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APPLICATION OF KAMAL TRANSFORM FOR SOLVING ABEL'S INTEGRAL EQUATION

Sudhanshu Aggarwal*[1] & Swarg Deep Sharma[2]
*[1]Assistant Professor, Department of Mathematics, National P.G. College, Barhalganj, Gorakhpur-273402, U.P., India
[2]Assistant Professor, Department of Mathematics, Nand Lal Singh College Jaitpur Daudpur Constituent of Jai PrakashUniversity Chhapra-841205, Bihar, India

ABSTRACT

Abel's integral equation is a singular integral equation which appears in many branches of sciences such as physics, mechanics, radio astronomy, atomic scattering, X-ray radiography, electron emission and seismology. In this paper, we apply Kamal transform to solve Abel's integral equation and some numerical applications are given in application section to explain the effectiveness of Kamal transform for solving Abel's integral equation.

Keywords: *Abel's integral equation, Kamal transform, Inverse Kamal transform, Convolution theorem.*

I. INTRODUCTION

In 1823, Niels Henrik Abel studied the motion of particle on smooth curve lying on a vertical plane and described it in mathematical form in terms of Abel's integral equation as [1-2]

$$f(x) = \int_0^x \frac{1}{\sqrt{x-t}} u(t) \, dt \tag{1}$$

Here the kernel $K(x,t) = \frac{1}{\sqrt{x-t}}$ becomes ∞ at $t = x$, the function $f(x)$ is known function and the function $u(t)$ is unknown function.

In the modern time, integral transforms are of great value in the treatment of differential equations with constant or variable coefficients, partial differential equations with constant or variable coefficients, partial integro-differential equations, integral equations, integro-differential equations etc. Many scholars [3-26] used different integral transforms such as Laplace transform, Fourier transform, Kamal transfom, Aboodh transform, Elzaki transform, Mohand transform, Hankel transform, Wavelet transform, Sumudu transform and solved many advanced problems of science, engineering and daily life.

In 2016, Abdelilah and Hassan [27] gave a new integral transform "Kamal transform'' of the function $F(t)$ for $t \geq 0$ as

$$K\{F(t)\} = \int_0^\infty F(t)e^{\frac{-t}{v}}dt = G(v), k_1 \leq v \leq k_2 \tag{2}$$

where operator K is called the Kamal transform operator.

Aggarwal et al. [28] gave a comparative study of Mohand and Kamal transforms. Aggarwal and Gupta [29] discussed the solution of linear Volterra integro-differential equations of second kind using Kamal transform. Abdelilah and Hassan [30] solved partial differential equations by applying Kamal transform. Aggarwal et al. [31] gave a new application of Kamal transform for solving linear Volterra integral equations. Gupta et al. [32] discussed the solution of linear partial integro-differential equations using Kamal transform. Application of Kamal transform for solving linear Volterra integral equations of first kind was given by Aggarwal et al. [33]. Aggarwal et al. [34]

used Kamal transform for solving population growth and decay problems. Aggarwal [35] defined Kamal transform of Bessel's functions.

In this paper, we solve Abel's integral equation using Kamal transform and explain all procedure by giving some numerical applications in application section.

II. SOME USEFUL PROPERTIES OF KAMAL TRANSFORM

2.1 Linearity property [28, 32-35]:
If Kamal transform of functions $F_1(t)$ and $F_2(t)$ are $G_1(v)$ and $G_2(v)$ respectively then Kamal transform of $[aF_1(t) + bF_2(t)]$ is given by $[aG_1(v) + bG_2(v)]$, where a,b are arbitrary constants.

2.2 Change of scale property [28, 35]:
If Kamal transform of function $F(t)$ is $G(v)$ then Kamal transform of function $F(at)$ is given by $\frac{1}{a}G(av)$.

2.3 Shifting property [28]:
If Kamal transform of function $F(t)$ is $G(v)$ then Kamal transform of function $e^{at}F(t)$ is given by $G\left(\frac{v}{1-av}\right)$.

