manufacturing illustrates the growing importance of computational analysis for understanding system behaviour, improving operational performance, and anticipating changes in engineering processes [21].

It has not yet been studied how non-linearly variable temperature-dependent thermal conductivity can be used to generate internal heat during transient heat transfer within a moving rod. So, the transference of heat via a moving rod by taking into account the power law function of thermal conductivity and internal heat generation depending on the temperature is explained in present research.

In the present thesis, we reviewed the research paper “Numerical Study of thermal distribution over a moving rod”. The research work is an attempt to go through the basic concepts about the transference of heat via a moving rod by taking into account the power law function of thermal conductivity and internal heat generation depending on temperature. We have considered convective heat transfer in this research and discussed the features of convection, conduction, and radiation through a moving rod which are analyzed by modelling the energy conservation equation. By using MATLAB software built in bvp4c function, we finally find out the results in graphical form. The increasing integration of artificial intelligence and advanced analytical techniques into modern engineering and operational systems further demonstrates the importance of computational approaches in contemporary problem-solving. Recent research on digital transformation highlights the role of artificial intelligence and advanced business analytics in improving analytical and operational decision-making [4]. Such developments provide a broader technological context for the numerical and computational analysis adopted in the present study.

Similarly, the increasing use of machine learning and business intelligence illustrates the broader movement toward data-driven analysis and computational decision-making in contemporary technical and operational environments[17]. These developments reinforce the relevance of numerical and computational tools for analysing complex systems whose behaviour depends on multiple interacting parameters.

The application of predictive computational approaches is also evident in areas such as supply-chain risk intelligence, where advanced analytical models are used to

anticipate disruptions and support decision-making under changing conditions [13]. Although these applications differ from thermal modelling, they demonstrate the wider use of computational and predictive techniques for analysing complex systems and supporting evidence-based engineering and operational decisions. Chapter 1

Preliminaries

Elementary concepts

This chapter firstly includes literature review, as well as some basic terminologies, definitions and equations relevant to important topics that will be covered in next chapter are also illustrated.

Literature Review

One of the key areas of study in the field today is the heat transfer process. Heat transmission process is initially noticed in condensers for the production of electricity and in the generation of steam which is used in engines of tanks. Later on, the petrochemical and petroleum sectors used heat exchangers for heat transfer processes. Several researchers looked into how to increase the rate of heat transmission. They discovered that employing unique liquid types: Nanofluid and hybrid Nanoliquid that contain small nanoparticles can provide a better rate of heat transfer than using base fluids. Magnetic dipole's impact on Nanoliquid by considering the transportation of heat and mass across an inclined surface was recently explained by Khan et al. [1]. Analysis of heat transference by thermal radiation, the steady state and forced convection propagation of a hybrid Nanoliquid over an elongated surface were described by Mabood et al. [2]. The substance's total surface area is increased by joining additional area to the central surface, which is an alternative method of achieving a high heat transfer rate. The thermal properties of a moving fin in which heat is transferred by convection and radiation by considering thermal conductivity depending on the temperature was explained by Dogonchi and Ganji [3]. The transferal of heat through a porous fin with the influence of radiation, magnetic field and thermal conductivity which changes with temperature was investigated by Madhura et al. [4]. The thermal distribution and one-dimensional transfer of heat of a fin with a power-law exponent of heat transfer coefficients were studied by Sun and Li [5]. The influence of electromagnetic effect on the heat which is transmitted via a porous fin was discussed by Das and Kundu [6]. Significant applications including casting, plastic extrusion, hot rolling, and wire drawing where a substance travels through a combustion chamber or a vessel, it exchanges heat with the air around it are linked to continuous moving surfaces.

A high-temperature material experiences a brief mechanism of conduction with loss of heat from the surface as it comes out from a heating system and exposed towards a reduced temperature. In the first instant, the materials which move slowly starts disappearing as time goes on, and the system gradually stabilizes. Conversely, if the substance moves quickly, the distribution of temperature could keep going to change over the course of the thermal treatment process. For these mobile substances, convectional coefficients of heat transmission plays an important role in the heat transference mechanism. Next, a theoretical framework which gives an energy equation with surface dispersal of heat, an interior heat source, heat conduction, and heat

convection is employed to calculate the moving material's thermal dispersion. After analyzing the thermal distribution inside a rod that was exposed to surface heat transference, Choudhury and Jaluria [7] were able to derive the analytical answer using infinite series. The thermal behavior of a moving rod in which heat is transmitted by convection and radiation by considering thermal conductivity which is continuously changing with temperature was examined by Aziz and Lopez [8]. In order to investigate thermal performance of a moving rod in which heat is transferred by convection and radiation Sun et al. [9] used a spectral collocation approach. The effects of magnetic field on a heat transmission and flow of a Casson nanoliquid via a sheet which is moving in vertical direction was demonstrated by Sarwe et al. [10].

One of the most crucial issues considered during the studying of fluid dynamics of several fluids is the symmetry of boundary conditions. We have taken convective heat transmission into consideration in this analysis. Internal heat production improves heat transport, and extra heat energy increases thermal distribution. Numerous researchers looked into the thermal performance and heat transmission of discs, fins, and other materials that generate heat internally. Taking varying thermal conductivity into account, Onyejekwe et al. [11] outlined the effects of temperature-dependent internal heat generation within a fin. By taking thermal conductivity into consideration, Kezzar et al. [12] were able to confer internal heat production and thermal distribution along a fin. Majhi and Kundu [13] assessed the annular disk's internal heat production and provided an explanation of its temperature distribution. Venkitesh and Mallick [14] investigated the thermal nature of porous fin in which heat is transmitted through the process of convection and radiation. In their discussion of the effects of internal heat generation in a radially permeable extended surface, Sowmya and Gireesha [15] took into account thermal conductivity that was both exponentially and linearly temperature dependent. Conversely, a number of researchers have put forth a numerical and semi-analytical solution to the heat equation that accounts for the peculiarities of power-law thermal conductivity. The thermal performance of a fin with power-law temperature dependent thermal properties was investigated by Mosayebidorcheh et al. [16].

We will first be forming our mathematical model. In this study, thermal dispersion via a moving rod is examined in this investigation. Modelled equations are non-dimensionalized after using the dimensionless quantities. The differences in the moving rod's thermal profile and tip temperature caused by dimensionless parameters are explained physically.

Fluid Mechanics

Fluid mechanics is the branch of engineering in which we study the force and the effect of force on fluids (liquids and gases) as well as we discuss the behavior, nature and properties of moving or stationary fluids. Further three categories of fluid mechanics are dynamics, statics, and kinematics of fluids.

It has wide range of applications like in civil engineering for the construction of dams and pipes to properly manage the waste water, Astrophysics, Physics and in the branch of mathematics to solve the differential equations, Non-linear differential equations.

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Fluid Statics

Fluid statics is the investigation of fluid particles that are at rest.

Fluid Kinematics

Examining of moving fluids without taking motion's cause into account is known as fluid kinematics.

Fluid Dynamics

By considering the cause of motion like acceleration, velocity, speed, etc. and when the fluid is in motion, this is known as fluid dynamics.

