

# Applications of Soham transform in Laminar Flow between Parallel Plates

D. P. Patil, R. K. Godage

*K. R. T. Arts, B. H. Commerce and A. M. Science College, Nashik*

Date of Submission: 17-01-2023

Date of Acceptance: 31-01-2023

**ABSTRACT:** We study unidirectional laminar flow between parallel plates directly, instead of finding the general solution of the differential equation which relates the characteristic equation of flow of the fluid in motion. In this paper we use Soham transform to solve the differential equation which relates the flow characteristic of the viscous liquid and find the velocity and shear stress distributions of one directional laminar flow between parallel plates which are stationary as well as in a relative motion.

**Key words:** Viscous fluid, Parallel plates, Laminar flow, Shear and velocity distributions, Soham transform.

## I. INTRODUCTION:

Recently, integral transforms are one of the most useful and simple mathematical technique for obtaining the solutions of advance problems occurred in many fields like science, Engineering, technology, commerce and economics. To provide exact solution of problem without lengthy calculations is the important feature of integral transforms.

Due to this important feature of the integral transforms many researchers are attracted to this field and are engaged in introducing various integral transforms. Recently, Kushare and Patil [1] introduced new integral transform called as Kushare transform for solving differential equations in time domain. Further, Savita Khakale and Dinkar Patil [2] introduced Soham transform in November 2021. As researchers are interested in introducing the new integral transforms at the same time they are also interested in applying the transforms to various fields, various equations in different domain. In January 2022, Patil et al [3, 4, 12, 31, 32, 34, 37, 40, 51] used Kushare transform solving different problems.

D.P. Patil [5, 6, 8] used Sawi transform for solving various types of problems. Laplace transforms and Shehu transforms are used in chemical sciences by Patil [7]. Using Mahgoub

transform, parabolic boundary value problems are solved by D.P. Patil [9]

D.P. Patil [10] used double Laplace and double Sumudu transforms to obtain the solution of wave equation. Further Dr. Patil [11] also obtained dualities between double integral transforms. D. P. Patil [13] solved boundary value problems of the system of ordinary differential equations by using Aboodh and Mahgoub transforms. Double Mahgoub transformed is used by Patil [14] to solve parabolic boundary value problems.

Laplace, Sumudu, Aboodh, Elazki and Mahagoub transforms are compared and used it for solving boundary value problems by Dinkar Patil [15]. Further, Patil with Tile and Shinde [17] used Anuj transform and solved Volterra integral equations for first kind. Rathi sisters and D. P. Patil [18] solved system of differential equations by using Soham transform. Vispute, Jadhav and Patil [19] used Emad Sara transform for solving telegraph equation. Kandalkar, Zankar and Patil [20] evaluate the improper integrals by using general integral transform of error function. Dinkar Patil, Prerana Thakare and Prajakta Patil [21] obtained the solution of parabolic boundary value problems by using double general integral transform.

D. P. Patil et al [22, 23, 25] used various integral transform to obtain the solution of Newton's law of cooling. Dinkar Patil et al [24, 28, 29, 30, 39, 46, 47] used integral transforms for handling growth and Decay problems, D. P. Patil et al [26] used Emad-Falih transform for general solution of telegraph equation. Dinkar Patil et al [27] introduced double kushare transform. Recently, Wagh sisters and Patil used Soham [33] transform in chemical Sciences. Raundal and Patil [35] used double general integral transform for solving boundary value problems in partial differential equations. Rahane, Derle and Patil [36] developed generalized double rangaig integral transform.

Kandekar et al [38] used new general integral equation to solve Abel's integral equations. Thakare and Patil [41] used general integral transform for solving mathematical models from health sciences. Rathi sisters used Soham transform for analysis of impulsive response of Mechanical and Electrical oscillators with Patil [42]. Patil [43, 45] used KKAT transform for solving growth and decay problems and Newton's law of cooling. Suryawanshi et al [16, 44] used Soham transform for solving volterra integral equations and mathematical models occurring in health science and biotechnology.