2.4 Kamal transform of the derivatives of the function $F(t)$ [27-29, 31-32, 34-35]:
If $K\{F(t)\} = G(v)$ then
   a) $K\{F'(t)\} = \frac{1}{v}G(v) - F(0)$
   b) $K\{F''(t)\} = \frac{1}{v^2}G(v) - \frac{1}{v}F(0) - F'(0)$
   c) $K\{F^{(n)}(t)\} = \frac{1}{v^n}G(v) - \frac{1}{v^{n-1}}F(0) - \frac{1}{v^{n-2}}F'(0)\ldots\ldots - F^{(n-1)}(0)$

2.5 Convolution theorem for Kamal transforms [28-29, 31-33]:
If Kamal transform of functions $F_1(t)$ and $F_2(t)$ are $G_1(v)$ and $G_2(v)$ respectively then Kamal transform of their convolution $F_1(t) * F_2(t)$ is given by
$K\{F_1(t) * F_2(t)\} = K\{F_1(t)\}K\{F_2(t)\}$
$\Rightarrow K\{F_1(t) * F_2(t)\} = G_1(v)G_2(v)$, where $F_1(t) * F_2(t)$ is defined by
$F_1(t) * F_2(t) = \int_0^t F_1(t-x) F_2(x)dx = \int_0^t F_1(x) F_2(t-x)dx$

III. KAMAL TRANSFORM OF FREQUENTLY ENCOUNTERED FUNCTIONS [27-29, 31-35]

Table: 1

S.N.	$F(t)$	$K\{F(t)\} = G(v)$
1.	1	v
2.	t	v^2
3.	t^2	$2!v^3$
4.	$t^n, n \in N$	$n!v^{n+1}$
5.	$t^n, n > -1$	$\Gamma(n+1)v^{n+1}$
6.	e^{at}	$\dfrac{v}{1-av}$
7.	$sinat$	$\dfrac{av^2}{1+a^2v^2}$
8.	$cosat$	$\dfrac{v}{1+a^2v^2}$
9.	$sinhat$	$\dfrac{av^2}{1-a^2v^2}$
10.	$coshat$	$\dfrac{v}{1-a^2v^2}$
11	$J_0(t)$	$\dfrac{v}{\sqrt{(1+v^2)}}$
12	$J_1(t)$	$1 - \dfrac{1}{\sqrt{(1+v^2)}}$

IV. INVERSE KAMAL TRANSFORM [28-29, 31-35]

If $K\{F(t)\} = G(v)$ then $F(t)$ is called the inverse Kamal transform of $G(v)$ and mathematically it is defined as $F(t) = K^{-1}\{G(v)\}$, where K^{-1} is the inverse Kamal transform operator.

V. LINEARITY PROPERTY OF INVERSE KAMAL TRANSFORMS [34]

If $K^{-1}\{H(v)\} = F(t)$ and $K^{-1}\{I(v)\} = G(t)$ then
$K^{-1}\{aH(v) + bI(v)\} = aK^{-1}\{H(v)\} + bK^{-1}\{I(v)\}$
$\Rightarrow K^{-1}\{aH(v) + bI(v)\} = aF(t) + bG(t)$, where a,b are arbitrary constants.

VI. INVERSE KAMAL TRANSFORM OF FREQUENTLY ENCOUNTERED FUNCTIONS [28-29, 31-35]

Table: 2

S.N.	$G(v)$	$F(t) = K^{-1}\{G(v)\}$
1.	v	1
2.	v^2	t
3.	v^3	$\dfrac{t^2}{2!}$
4.	$v^{n+1}, n \epsilon N$	$\dfrac{t^n}{n!}$
5.	$v^{n+1}, n > -1$	$\dfrac{t^n}{\Gamma(n+1)}$
6.	$\dfrac{v}{1-av}$	e^{at}
7.	$\dfrac{v^2}{1+a^2v^2}$	$\dfrac{sinat}{a}$
8.	$\dfrac{v}{1+a^2v^2}$	$cosat$
9.	$\dfrac{v^2}{1-a^2v^2}$	$\dfrac{sinhat}{a}$
10.	$\dfrac{v}{1-a^2v^2}$	$coshat$
11.	$\dfrac{v}{\sqrt{(1+v^2)}}$	$J_0(t)$
12.	$1 - \dfrac{1}{\sqrt{(1+v^2)}}$	$J_1(t)$