Fluid

A material that continually deforms when shear stress is applied no matter how little it is. Stated differently, a fluid (liquids, gases) is any material that has the ability to flow and adapt to the shape of the vessel it is in.

Heat Transfer

The movement of thermal energy from a location with greater temperature to one with lesser temperature is known as heat transfer. A non-equilibrium process for which temperature difference or gradient acting as a driving force. Further, this process is helpful in the prediction of distribution in temperature and to figure out the rate at which energy moves through a certain given surface. Heat can be transferred by three different methods: conduction, convection, and radiation.

Conduction

Heat is transmitted from a location with a higher temperature to one with a lower temperature through the process of conduction without the actual movement of molecules. When two bodies or substances come into direct physical contact this process occurs. It mostly occurs in solids where the heat is transferred by vibration of molecules or by transportation of free electrons within the structure. This process stops when the temperature of two bodies becomes the same.

Convection

In convection, the transference of heat from an area of higher energetic molecules to the area having less energetic molecules with the actual movement of fluid molecules (gases, liquids). Like conduction it does not require any direct physical contact of two bodies. This process is a fast process as compared to conduction. There are two categories of convection which are named as forced convection and natural convection.

Mathematically,

$$q = hA(T_s - T_\infty)$$

(1.1)

Here h , q , A , T_s and T_∞ expresses the coefficient of heat transfer, rate of energy

transfer, the area, surface temperature and the fluid temperature away from the surface respectively.

Natural convection

Due to the buoyancy effect which is due to the difference in densities, the fluid particles move from one location to another this is known as natural convection which is often referred to as direct or free convection. Outside variables do not have any effect in free convection.

Forced convection

The fluid particles whose motion is propelled by using outside factors like pump, blower etc. is known as forced convection or in other words, in forced convection fluid is forced to pass through a surface. Transferring a greater quantity of heat, making it the most efficient way of heat transmission. It is a most efficient method which is easy to control and manage as compared to natural convection.

Radiation

The movement of heat energy through electromagnetic radiations (such as infrared radiation, microwaves, gamma rays, etc.) which travels with the velocity of light from one substance to another in empty space or vacuum is known as radiation. There is no requirement of medium in radiation as like the other two processes where medium is required. Heat which is coming from sun to earth is the most prevalent form of radiation. This process of heat transfer is efficient, because it also occur in vacuum.

Fourier's Law

It defines as “the rate of heat transfer is directly proportional to the area normal to the direction of heat flow and temperature gradient.” Mathematically,

$$Q = -kA \frac{dT}{dx} \quad \text{---}$$

(1.2)

The material's thermal conductivity k which is a positive constant and the temperature decrease along the flow direction is shown by the negative sign.

Thermal Conductivity

One physical characteristic of a substance is its thermal conductivity, which is often dependent on the substance's composition, temperature, and pressure. An assessment of the potential of heat transfer of a substance. When quantifying conductive heat transmission, thermal conductivity is a crucial factor. Mathematically,

$$k = \frac{q \cdot l}{S \cdot \Delta T} \quad \text{---}$$

(1.3)

Where q is the heat passing through a surface area denoted by S which causes difference in temperature ΔT over a distance of l . Here l , S and ΔT all are supposed

to be of unit measurement. In SI system the unit of thermal conductivity is its dimension is $[MLT^{-3}K^{-1}]$.

W

$m.K$

and

Density

One of a substance's properties is its density. It describes the process of calculating a substance's mass per unit of volume. It can be written as follows in equation form:

$$\rho = \frac{m}{V}$$

(1.4)

Where, m the mass and V is the volume occupied by the substance. This indicates that the material is dense, a property that is explained by the arrangement of atoms in a material.

Peclet Number

Peclet number, denoted by the symbol Pe are dimensionless numbers. It is the convective mass heat transmission rate divided to the conductive mass heat transmission rate through a thickness L and along a unit temperature gradient. It creates the link between convection and conduction as methods of heat transmission. Convection dominates over conduction in heat transfer when the Peclet number is higher.

Specific heat Capacity

Specific heat capacity c_p $J/kg.K$ is the amount of heat needed to raise the temperature of

$$1 \text{ kg} \cdot K$$

an entity by one mass unit per unit of time. Another name for it is specific heat. Like density, Color and other intense properties, it is independent of the quantity of a substance that is present. This makes it possible to identify compounds based on their specific heat.

Power law function of thermal conductivity

To describe the relationship between thermal conductivity and temperature in materials, power-law function is often used. Mathematically,

$$k(T) = k_a \left(\frac{T - T_a}{T_b - T_a} \right)^r$$

(1.5)

Here r is the power exponent of $k(T)$, which tells the variations in thermal conductivity due to the changes in temperature. Thermal conductivity is constant for $r = 0$, for $r = 1$ and, $r = 2$ thermal conductivity is acting linearly and non-linearly respectively.

It's worth noting that while the power-law function is a useful approximation for many materials over certain temperature ranges, it may not perfectly describe the behavior of all materials under all conditions.

Chapter 2

Numerical Study of thermal distribution over a moving rod

This chapter focuses to numerically investigate the transference of heat via a moving rod by taking into account the power law function of thermal conductivity and internal heat generation depending on the temperature. By utilizing all of the non-dimensionalized parameters, the energy equation is reduced to a PDE under constant initial and boundary conditions. Further the effect of non-dimensionalized terms on the dimensionless temperature are explored, including internal heat generation, Peclet number, conductive and radiative parameters. Plot graphs in the MATLAB software built in bvp4c function and compute results in graphical form.

Mathematical formulation

Suppose a rod with a cross sectional area A is moving with a velocity U and the perimeter P where T_b the constant temperature, T_a the ambient temperature. Some assumptions for this model are as follows:

Assumptions

There is a constant surface emissivity ϵ^* .

It is considered that the transient temperature distribution is longitudinal.

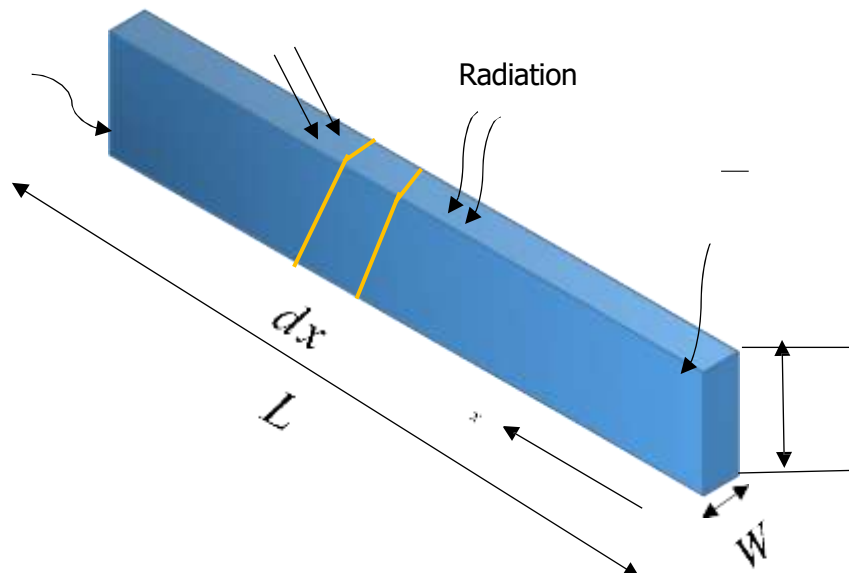
It is thought that temperature affects both internal heat generation q^* and the heat transfer coefficient h^* .