This paper is organized as follows. Introduction is in first section. Second section is for preliminary concepts. Third section is devoted to application of Soham transform for study of laminar flow between parallel plates.

## II. PRELIMINARY:

In this section we state some preliminary formulae, theorems and definitions which are required.

- **Definition:** The Soham transform of the function  $f(t)$  is defined as

$$S[f(t)] = P(v) = \frac{1}{v} \int_0^{\infty} f(t) e^{-vt^{\alpha}} dt, \quad \because \alpha \text{ is non zero real numbers } t \geq 0, k_1 \leq v \leq k_2 \dots (2.1)$$

- **Soham transform of the elementary functions:**

1.  $S[1] = P(v) = \frac{1}{v^{\alpha+1}}, t \geq 0$
2.  $S[t] = \frac{1}{v^{2\alpha+1}}$

In the general case if  $n = 0, 1, 2, 3, \dots$  is integer number, then,

$$S[t^n] = \frac{n!}{v^{n\alpha + \alpha + 1}}$$

- **Theorem:** Let  $(v)$  Soham transform of  $[f(t) = P(v)]$  then:

$$S[f''(t)] = v^{2\alpha} P(v) - v^{\alpha-1} f'(0) - \frac{1}{v} f''(0)$$

## III. APPLICATION OF SOHAM TRANSFORM IN PARALLEL PLATES:

Consider a steady and uniform laminar flow of the viscous fluid between the two flat parallel plates situated at a perpendicular distance  $L$ . Let the distance in which the fluid is flowing be represented by  $x$  and the distance which is normal to the flow of fluid and parallel to the plane of paper be represented by  $y$  such that the lower plate is situated at  $y = 0$  and the upper plate is situated at  $y = L$  [2].

The flow characteristics equation of motion of a viscous fluid is given by

$$\mu \ddot{U}(y) = \frac{dP}{dx} \dots \dots \dots (1)$$

We will study the laminar flow of viscous fluid on the basis of following assumptions:[52]

i. The flow is steady and incompressible and the properties of the fluid do not vary in the directions normal to the direction of flow of the fluid.

ii. There are no end effects of the surfaces on the viscous fluid.

iii. There is no relative velocity of the fluid with respect to the surfaces of the plates.

iv. There is a uniform effective pressure gradient in the direction of flow of fluid i.e.,  $\frac{dP}{dx}$  is a constant in the  $x$ -direction.

Now applying Soham Transform of equation (1), we get

$$S[\mu \ddot{U}(y)] = \frac{dP}{dx} S[1]$$

By Theorem,

$$\mu \left[ v^{2\alpha} p(v) - v^{\alpha-1} f(0) - \frac{1}{v} f'(0) \right] = \frac{dP}{dx} \frac{1}{v^{\alpha+1}} \dots \dots \dots (2)$$

A. For Laminar Flow Between Stationary (Fixed) Parallel Plates

Considering the flow of fluid between two parallel fixed plates, we can write the relevant boundary conditions as given below at  $y = 0$  and  $y = L, f = 0$ . Applying boundary condition:  $f(0) = 0$ , equation (2) becomes,[51]

$$\mu \left[ v^{2\alpha} p(v) - \frac{1}{v} f'(0) \right] = \frac{1}{v^{\alpha+1}} \frac{dP}{dx} \dots \dots \dots (3)$$

In this equation,  $f'(0)$  is some constant so let us substitute. Also,  $f'(0) = \epsilon$ .