VII. KAMAL TRANSFORM FOR SOLVING ABEL'S INTEGRAL EQUATION:

In this section, we present Kamal transform for solving Abel's integral equation.
Taking Kamal transform of both sides of (1), we have

$$K\{f(x)\} = K\left\{\int_0^x \frac{1}{\sqrt{x-t}} u(t)\, dt\right\}$$

$$\Rightarrow K\{f(x)\} = K\{x^{-1/2} * u(x)\} \tag{3}$$

Applying convolution theorem of Kamal transform in (3), we have

$$K\{f(x)\} = K\{x^{-1/2}\} K\{u(x)\}$$

$$\Rightarrow K\{f(x)\} = \sqrt{\pi} v^{1/2} K\{u(x)\}$$

$$\Rightarrow K\{u(x)\} = \frac{1}{\sqrt{\pi} v^{1/2}} K\{f(x)\}$$

$$\Rightarrow K\{u(x)\} = \frac{1}{\pi v}\left[\sqrt{\pi} v^{1/2} K\{f(x)\}\right]$$

$$\Rightarrow K\{u(x)\} = \frac{1}{\pi v}\left[K\{x^{-1/2}\} K\{f(x)\}\right]$$

$$\Rightarrow K\{u(x)\} = \frac{1}{\pi v} K\{x^{-1/2} * f(x)\}$$

$$\Rightarrow K\{u(x)\} = \frac{1}{\pi v}\left[K\left\{\int_0^x \frac{1}{\sqrt{x-t}} f(t)\, dt\right\}\right]$$

$$\Rightarrow K\{u(x)\} = \frac{1}{\pi v} K\{F(x)\} \tag{4}$$

where $F(x) = \int_0^x \frac{1}{\sqrt{x-t}} f(t)\, dt$ (5)

Now applying the property, Kamal transform of derivative of the function, on (5), we have

$K\{F'(x)\} = \frac{1}{v} K\{F(x)\} - F(0)$

$\Rightarrow K\{F'(x)\} = \frac{1}{v} K\{F(x)\}$

$\Rightarrow K\{F(x)\} = v K\{F'(x)\}$ (6)

Now from (4) and (6), we have

$K\{u(x)\} = \frac{1}{\pi} K\{F'(x)\}$ (7)

Applying inverse Kamal transform on both sides of (7), we get

$u(x) = \frac{1}{\pi} F'(x) = \frac{1}{\pi} \frac{d}{dx} F(x)$ (8)

Using (5) in (8), we have

$u(x) = \frac{1}{\pi} \left[\frac{d}{dx} \int_0^x \frac{1}{\sqrt{x-t}} f(t)\, dt \right]$ (9)

which is the required solution of (1).

VIII.   APPLICATIONS

In this section, we present some numerical applications to explain the complete procedure of solving Abel's integral equation using Kamal transform.

8.1 Consider the Abel's integral equation:

$x = \int_0^x \frac{1}{\sqrt{x-t}} u(t)\, dt$ (10)

Taking Kamal transform of both sides of (10), we have

$K\{x\} = K\left\{ \int_0^x \frac{1}{\sqrt{x-t}} u(t)\, dt \right\}$

$\Rightarrow v^2 = K\{x^{-1/2} * u(x)\}$ (11)

Applying convolution theorem of Kamal transform in (11), we have

$v^2 = K\{x^{-1/2}\} K\{u(x)\}$

$\Rightarrow v^2 = \sqrt{\pi} v^{1/2} K\{u(x)\}$

$\Rightarrow K\{u(x)\} = \frac{v^{3/2}}{\sqrt{\pi}}$ (12)

Applying inverse Kamal transform on both sides of (12), we get

$u(x) = \frac{1}{\sqrt{\pi}} K^{-1}\{v^{3/2}\}$

$\Rightarrow u(x) = \frac{2}{\pi} x^{1/2}$ (13)

which is the required solution of (10).

8.2 Consider the Abel's integral equation:

$1 + x + x^2 = \int_0^x \frac{1}{\sqrt{x-t}} u(t)\, dt$ (14)

Taking Kamal transform of both sides of (14), we have

$K\{1\} + K\{x\} + K\{x^2\} = K\left\{ \int_0^x \frac{1}{\sqrt{x-t}} u(t)\, dt \right\}$

$\Rightarrow v + v^2 + 2v^3 = K\{x^{-1/2} * u(x)\}$ (15)

Applying convolution theorem of Kamal transform in (15), we have

$v + v^2 + 2v^3 = K\{x^{-1/2}\} K\{u(x)\}$

$\Rightarrow v + v^2 + 2v^3 = \sqrt{\pi} v^{1/2} K\{u(x)\}$

$$\Rightarrow K\{u(x)\} = \frac{1}{\sqrt{\pi}}\left[v^{1/2} + v^{3/2} + 2v^{5/2}\right] \tag{16}$$

Applying inverse Kamal transform on both sides of (16), we get

$$u(x) = \frac{1}{\sqrt{\pi}}K^{-1}\{v^{1/2} + v^{3/2} + 2v^{5/2}\}$$

$$\Rightarrow u(x) = \frac{1}{\sqrt{\pi}}\left[K^{-1}\{v^{1/2}\} + K^{-1}\{v^{3/2}\} + 2K^{-1}\{v^{5/2}\}\right]$$

$$\Rightarrow u(x) = \frac{1}{\pi}\left[x^{-1/2} + 2x^{1/2} + \frac{8}{3}x^{3/2}\right] \tag{17}$$

which is the required solution of (14).