$$T|_{x=L} = T_b$$

Convection

$$T|_{x=0} = T_a$$

$$T|_{x=0} = T_a$$



$$T|_{x=0} = T_a$$

Fig. 2.1. Geometrical representation of a moving rod

Energy equation

The following energy equation illustrates the transmission of heat through a moving rod in one dimensional transient state.

$$\frac{\partial T}{\partial t} + v \frac{\partial T}{\partial x} = \frac{k}{\rho c_p U} \frac{\partial^2 T}{\partial x^2} + \frac{h^* P}{\rho c_p U} (T_a - T) \quad (2.1)$$

$$\frac{\partial T}{\partial x} = 0 \text{ at } x = 0 \text{ and } x = L$$

we have the following initial and boundary conditions for the above equation

$$T = T_0 \text{ at } t = 0$$

$$T = T_b \text{ at } x = L$$

$$T = T_0$$

$$\frac{\partial T}{\partial x} = 0$$

$$T = 0$$

Temperature dependent variables such as internal heat generation and coefficient of heat transfer are,

$$q = T - q_a = 1 - C(T - T_a) \quad (2.3)$$

$$h^* = T - h = \frac{a}{b + T}$$

Here n is the power exponent of $h^* = T$ which is dependent upon convective heat

transfer process. Forced convection and nucleate boiling heat transmission is specified by $n = 0$ and $n = 2$, respectively. For different conditions such as $n = 1/3$ indicates turbulent and $n = 1/4$ indicates laminar natural convection.

Two cases through which distribution of temperature in moving rod is explained are,

Case 1: Thermal conductivity is constant

By considering $k(T)$ as constant such as $k(T) = ka^*$

Using equation (2.3), (2.4) in equation (2.1) and assuming $k(T) = ka^*$, we get the non-dimensional form of the equation:

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$$\frac{\rho}{\rho_0} = \frac{1}{1 + \beta(T - T_0)}$$

$$n = 1 \quad \frac{\rho}{\rho_0}$$

$$4 \quad \frac{\rho}{\rho_0}$$

$$Nc$$

$$Nr \quad (Nt)$$

$$Nt \quad Pe \quad Q \quad 1 \quad \frac{\rho}{\rho_0}$$

(2.5)

Case 2: Power law thermal conductivity

In this case, considering $k(T)$ as the function of temperature

$$T \quad T \quad r$$

$$k \quad T \quad ka^* \quad \frac{a}{T} \quad \frac{\rho}{\rho_0}$$

$$T_b \quad T_a \quad \frac{\rho}{\rho_0}$$

(2.6) Here r is the power exponent of $k(T)$, which tells the variations in thermal conductivity due to the changes in temperature. Thermal conductivity is constant for

$r = 0$, for $r = 1$ and $r = 2$, thermal conductivity is acting linearly and non-linearly

respectively. Only the positive values of r are considered in this examination.

Using equation (2.6) in equation (2.1) we get the dimensionless form for second case which is given as:

$$\frac{\rho}{\rho_0}$$

$$r \quad \frac{\rho}{\rho_0}$$

$$n = 1 \quad \frac{\rho}{\rho_0}$$

$$4 \quad 4 \quad \frac{\rho}{\rho_0}$$

$$\frac{\rho}{\rho_0}$$

$$Nc$$

$$X^2$$

$$A^2 \quad U$$

$$Nr \quad (Nt)$$

$$Nt$$

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$$\frac{1}{Pe} = \frac{Q}{1 + \frac{1}{Pe}}$$

Ah_b

(2.7)

Where

$Pe = \frac{1}{\frac{1}{Pe}}$

p

$k^* p^2$

is the Peclet number, $Nc = \frac{1}{\frac{1}{Pe}}$

$\frac{k^* P}{a}$

is the conductive and

$\frac{1}{\frac{1}{Pe}} A(T_b - T)^3$

convective parameter,

conductive

Pk^*

parameter, temperature ratio

$Nt = \frac{T_a}{\frac{1}{Pe}}$

$A^2 q$

the generation parameter $\frac{1}{\frac{1}{Pe}}$,

$\frac{T_b - T}{\frac{1}{Pe}}$

$*p^2$

b

$k = P^2 \frac{1}{\frac{1}{Pe}} C(T_b - T_a)$

is the non-dimensional heat generation,

$\frac{1}{\frac{1}{Pe}}$

a^*

$\frac{1}{\frac{1}{Pe}} A^2$

is non

dimensionalized time, dimensionless temperature

$\frac{1}{\frac{1}{Pe}} T_b - T_a$

$T_b - T_a$

and axial coordinate

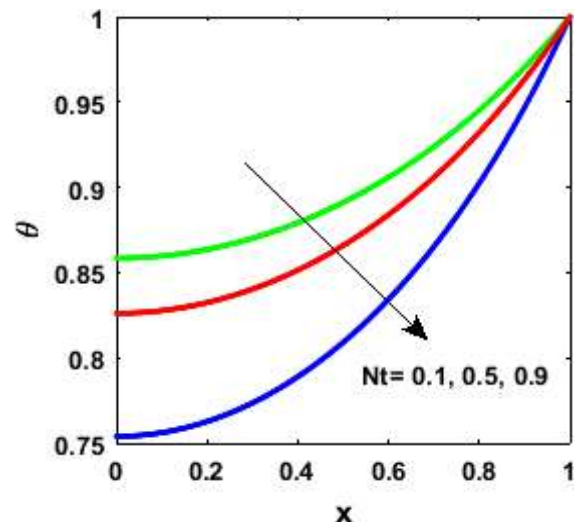
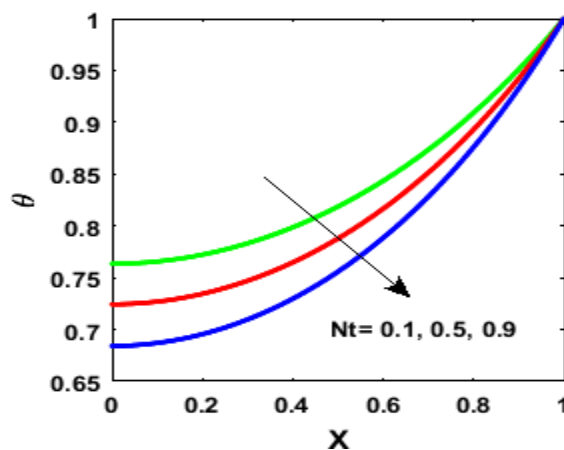
$X = \frac{xP}{A}$