Also, since  $\frac{dP}{dx}$  is uniform, therefore, put  $\frac{dP}{dx} = -\phi$ , where  $\phi$  is a constant and negative sign indicates that the pressure of fluid decreases in the direction of flow of the fluid. Equation (3) becomes

$$\mu \left[ v^{2\alpha} p(v) - \frac{1}{v} \epsilon \right] = \frac{-1}{v^{\alpha+1}} \phi$$

$$P(v) = \frac{\epsilon}{v^{2\alpha+1}} - \frac{\phi}{\mu v^{3\alpha+1}} \dots \dots \dots (4)$$

Taking inverse Soham transform of equation (4), we get

$$P_0(y) = \epsilon y - \frac{\phi}{\mu} \frac{y^2}{2} \dots \dots \dots (5)$$

1. Determination of the Constant To find the value of constant  $\epsilon$

applying boundary condition:  $P_0(L) = 0$  equation (5) provides,

$$0 = \epsilon L - \frac{\phi}{2\mu} L^2$$

Upon rearranging and simplification of the above equation,

$$\text{we get } \epsilon = \frac{\phi}{2\mu} L \dots \dots \dots (6)$$

Substitute the value of  $\epsilon$  from equation (6) in equation (5) we get

$$P_o(y) = \frac{\phi}{2\mu}Ly - \frac{\phi y^2}{\mu 2}$$

Or

$$P_o(y) = \frac{\phi}{2\mu}(Ly - y^2) \dots \dots \dots (7)$$

Differentiating equation (7) w.r.t. y, we get

$$P_o'(y) = \frac{\phi}{2\mu}(L - 2y) \dots \dots \dots (8)$$

For maximum velocity,  $P_o'(y) = 0$

These results

$$y = \frac{L}{2} \dots \dots \dots (9)$$

Put the value of y from equation (9) in equation (7), we get

$$P_o \text{ max} = \frac{\phi}{2\mu} \left[ \frac{L^2}{2} - \frac{L^2}{4} \right]$$

$$\text{Or } P_o \text{ max} = \frac{\phi}{8\mu} L^2 \dots \dots \dots (10)$$

The shear stress distribution is determined by the application of Newton's law of viscosity as

$$\tau(y) = \mu P_o'(y)$$

Using equation (5), we get

$$\tau(y) = \frac{\phi}{2} [L - 2y] \dots \dots \dots (11)$$

At  $y = \frac{L}{2}$  i.e., at the mid of the fixed parallel plates,  $\tau\left(\frac{L}{2}\right) = \frac{\phi}{2} \left[ L - 2\left(\frac{L}{2}\right) \right] = 0$  i.e., there is no shear stress even when there is constant pressure gradient.

At  $y = 0$  i.e., at the surface of the lower fixed plate,  $\tau(0) = \frac{\phi}{2}L$

At  $y = L$  i.e., at the surface of the upper fixed plate,  $\tau(L) = \frac{\phi}{2}L$

For a particular case, when  $\phi = 0$ ,  $\tau(y) = 0$  i.e., there is no shear stress between the fixed parallel plates if there is no pressure gradient

### B. For Laminar Flow Between Parallel Plates Having Relative Motion

Considering the flow of fluid between the parallel flat plates such that the lower plate is fixed at  $y = 0$  and upper plate is moving uniformly with velocity  $f_o$  relative to the lower fixed plate in the direction of flow of the fluid, we can write the relevant boundary conditions as given below:

At  $y = 0$ ,  $f = 0$  and at  $y = L$ ,  $f = f_o$ .

Applying boundary condition:  $f(0) = 0$ , equation (2) becomes,

$$\mu [v^{2\alpha} p(v) - \frac{1}{v} f'(0)] = \frac{-1}{v^{\alpha+1}} \phi \dots \dots (12)$$

In this equation,  $f'(0)$  is some constant. Let us substitute  $f'(0) = \delta$ ,

Equation (12) becomes

$$\mu [v^{2\alpha} p(v) - \frac{1}{v} \delta] = \frac{-1}{v^{\alpha+1}} \phi$$

$$\text{Or } P(v) = \frac{\delta}{v^{2\alpha+1}} - \frac{1}{\mu v^{3\alpha+1}} \phi \dots \dots \dots (13)$$