8.3 Consider the Abel's integral equation:

$$3x^2 = \int_0^x \frac{1}{\sqrt{x-t}}u(t)\,dt \tag{18}$$

Taking Kamal transform of both sides of (18), we have

$$3K\{x^2\} = K\left\{\int_0^x \frac{1}{\sqrt{x-t}}u(t)\,dt\right\}$$

$$\Rightarrow 6v^3 = K\{x^{-1/2} * u(x)\} \tag{19}$$

Applying convolution theorem of Kamal transform in (19), we have

$$6v^3 = K\{x^{-1/2}\}K\{u(x)\}$$

$$\Rightarrow 6v^3 = \sqrt{\pi}v^{1/2}K\{u(x)\}$$

$$\Rightarrow K\{u(x)\} = \frac{6}{\sqrt{\pi}}v^{5/2} \tag{20}$$

Applying inverse Kamal transform on both sides of (20), we get

$$u(x) = \frac{6}{\sqrt{\pi}}K^{-1}\{v^{5/2}\}$$

$$\Rightarrow u(x) = \frac{8}{\pi}x^{3/2} \tag{21}$$

which is the required solution of (18).

8.4 Consider the Abel's integral equation:

$$\frac{4}{3}x^{3/2} = \int_0^x \frac{1}{\sqrt{x-t}}u(t)\,dt \tag{22}$$

Taking Kamal transform of both sides of (22), we have

$$\frac{4}{3}K\{x^{3/2}\} = K\left\{\int_0^x \frac{1}{\sqrt{x-t}}u(t)\,dt\right\}$$

$$\Rightarrow \sqrt{\pi}v^{5/2} = K\{x^{-1/2} * u(x)\} \tag{23}$$

Applying convolution theorem of Kamal transform in (23), we have

$$\sqrt{\pi}v^{5/2} = K\{x^{-1/2}\}K\{u(x)\}$$

$$\Rightarrow \sqrt{\pi}v^{5/2} = \sqrt{\pi}v^{1/2}K\{u(x)\}$$

$$\Rightarrow K\{u(x)\} = v^2 \tag{24}$$

Applying inverse Kamal transform on both sides of (24), we get

$$u(x) = K^{-1}\{v^2\}$$

$$\Rightarrow u(x) = x \tag{25}$$

which is the required solution of (22).

8.5 Consider the Abel's integral equation:

$$2\sqrt{x} + \frac{8}{3}x^{3/2} = \int_0^x \frac{1}{\sqrt{x-t}}u(t)\,dt \tag{26}$$

Taking Kamal transform of both sides of (26), we have

$$2K\{x^{1/2}\} + \frac{8}{3}K\{x^{3/2}\} = K\left\{\int_0^x \frac{1}{\sqrt{x-t}}u(t)\,dt\right\}$$

$$\Rightarrow \sqrt{\pi}v^{3/2} + 2\sqrt{\pi}v^{5/2} = K\{x^{-1/2} * u(x)\} \tag{27}$$

Applying convolution theorem of Kamal transform in (27), we have

$\sqrt{\pi}v^{3/2} + 2\sqrt{\pi}v^{5/2} = K\{x^{-1/2}\}K\{u(x)\}$

$\Rightarrow \sqrt{\pi}v^{3/2} + 2\sqrt{\pi}v^{5/2} = \sqrt{\pi}v^{1/2}K\{u(x)\}$

$\Rightarrow K\{u(x)\} = v + 2v^2$ (28)

Applying inverse Kamal transform on both sides of (28), we get

$u(x) = K^{-1}\{v\} + 2K^{-1}\{v^2\}$

$\Rightarrow u(x) = 1 + 2x$ (29)

which is the required solution of (26).