A

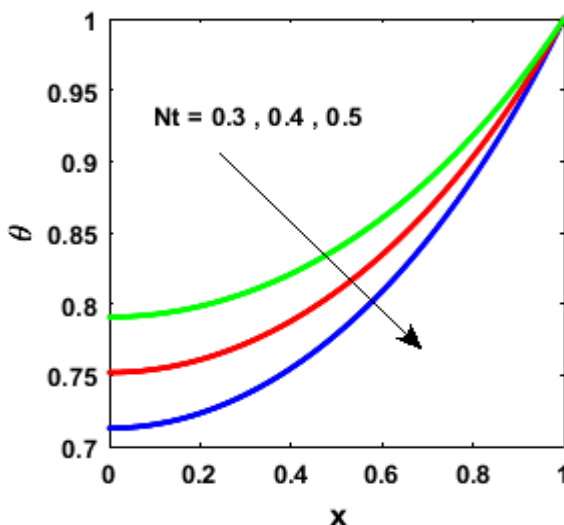
Results and Discussion

An extensive analysis of the numerical data in the form of graphs is presented in this part. This section will primarily address the effects of dimensionless factors on the transient thermal dispersion via a moving rod, taking into account different situations (for $n \leq 0$ and $n \leq 2$) when the temperature conductivity is constant or power law.

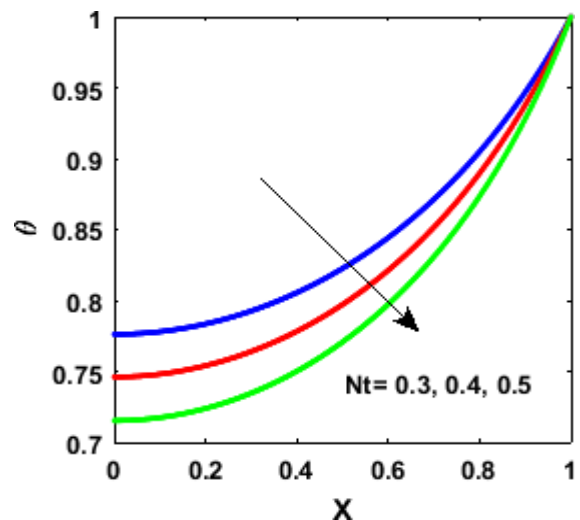
Fig. 2.2a- Fig. 2.2b illustrates the mechanism of transient thermal dispersion via a moving rod with the consequence of Nt for both $n \leq 0$ and $n \leq 2$ by taking non-varying thermal conductivity into consideration, While Fig. 2.2c -Fig. 2.2d depicts a power-law thermal conductivity. Such numbers guarantee that the transient thermal distribution is reduced when the temperature ratio rises. Furthermore, when $n \leq 0$, the transient temperature distribution decreases more quickly. Here, for a particular standard temperature, outside temperature fluctuates. Resulting in higher values of Nt and consequent increases in the heat transfer rate.



(a)



(b)

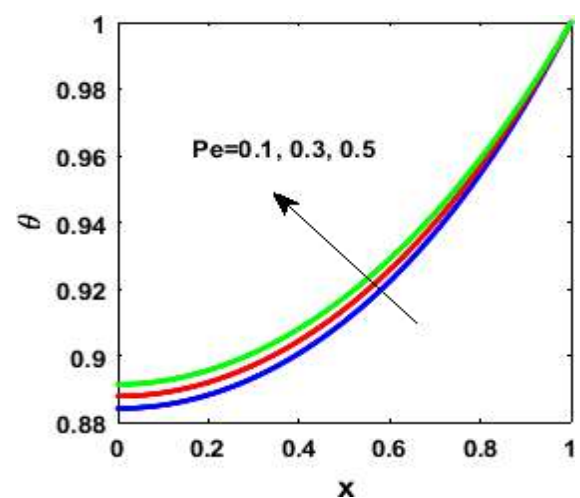
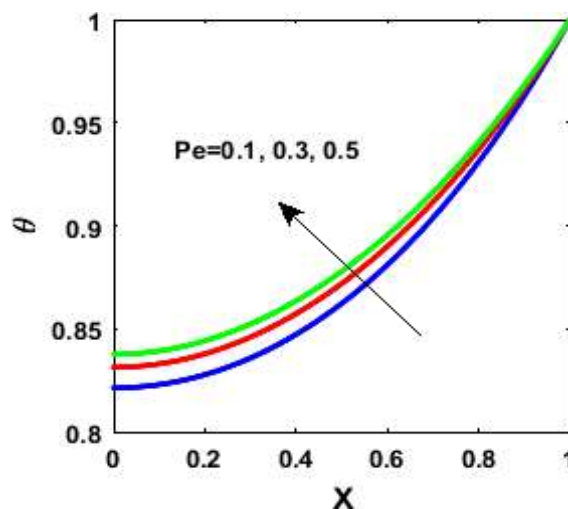


(c)

(d)

Fig. 2.2. Impact of Nt on θ for non-varying thermal conductivity and power-law function ($n = 0$ and $n = 2$)

Fig. 2.3a–Fig. 2.3b, respectively, shows the effect of Pe on the transient thermal profile for transmission of heat by forced convection $n = 0$ and $n = 2$ nucleate boiling heat transference. The thermal distribution in both figures greatly improves as the Peclet number Pe rises. For specific values of $Pe = (0.1, 0.3, 0.5)$, the transient thermal distribution in the nucleate boiling scenario ($n = 2$) is higher than in the other case. The movement of rod is with high speed which shorter the exposure time of rod to surroundings as Pe rises. The temperature distribution is typically higher as a result. For temperature dependent thermal conductivity that varies nonlinearly, Fig. 2.3c–Fig. 2.3d, illustrates the similar pattern in the thermal distribution with the influence of Pe by considering specific values of $Pe = (0.0, 0.5, 1.0)$.



(a)

(b)

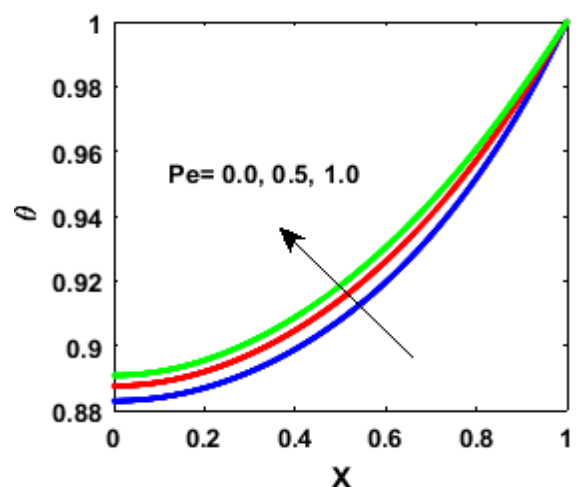
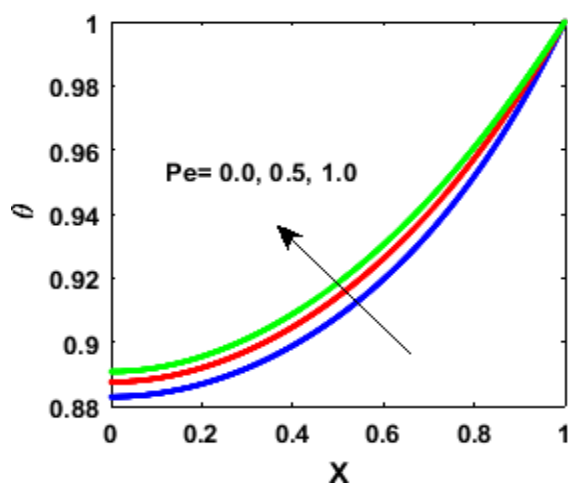