Taking inverse Soham transform of equation (13), we get

$$P_o(y) = \delta y - \frac{\phi}{2\mu} y^2 \dots \dots \dots (14)$$

1) Determination of the Constant  $\delta$

To find the Value  $P_o(y)$  of  $\delta$  constant, applying boundary condition:  $P_o(L) = P$  equation (14) becomes,

$$P = \delta L - \frac{\phi}{2\mu} L^2$$

Upon rearranging and simplification of the above equation, we get

$$L\delta = P + \frac{\phi}{2\mu} L^2$$

$$\delta = \frac{P}{L} + \frac{\phi}{2\mu} L \dots \dots \dots (15)$$

Substitute the value of  $\delta$  from equation (15) in equation (14), we get

$$P_o(y) = \left( \frac{P}{L} + \frac{\phi}{2\mu} L \right) y - \frac{\phi}{2\mu} y^2$$

$$\begin{aligned} \text{Or } P_o(y) &= \frac{P}{L} y \\ &+ \frac{\phi}{2\mu} (Ly - y^2) \dots \dots (16) \end{aligned}$$

This equation (16) confirms that the velocity distribution is parabolic with minimum at the lower fixed plate.

Differentiating equation (16) w.r.t. y, we get

$$P_o'(y) = \frac{P}{L} + \frac{\phi}{2\mu} (L - 2y) \dots \dots (17)$$

For maximum velocity,  $P_o'(y) = 0$

These results

$$y = \frac{L}{2} + \frac{\mu P}{\phi L} \dots \dots \dots (18)$$

Put the value of y from equation (18) in equation (16), we get

$$P_o \text{ max} = \frac{P}{2} + \frac{\mu P^2}{2L^2 \phi} + \frac{L^2 \phi}{8\mu} \dots \dots (19)$$

The shear stress distribution is determined by the application of Newton's law of viscosity as

$$\tau(y) = \mu P_o'(y)$$

Using equation (17), we get

$$\tau(y) = \frac{\mu P}{L} + \frac{\phi}{2} (L - 2y) \dots \dots \dots (20)$$

At  $y = \frac{L}{2}$  i.e., at the mid of the flow passage,

$$\tau\left(\frac{L}{2}\right) = \frac{\mu P}{L}$$

At  $y = 0$  i.e., at the surface of the lower plate,

$$\tau(0) = \frac{\mu P}{L} + \frac{\phi}{2} L$$

At  $y = L$  i.e., at the surface of the upper plate,

$$\tau(L) = \frac{\mu P}{L} - \frac{\phi}{2} L$$

For a particular case, when  $\phi = 0$ ,  $\tau(y) = \frac{\mu P}{L}$

i.e., the shear stress between the plates is not zero and having a constant value even if there is no pressure gradient