8.6 Consider the Abel's integral equation:

$\frac{3}{8}\pi x^2 = \int_0^x \frac{1}{\sqrt{x-t}}u(t)\,dt$ (30)

Taking Kamal transform of both sides of (30), we have

$\frac{3}{8}\pi K\{x^2\} = K\left\{\int_0^x \frac{1}{\sqrt{x-t}}u(t)\,dt\right\}$

$\Rightarrow \frac{3}{4}\pi v^3 = K\{x^{-1/2} * u(x)\}$ (31)

Applying convolution theorem of Kamal transform in (31), we have

$\frac{3}{4}\pi v^3 = K\{x^{-1/2}\}K\{u(x)\}$

$\Rightarrow \frac{3}{4}\pi v^3 = \sqrt{\pi}v^{1/2}K\{u(x)\}$

$\Rightarrow K\{u(x)\} = \frac{3}{4}\sqrt{\pi}v^{5/2}$ (32)

Applying inverse Kamal transform on both sides of (32), we get

$u(x) = \frac{3}{4}\sqrt{\pi}K^{-1}\{v^{5/2}\}$

$\Rightarrow u(x) = x^{3/2}$ (33)

which is the required solution of (30).

IX.   CONCLUSION

In this paper, we have successfully discussed the application of Kamal transform for solving Abel's integral equation. The given numerical applications in the application section explain the whole procedure of this scheme. The results show that Kamal transform is a powerful integral transform for handling Abel's integral equation. In future, Kamal transform can be used for solving other singular integral equations and their systems.

REFERENCES
1. *Rahman, M., Integral equation and their applications, Wit Press Southampton, Boston, 2007.*
2. *Wazwaz, A.M., Linear and nonlinear integral equations: Methods and applications, Higher Education Press, Beijing, 2011.*
3. *Lokenath Debnath and Bhatta, D., Integral transforms and their applications, Second edition, Chapman & Hall/CRC, 2006.*
4. *Watugula, G.K., Sumudu transform: A new integral transform to solve differential equations and control engineering problems, International Journal of Mathematical Education in Science and Technology, 24(1), 35-43, 1993.*
5. *Aggarwal, S., Gupta, A.R., Singh, D.P., Asthana, N. and Kumar, N., Application of Laplace transform for solving population growth and decay problems, International Journal of Latest Technology in Engineering, Management & Applied Science, 7(9), 141-145, 2018.*
6. *Aggarwal, S., Chauhan, R. and Sharma, N., Application of Elzaki transform for solving linear Volterra integral equations of first kind, International Journal of Research in Advent Technology, 6(12), 3687-3692, 2018.*
7. *Aggarwal, S., Singh, D.P., Asthana, N. and Gupta, A.R., Application of Elzaki transform for solving population growth and decay problems, Journal of Emerging Technologies and Innovative Research, 5(9), 281-284, 2018.*

8. Aggarwal, S., Sharma, N., Chauhan, R., Gupta, A.R. and Khandelwal, A., *A new application of Mahgoub transform for solving linear ordinary differential equations with variable coefficients, Journal of Computer and Mathematical Sciences, 9(6), 520-525, 2018.*

9. Aggarwal, S., Chauhan, R. and Sharma, N., *A new application of Mahgoub transform for solving linear Volterra integral equations, Asian Resonance, 7(2), 46-48, 2018.*

10. Aggarwal, S., Sharma, N. and Chauhan, R., *Solution of linear Volterra integro-differential equations of second kind using Mahgoub transform, International Journal of Latest Technology in Engineering, Management & Applied Science, 7(5), 173-176, 2018*

11. Aggarwal, S., Sharma, N. and Chauhan, R., *Application of Mahgoub transform for solving linear Volterra integral equations of first kind, Global Journal of Engineering Science and Researches, 5(9), 154-161, 2018.*

12. Aggarwal, S., Pandey, M., Asthana, N., Singh, D.P. and Kumar, A., *Application of Mahgoub transform for solving population growth and decay problems, Journal of Computer and Mathematical Sciences, 9(10), 1490-1496, 2018.*

13. Aggarwal, S., Sharma, N. and Chauhan, R., *Application of Aboodh transform for solving linear Volterra integro-differential equations of second kind, International Journal of Research in Advent Technology, 6(6), 1186-1190, 2018.*

14. Aggarwal, S., Sharma, N. and Chauhan, R., *A new application of Aboodh transform for solving linear Volterra integral equations, Asian Resonance, 7(3), 156-158, 2018.*

15. Aggarwal, S., Asthana, N. and Singh, D.P., *Solution of population growth and decay problems by using Aboodh transform method, International Journal of Research in Advent Technology, 6(10), 2706-1190, 2710.*