Fig. 2.3. Impact of Pe on θ for non-varying thermal conductivity and power-law

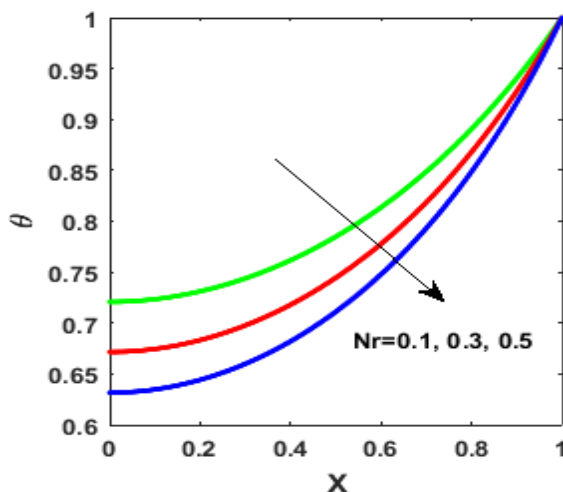
function ($n = 0$ and $n = 2$)

A graphic discussion of the influence of Nr on the transient temperature profile θ is provided in Fig. 2.4a- Fig.2.4b. Additionally, the power-law of the variant thermal conductivity is shown in Fig. 2.4c-Fig.2.4d. As predicted, for both scenarios, the transient thermal distribution rapidly decreases as radiation-conduction parameter increases in magnitude. These numbers suggest that, in the situation of heat transfer by forced convection

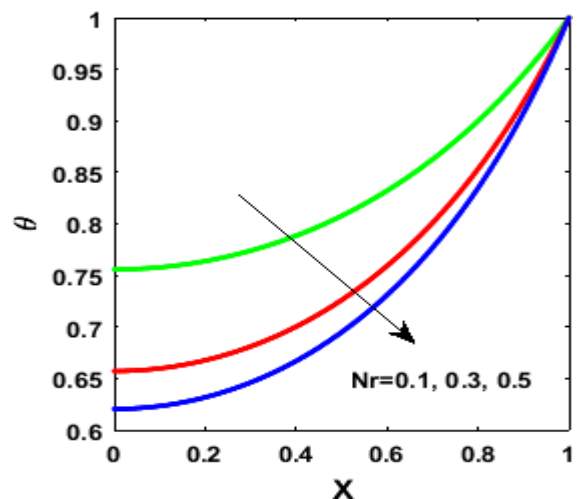
$n = 0$

, the transient temperature distribution falls off rapidly.

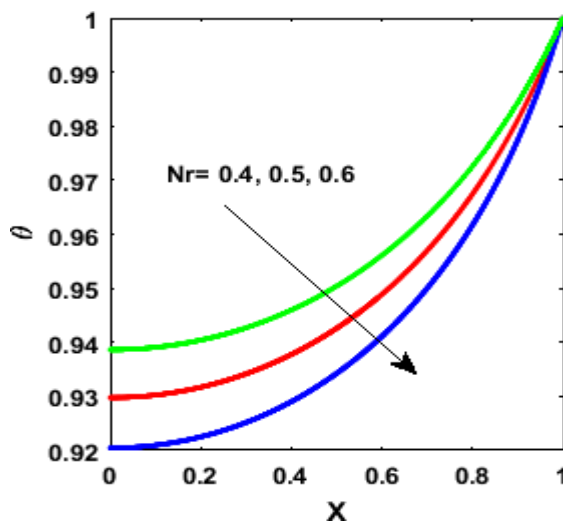
Physically, as the radiation gets stronger, heat begins to loss from the rod to the neighboring fluid, the temperature inside the rod decreases as a result.



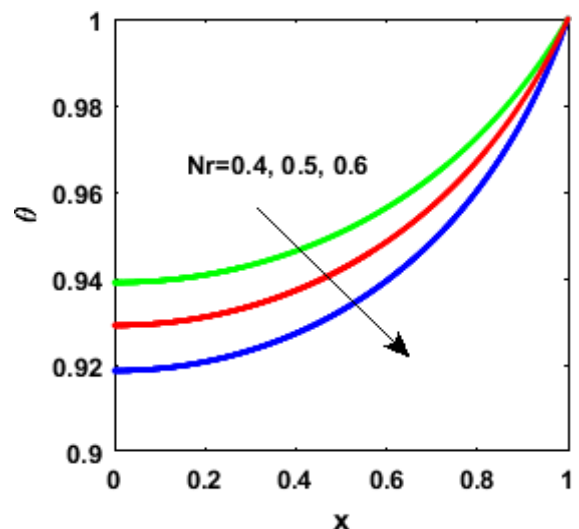
(a)



(b)



(c)



(d)