#### REFERENCES

- [1]. Rahul Gupta, Rohit Gupta, Dinesh Verma, Application of Convolution Method to the Impulsive Response of a Lightly Damped Oscillators, International Journal of Scientific Research in Physics and Applied Sciences, Vol.7, Issue.3, pp.173-175, June(2019).
- [2]. Rohit Gupta, Shivam Sharma, Rahul Gupta; Study of Laminar flow between parallel plates, Via Gupta integral transform, International Journal for Research in Applied Science and Engineering Technology, Vol. 10, Issue 6, pp. 385- 389, (2022)
- [3]. Rohit Gupta, Rahul Gupta, Ajay Kumar, Analysis of Impulsive Response of Mechanical and Electrical Oscillators by Rohit Transform, Engineering and Scientific International Journal(ESIJ), Vol.9, Issue,3, July-September 2022.
- [4]. S. R. Kushare, D. P. Patil and A. M. Takate, The new integral transform, "Kushare transform", International Journal of Advances in Engineering and Management , Vol.3, Issue 9, Sept.2021, PP. 1589-1592
- [5]. P. Patil and S. S. Khakale, The new integral transforms "Soham transform, International Journal of Advances in Engineering and Management, Vol.3, issue 10, Oct. 2021.
- [6]. R. S. Sanap and D. P. Patil, Kushare integral transform for Newton's law of Cooling, International Journal of Advances in Engineering and Management vol.4, Issue1, January 2022, PP. 166-170
- [7]. P. Patil, P. S. Nikam, S. D. Shirsath and A. T. Aher, kushare transform for solving the problems on growth and decay; journal of Emerging Technologies and Innovative Research, Vol. 9, Issue-4, April 2022, PP h317 – h-323.
- [8]. P. Patil, Sawi transform in Bessel functions, Aayushi International Interdisciplinary Research Journal, Special Issue No. 86, PP 171-175.
- [9]. D. P. Patil, Application of Sawi transform of error function for evaluating Improper integrals, Vol. 11, Issue 20 June 2021, PP 41-45 .
- [10]. D. P. Patil , Applications of integral transforms (Laplace and Shehu) in Chemical Sciences , Aayushi International Interdisciplinary Research Journal , Special Issue 88 PP.437-477 .
- [11]. D. P. Patil, Sawi transform and Convolution theorem for initial boundary value problems (Wave equation), Journal of Research and Development , Vol.11 , Issue 14 June 2021, PP. 133-136 .
- [12]. D. P. Patil, Application of Mahgoub transform in parabolic boundary value problems , International Journal of Current Advanced Research , Vol-9, Issue 4(C), April.2020 , PP. 21949-21951.
- [13]. D. P. Patil, Solution of Wave equation by double Laplace and double Sumudu transform , Vidyabharti International Interdisciplinary Research Journal , Special Issue IVCIMS 2021 , Aug 2021 , PP.135-138.
- [14]. D. P. Patil, Dualities between double integral transforms , International Advanced Journal in Science , Engineering and Technology , Vol.7 , Issue 6 , June 2020 , PP.74-82.
- [15]. Dinkar P. Patil, Shweta L. Kandalkar and Nikita D. Gatkal, Applications of Kushare transform in the system of differential equations, International Advanced Research in Science, Engineering and Technology, Vol. 9, Issue 7, July 2022, pp. 192-195.
- [16]. D. P. Patil, Aboodh and Mahgoub transform in boundary Value problems of System of ordinary differential equations, International Journal of Advanced Research in Science, communication and Technology, Vol.6, Issue 1, June 2021, pp. 67-75.
- [17]. D. P. Patil, Double Mahgoub transform for the solution of parabolic boundary value problems, Journal of Engineering Mathematics and Stat , Vol.4 , Issue (2020).
- [18]. D. P. Patil, Comparative Study of Laplace ,Sumudu , Aboodh , Elazki and Mahgoub transform and application in boundary value problems , International Journal of Reasearch and Analytical Reviews , Vol.5 , Issue -4 (2018) PP.22-26.
- [19]. D .P. Patil , Y .S. Suryawanshi , M .D. Nehete , Application of Soham transform for solving volterra Integral Equation of first kind , International Advanced