16. Aggarwal, S., Sharma, N. and Chauhan, R., *Solution of population growth and decay problems by using Mohand transform, International Journal of Research in Advent Technology, 6(11), 3277-3282, 2018.*

17. Aggarwal, S., Sharma, N. and Chauhan, R., *Solution of linear Volterra integral equations of second kind using Mohand transform, International Journal of Research in Advent Technology, 6(11), 3098-3102, 2018.*

18. Elzaki, T.M. and Ezaki, S.M., *On the Elzaki transform and ordinary differential equation with variable coefficients, Advances in Theoretical and Applied Mathematics, 6(1), 41-46, 2011.*

19. Elzaki, T.M. and Ezaki, S.M., *Applications of new transform ''Elzaki transform'' to partial differential equations, Global Journal of Pure and Applied Mathematics, 7(1), 65-70, 2011.*

20. Shendkar, A.M. and Jadhav, P.V., *Elzaki transform: A solution of differential equations, International Journal of Science, Engineering and Technology Research, 4(4), 1006-1008, 2015.*

21. Aboodh, K.S., *Application of new transform "Aboodh Transform" to partial differential equations, Global Journal of Pure and Applied Mathematics, 10(2), 249-254, 2014.*

22. Aboodh, K.S., Farah, R.A., Almardy, I.A. and Osman, A.K., *Solving delay differential equations by Aboodh transformation method, International Journal of Applied Mathematics & Statistical Sciences, 7(2), 55-64, 2018.*

23. Aboodh, K.S., Farah, R.A., Almardy, I.A. and Almostafa, F.A., *Solution of partial integro-differential equations by using Aboodh and double Aboodh transforms methods, Global Journal of Pure and Applied Mathematics, 13(8), 4347-4360, 2016.*

24. Mohand, D., Aboodh, K.S. and Abdelbagy, A., *On the solution of ordinary differential equation with variable coefficients using Aboodh transform, Advances in Theoretical and Applied Mathematics, 11(4), 383-389, 2016.*

25. Kumar, P.S., Saranya, C., Gnanavel, M.G. and Viswanathan, A., *Applications of Mohand transform for solving linear Volterra integral equations of first kind, International Journal of Research in Advent Technology, 6(10), 2786-2789, 2018.*

26. Kumar, P.S., Gomathi, P., Gowri, S. and Viswanathan, A., *Applications of Mohand transform to mechanics and electrical circuit problems, International Journal of Research in Advent Technology, 6(10), 2838-2840, 2018.*

27. Abdelilah, K. and Hassan, S., *The new integral transform "Kamal Transform", Advances in Theoretical and Applied Mathematics, 11(4), 451-458, 2016.*

28. Aggarwal, S., Sharma, N., Chaudhary, R. and Gupta, A.R., *A comparative study of Mohand and Kamal transforms, Global Journal of Engineering Science and Researches, 6(2), 113-123, 2019.*

29. Aggarwal, S. and Gupta, A.R., *Solution of linear Volterra integro-differential equations of second kind using Kamal transform, Journal of Emerging Technologies and Innovative Research, 6(1), 741-747, 2019.*

30. Abdelilah, K. and Hassan, S., *The use of Kamal transform for solving partial differential equations, Advances in Theoretical and Applied Mathematics, 12(1), 7-13, 2017 .*

31. *Aggarwal, S., Chauhan, R. and Sharma, N., A new application of Kamal transform for solving linear Volterra integral equations, International Journal of Latest Technology in Engineering, Management & Applied Science, 7(4), 138-140, 2018.*
32. *Gupta, A.R., Aggarwal, S. and Agrawal, D., Solution of linear partial integro-differential equations using Kamal transform, International Journal of Latest Technology in Engineering, Management & Applied Science, 7(7), 88-91, 2018.*
33. *Aggarwal, S., Sharma, N. and Chauhan, R., Application of Kamal transform for solving linear Volterra integral equations of first kind, International Journal of Research in Advent Technology, 6(8), 2081-2088, 2018.*
34. *Aggarwal, S., Gupta, A.R., Asthana, N. and Singh, D.P., Application of Kamal transform for solving population growth and decay problems, Global Journal of Engineering Science and Researches, 5(9), 254-260, 2018.*
35. *Aggarwal, S., Kamal transform of Bessel's functions, International Journal of Research and Innovation in Applied Science, 3(7), 1-4, 2018.*