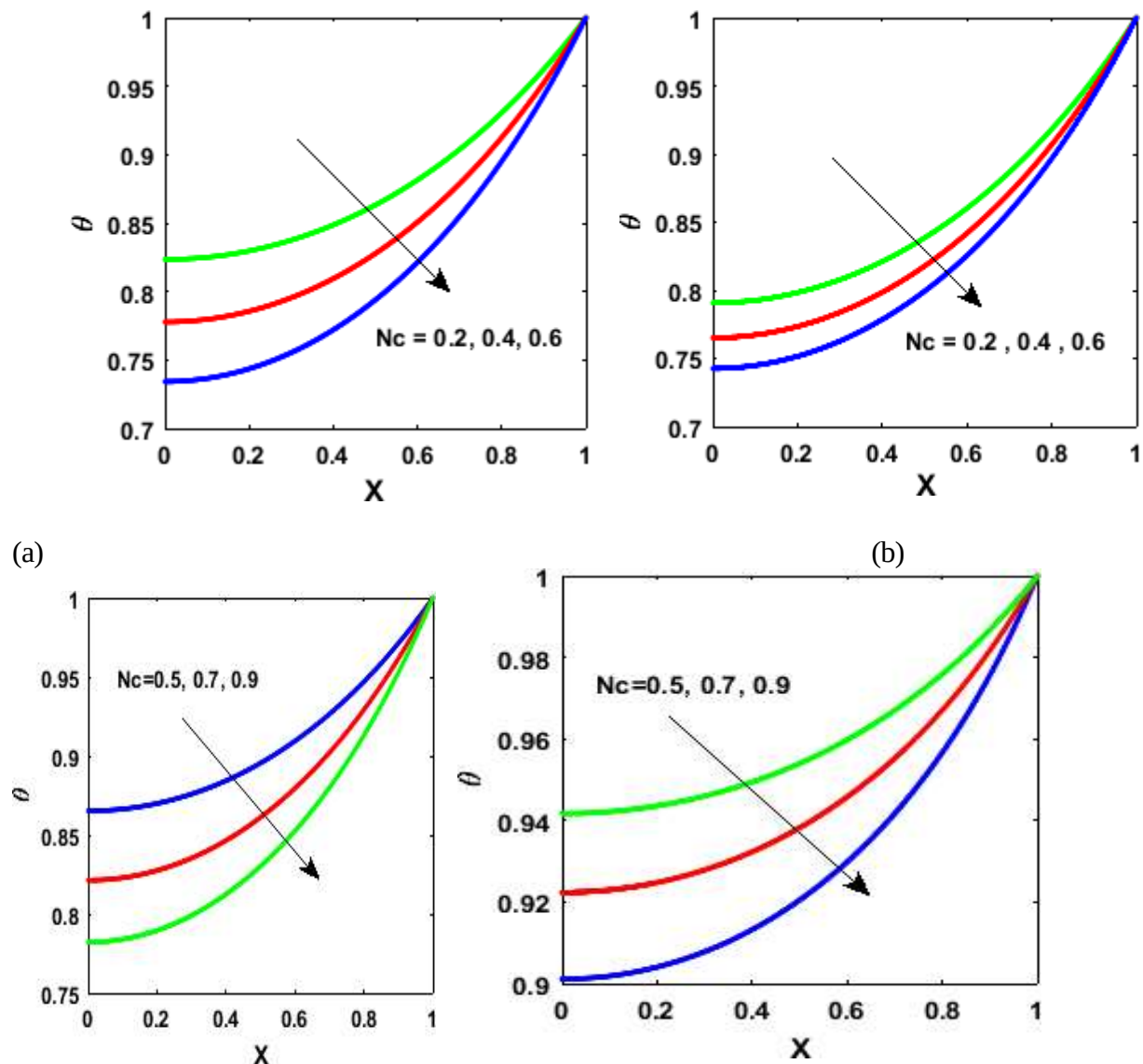
Fig. 2.4. Impact of Nr on θ for non-varying thermal conductivity and power-law function ($n = 0$ and $n = 2$)

Examining both situations, $n = 0$ and $n = 2$, respectively, Fig. 2.5a –Fig.2.5b reveals the influence of Nc on the transient thermal distribution. Enhancement of the magnitude of Nc result in a decrease in the transient thermal distribution in both figures. Further, heat transference by forced convection

$n = 0$

a quick decrease in the transient thermal

distribution is observed. Physically, convection increases in amplitude as Nc grows, and this effectively cools the moving rod, as evidenced by the observable drop in temperature. The effect of Nc for non-linearly increasing temperature dependent examples, heat transfer by nucleate boiling and forced convection, is indicated in Fig. 2.5c-Fig.2.5d. These numbers demonstrate that when Nc values increase, the transient thermal dispersion drops.

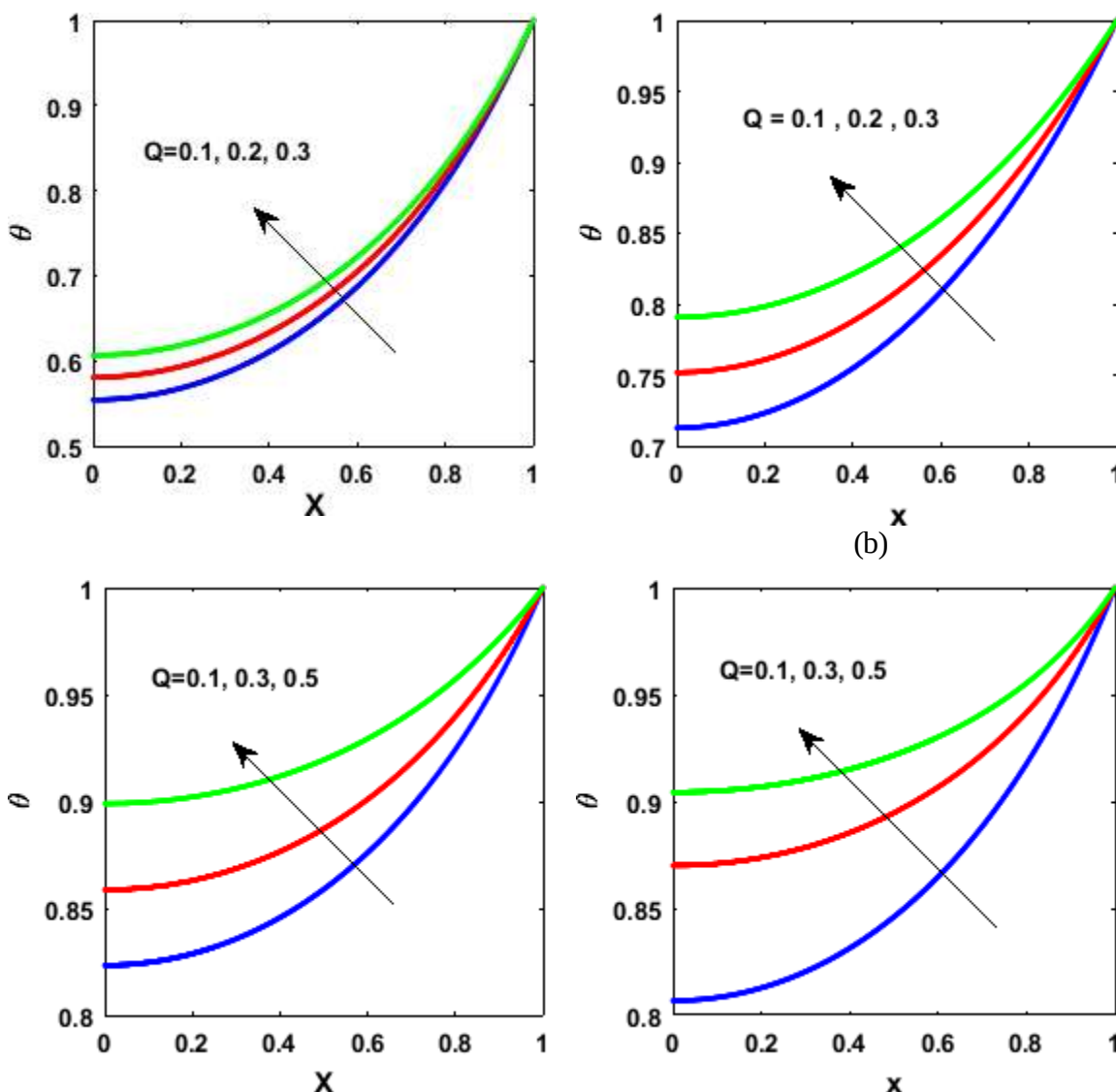


(c) (d)
Fig. 2.5. Impact of N_c on θ for non-varying thermal conductivity and power-law function ($n = 0$ and $n = 2$)

Fig. 2.6a-Fig 2.6b depict the deviation with the result of the dimensionless generation parameter Q for constant

$k(T)$, Fig. 2.6c-Fig.2.6d represent the power law of $k(T)$. In

both cases, there is a notable enhancement of the transient thermal dispersion from a moving rod as the size of the dimensionless generation parameter Q increases. For the nucleate boiling example, the transient temperature distribution also rapidly improves.