- Research Journal in Science , Engineering and Technology , Vol.9, Issue 4 (2022) .
- [20]. D. P. Patil, P. D. Shinde and G. K. Tile, Volterra integral equations of first kind by using Anuj transform, International Journal of Advances in Engineering and Management, Vol. 4, Issue 5 , May 2022, pp. 917-920.
- [21]. D. P. Patil, Shweta Rathi and Shrutika Rathi, The new integral transform Soham transform for system of differential equations, International Journal of Advances in Engineering and Management, Vol. 4, Issue 5 , May 2022, PP. 1675- 1678.
- [22]. D. P. Patil, Shweta Vispute and Gauri Jadhav, Applications of Emad-Sara transform for general solution of telegraph equation, International Advanced Research Journal in Science , Engineering and Technology, Vol. 9, Issue 6, June2022, pp. 127-132.
- [23]. D. P. Patil, K. S. Kandakar and T. V. Zankar, Application of general integral transform of error function for evaluating improper integrals, International Journal of Advances in Engineering and Management, Vol. 4, Issue 6, June 2022.
- [24]. Dinkar Patil, Prerana Thakare and Prajakta Patil, A double general integral transform for the solution of parabolic boundary value problems, International Advanced Research in Science, Engineering and Technology, Vol. 9, Issue 6, June 2022, pp. 82-90.
- [25]. D. P. Patil, S. A. Patil and K. J. Patil, Newton's law of cooling by Emad- Falih transform, International Journal of Advances in Engineering and Management, Vol. 4, Issue 6, June 2022, pp. 1515-1519.
- [26]. D. P. Patil, D. S. Shirsath and V. S. Gangurde, Application of Soham transform in Newton's law of cooling, International Journal of Research in Engineering and Science, Vol. 10, Issue 6, (2022) pp. 1299- 1303.
- [27]. Dinkar Patil, Areen Fatema Shaikh, Neha More and Jaweria Shaikh, The HY integral transform for handling growth and Decay problems, Journal of Emerging Technology and Innovative Research, Vol. 9, Issue 6, June 2022, pp. f334-f 343.
- [28]. Dinkar Patil, J. P. Gangurde, S. N. Wagh, T. P. Bachhav, Applications of the HY transform for Newton's law of cooling, International Journal of Research and Analytical Reviews, Vol. 9, Issue 2, June 2022, pp. 740-745.
- [29]. D. P. Patil, Sonal Borse and Darshana Kapadi, Applications of Emad-Falih transform for general solution of telegraph equation, International Journal of Advanced Research in Science, Engineering and Technology, Vol. 9, Issue 6, June 2022, pp. 19450-19454.
- [30]. Dinkar P. Patil, Divya S. Patil and Kanchan S. Malunjar, New integral transform, " Double Kushare transform" , IRE Journals, Vol.6, Issue 1, July 2022, pp. 45-52.
- [31]. Dinkar P. Patil, Priti R. Pardeshi, Rizwana A. R. Shaikh and Harshali M. Deshmukh, Applications of Emad Sara transform in handling population growth and decay problems, International Journal of Creative Research Thoughts, Vol. 10, Issue 7, July 2022, pp. a137-a141.
- [32]. D. P. Patil, B. S. Patel and P. S. Khelukar, Applications of Alenzi transform for handling exponential growth and decay problems, International Journal of Research in Engineering and Science, Vol. 10, Issue 7, July 2022, pp. 158-162.
- [33]. D. P. Patil, A. N. Wani and P. D. Thete, Solutions of Growth Decay Problems by "Emad-Falih Transform", International Journal of Innovative Science and Research Technology, Vol. 7, Issue 7, July 2022, pp. 196-201.
- [34]. Dinkar P. Patil, Vibhavari J. Nikam, Pranjal S. Wagh and Ashwini A. Jaware, Kushare transform of error functions in evaluating improper integrals, International Journal of Emerging Trends and Technology in Computer Science, Vol. 11, Issue 4, July-Aug 2022, pp. 33-38.
- [35]. Dinkar P. Patil, Priyanka S. Wagh, Pratiksha Wagh, Applications of Kushare Transform in Chemical Sciences, International Journal of Science, Engineering and Technology, 2022, Vol 10, Issue 3.
- [36]. Dinkar P. Patil, Prinka S. Wagh, Pratiksha Wagh, Applications of Soham Transform in Chemical Sciences, International Journal of Science, Engineering and Technology, 2022, Vol 10, Issue 3, pp. 1-5.
- [37]. Dinkar P. Patil, Saloni K. Malpani, Prachi N. Shinde, Convolution theorem for



- Kushare transform and applications in convolution type Volterra integral equations of first kind, International Journal of Scientific Development and Research, Vol. 7, Issue 7, July 2022, pp. 262-267.
- [38]. Dinkar Patil and Nikhil Raundal, Applications of double general integral transform for solving boundary value problems in partial differential equations, International Advanced Research Journal in Science, Engineering and Technology, Vol. 9, Issue 6, June 2022, pp. 735-739.
- [39]. D. P. Patil, M. S. Derle and N. K. Rahane, On generalized Double rangaig integral transform and applications, Stochastic Modeling and Applications, VOL. 26, No.3, January to June special issue 2022 part-8, pp. 533- 545.
- [40]. D. P. Patil, P. S. Nikam and P. D. Shinde; Kushare transform in solving Faltung type Volterra Integro-Differential equation of first kind, International Advanced Research Journal in Science, Engineering and Technology, vol. 8, Issue 10, Oct. 2022,
- [41]. D. P. Patil, K. S. Kandekar and T. V. Zankar; Application of new general integral transform for solving Abel's integral equations, International Journal of All Research Education and Scientific method, vol. 10, Issue 11, Nov.2022, pp. 1477-1487.
- [42]. Dinkar P. Patil, Priti R. Pardeshi and Rizwana A. R. Shaikh, Applications of Kharrat Toma Transform in Handling Population Growth and Decay Problems, Journal of Emerging Technologies and Innavative Research, Vol. 9, Issue 11, November 2022, pp. f179-f187.
- [43]. Dinkar P. Patil, Pranjal S. Wagh, Ashwini A. Jaware and Vibhavari J. Nikam; Evaluation of integrals containing Bessel's functions using Kushare transform, International Journal of Emerging Trends and Technology in Computer Science, Vol. 11, Issue 6, November- December 2022, pp. 23-28.
- [44]. Dinkar P. Patil, Prerana D. Thakare and Prajakta R. Patil, General Integral Transform for the Solution of Models in Health Sciences, International Journal of Innovative Science and Research Technology, Vol. 7, Issue 12, December 2022, pp. 1177- 1183.
- [45]. Dinkar P. Patil, Shrutika D. Rathi and Shweta D. Rathi; Soham Transform for Analysis of Impulsive Response of Mechanical and Electrical Oscillators, International Journal of All Research Education and Scientific Method, Vol. 11, Issue 1, January 2023, pp. 13-20.
- [46]. D. P. Patil, K. J. Patil and S. A. Patil; Applications of Karry-Kalim-Adnan Transformation(KKAT) in Growth and Decay Problems, International Journal of Innovative Research in Technology, Vol. 9, Issue 7, December 2022, pp. 437- 442.
- [47]. Dinkar P. Patil, Yashashri S. Suryawanshi and Mohini D. Nehete, Application of Soham transform for solving mathematical models occuring in health science and biotechnology, International Journal of Mathematics, Statistics and Operations Research, Vol. 2, Number 2, 2022, pp. 273-288.
- [48]. D. P. Patil, A. N. Wani, P. D. Thete, Applications of Karry-Kalim-Adnan Transformations (KKAT) to Newtons Law of Cooling, International Journal of Scientific Development and Research, Vol. 7, Issue 12,(2022) pp 1024-1030.
- [49]. Dinkar P. Patil, S. D. Shirath, A. T. Aher, Application of ARA transform for handling growth and decay problems, International Journal of Research and Analytical Reviews, Vol. 9, Issue 4, Dec.2022, pp. 167-175.
- [50]. Dinkar P. Patil, Maya Y. Paradhi, Pallavi S. Pansare, Rangaig integral transform for handling exponential growth and decay problems, International Journal of Research and Analytical Reviews, Vo. 10, Issue 1, January 2023, pp. 200-208.
- [51]. Dinkar P. Patil, Sonal R. Borse, Darshana P. Kapadi, Kushare transform for the solution of models in health sciences, International Journal of Novel Research and Development, Vol. 8, Issue 1, January2023, pp. c617-c623.
- [52]. Rohit Gupta, Shivam Sharma, Rahul Gupta, Study of laminar flow between parallel plates via Gupta integral transform, International Journal of Research in Applied Science and Engineering Technology, Vol. 10, Issue – VI, June 2022, pp. 385-389.