(c) (d)
Fig. 2.6. Impact of Q on θ for non-varying thermal conductivity and power-law

function ($n \geq 0$ and $n \leq 2$)

By taking into account both scenarios, Fig. 2.7a-Fig. 2.7b clarifies the influence of

on the transient thermal distribution. It is evident from both pictures that a rise in the dimensionless heat generation parameter

(0.3, 0.5, 0.7)

causes an increase in the

transient thermal profile. When comparing two scenarios, it can be seen that the transient thermal profile for ($n \leq 2$) improves more quickly. Fig. 2.7c-Fig.2.7d illustrates the comparable nature of the temperature profile for power-law thermal conductivity.

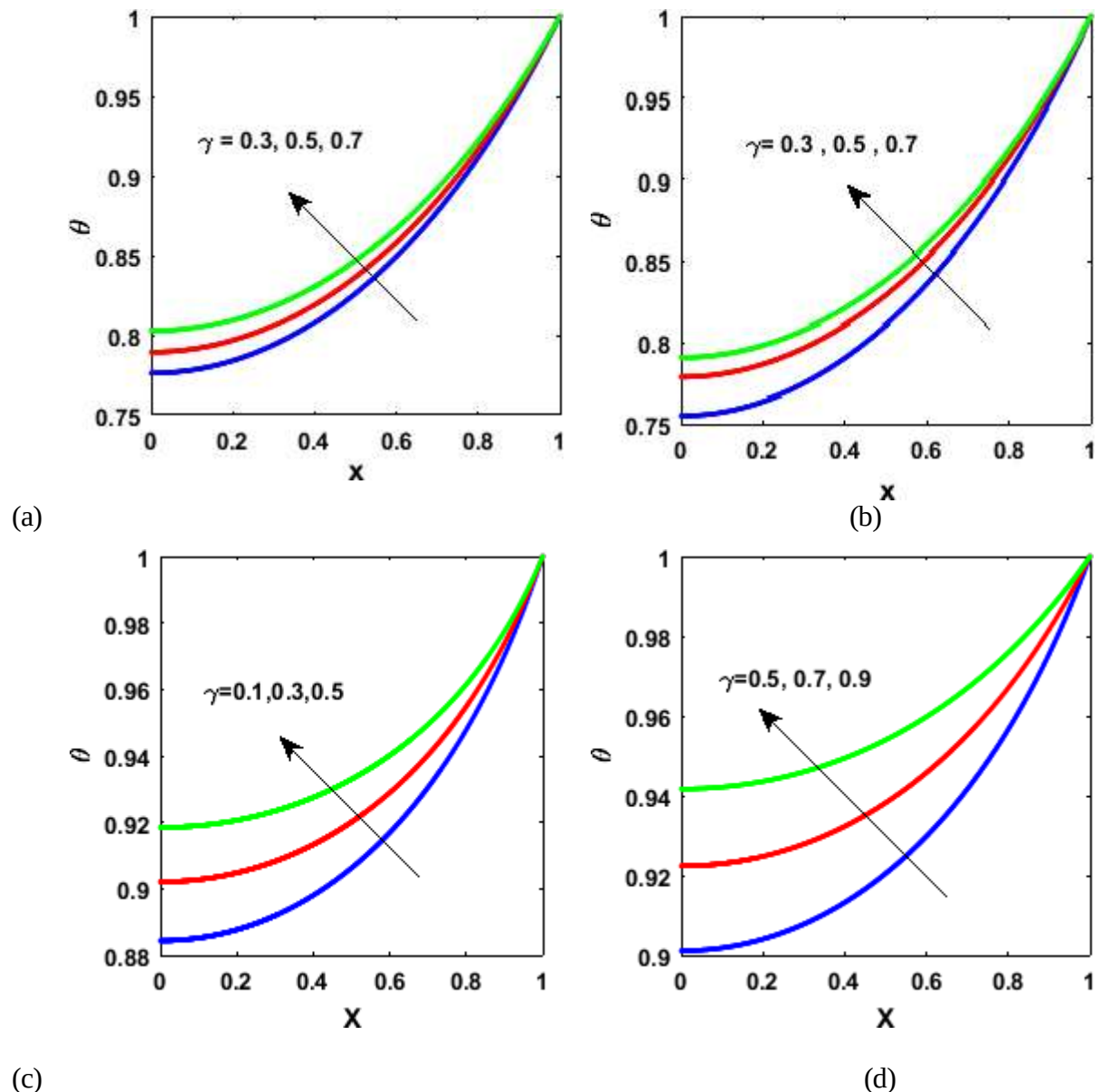


Fig. 2.7. Impact of γ on θ for non-varying thermal conductivity and power-law

function ($n = 0$ and $n = 2$)

The effect of Nr on

$\theta(0)$

with respect to the rise in the convective-conductive parameter is shown in Fig. 2.8. As seen in Fig. 2.8, $\theta(0)$

Decreases with Nr . This is

because convective transmission of heat along the moving rod gets greater as Nc increases, and thus results in increased heat release from the rotating rod.

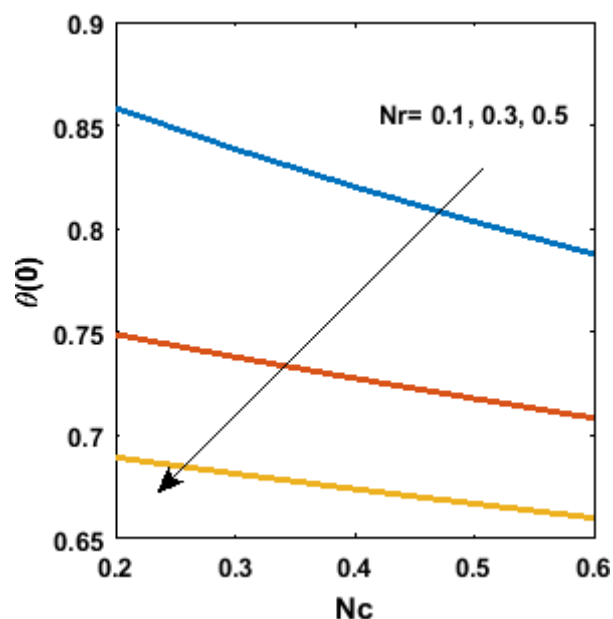


Fig. 2.8. Impact of Nr and Nc on $\theta(0)$

The numerical values for radiation-conduction parameter Nr and dimensionless convection-conduction parameter Nc to describe the impact of $\theta(0)$ are presented in Table 2.1.

Nr	Nc	$\theta(0)$
0.1	0.2	0.85844
	0.3	0.83855
	0.4	0.82026
	0.5	0.80339
	0.6	0.78774

0.3	0.2	0.74892
	0.3	0.73792
	0.4	0.72764
	0.5	0.71781
	0.6	0.7084
0.5	0.2	0.6894
	0.3	0.68148
	0.4	0.67411
	0.5	0.66697
	0.6	0.66007

Table. 2.1: value of $\theta(0)$ for specific values of Nr and Nc

The effect of Pe on $\theta(0)$ is seen in Fig. 2.9. When the rod speed increases, the non-dimensional tip temperature rises (as Pe grows). Furthermore, as the temperature ratio factor enhanced, the non-dimensional tip temperature decreases.

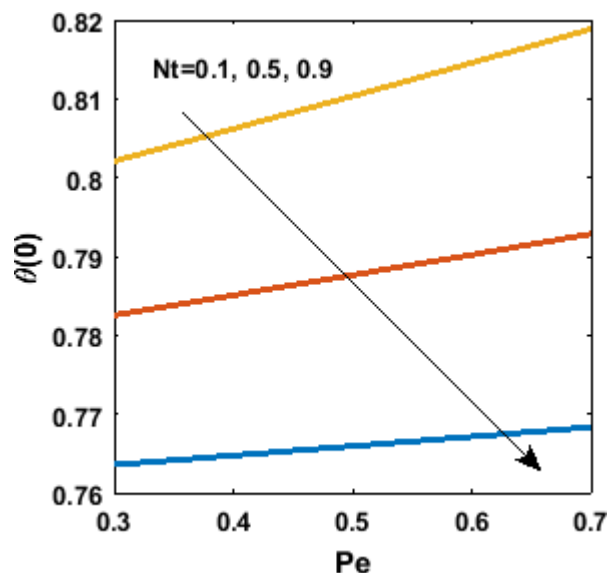
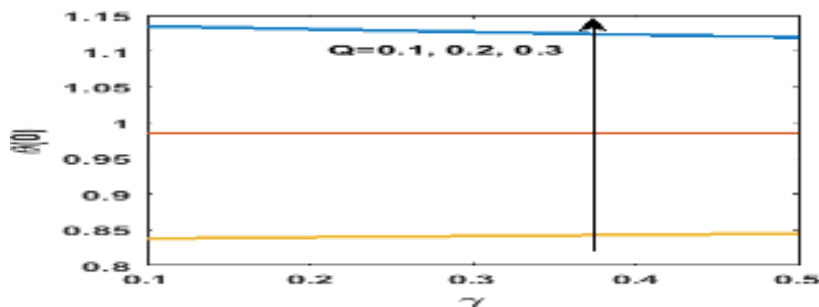


Fig. 2.9. Impact of Nt and Pe on $\theta(0)$

The numerical values for Temperature ratio Nt and Peclet number Pe to describe the impact of $\theta(0)$ are presented in Table 2.2.



Nt	Pe	$\theta(0)$
0.1	0.1	1.135
	0.2	1.1308
	0.3	1.1268
	0.4	1.123
	0.5	1.1194
0.5	0.1	0.98475
	0.2	0.98503
	0.3	0.98531
	0.4	0.98558
	0.5	0.98584
0.9	0.1	0.8377
	0.2	0.83958
	0.3	0.84123
	0.4	0.84293
	0.5	0.84471

Table. 2.2: value of $\theta(0)$ for specific values of Pe and Nt

Fig. 2.8 shows the effect of the dimensionless heat generation parameter Q on the dimensionless tip temperature. In this case, when the values of the heat generation parameter increases, as a result the tip temperature also increases.

Fig. 2.10 Impact of Q and θ on $\theta(0)$

The numerical values for Generation parameter Q and non-dimensionalized heat

generation parameter β to describe the impact of $\beta(0)$ are presented in Table 2.3.

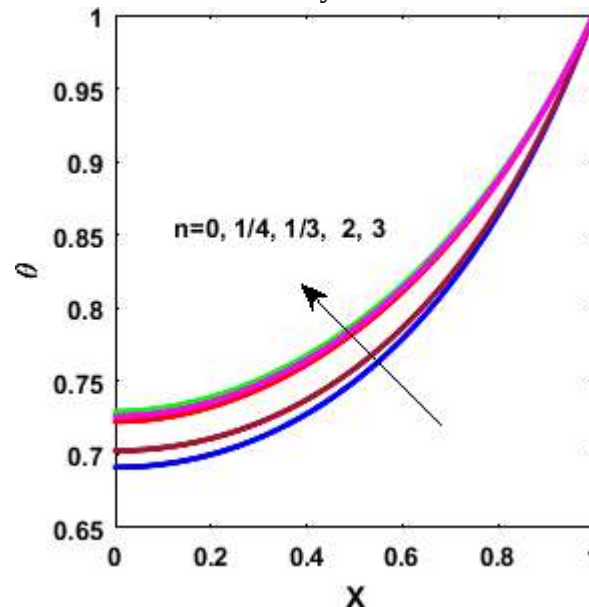
Q	β	$\beta(0)$
0.1	0.3	0.76355
	0.4	0.76474
	0.5	0.76593
	0.6	0.76713
	0.7	0.76833
0.2	0.3	0.78253
	0.4	0.78508
	0.5	0.78764
	0.6	0.79021
	0.7	0.79285
0.3	0.3	0.80208
	0.4	0.8062
	0.5	0.81034
	0.6	0.81456
	0.7	0.81886

Table. 2.3: value of $\beta(0)$ for specific values of β and Q

The dimensionless temperature profile of the moving rod for different heat transmission modes is depicted in Fig. 2.11. The mode of heat transport is determined by the heat transfer coefficient's exponent index, or n . As the heat transfer's exponent index changes so as a result the dimensionless temperature profile varies with increasing coefficient. To be more precise, in the forced convective heat transfer scenario $n \leq 0$ the temperature distribution is lower and in the radiation case $n \geq 3$ is greater. In contrast, the dimensionless temperature profile demonstrates a rising trend for radiation

($n \geq 3$), nucleate boiling ($n \geq 2$), turbulent natural convection ($n \geq 1/3$), laminar natural convection ($n \geq 1/4$), and forced convective heat transfer ($n \leq 0$).

Fig. 2.11. Behavior of θ for several ways of heat transfer



Conclusion

In this study, the temperature distribution for non-steady temperature in a convective-radiative rod which is not stationary with the temperature depending internal energy was examined numerically. The effect of different parameters are also discussed by the help of graphs.

Some noteworthy findings from this study are as follows:

By increasing conduction-convection variable values, temperature distribution in a moving rod for unsteady temperature also decreases.

It can be noticed that within a moving rod by increasing Peclet number, transient temperature distribution also rises.

An increase in the heat generation parameter's values results in an improvement in the transient distribution of temperature.

A variation in the non-dimensionalized time enhances the transient heat distribution across a moving rod.

By comparing the convective and radiative heat transfer, temperature distribution within convective heat transference is lower than the other one.

Higher levels of N_c and N_r parameters result in a considerable drop in tip temperature.

By increasing the values of temperature ratio and radiation-conduction parameter non dimensionalized temperature also increases.

In this examination, it is supposed that thermal conductivity and coefficients of heat transference are temperature dependent. Power laws are used to represent the highly non-linear conduction and heat transmission parameters.

A graphical illustration explains the non-dimensionalized temperature aspect in the various thermal energy transmission processes. When comparing the radiative heat transmission method to other mechanisms, a higher thermal dispersion is observed of the transmission of heat.

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