**Applications of Soham Integral Transform to Solve Volterra Integral Equations of Second Kind**

1. P. Patil,

[sdinkarpatil95@gmail.com](mailto:sdinkarpatil95@gmail.com)

Department of Mathematical Sciences,

K. T. H. M. College, Gangapur road ,Nashik.

**ABSTRACT**

Many advanced scientific and engineering problems can be theoretically represented as linear Volterra integral equations. In this work, we use Soham transform for obtaining solution of Volterra integral equations of 2nd kind. To demonstrate the applicability of the Soham transform, some numerical problems were presented and solved by the Soham transform. Numerical results show that the Soham transform is very much useful to obtain the accurate solution of the 2nd kind Linear Volterra integral equations.

**Keywords:** Volterra integral equations of 2nd kind, Soham transform, Soham inverse transform, Convolution theorem.

1. **INTRODUCTION :** The 2nd kind of linear Volterra integral equation is defined as follows

Here the function f(y) and kernel k(y, t) are known real- valued functions. The unknown Function

is denoted by and is a non-zero real parameter.

We solve linear Volterra integral equations of 2nd kind. For that purpos we use the Soham transform To obtain the solutions of advanced problems which occurs in fields like Science, Engineering, Health Sciences, Pharmacy, Technology, Commerce and Economics, the most useful and simple mathematical technique is use of integral transform. It is very useful and effective technique for solving a linear differential equations and system of such equations and integral equations under the given initial conditions. Integral transforms provides exact solution of the problem without doing lengthy calculations is the important feature of integral transforms .

As integral transforms has this important feature of obtaining solution of the problem using small number of calculations, many researchers are interested to use this field. They make themselves busy in formation of various new integral transforms with various Kernels on various domains. Recently, the integral transform called as Kushare transform is developed by S. R. Kushare and D. P. Patil [1] in October 2021 and used it to solve differential equations and system of differential equations. Further new integral transform named as Soham transform is introduced by Savita Khakale and Dinkar Patil [2] in November 2021. Further, Patil and some authors [5, 6, 7] used Kushare transform for solving different problems.

Anuj integral transform is used by Patil et al [4] to solve first kind Volterra integral equations . Patil together with Suryawanshi [3, 8] solved volterra integral equations and solve system of differential equations in the mathematical models occurring in health sciences and biotechnology by using Soham transform.

We organize this paper as follows. First section contains introduction . Second section is devoted for preliminary concepts. In third section we state and prove Convolution theorem of Soham transform. Soham transform is applied to obtain the solution of Volterra integral equations in fourth section.

1. **PRELIMINARIES:** We state some basic required concepts here. Now we state some definitions, properties and formulae which are required .
   1. **Soham transform:** Soham Transform is denoted by the operator S(.) and it is defined by the integral equation dt

where is a non zero real number, t ≥ 0,

* 1. **Inverse Soham Transform:**

If we dwnote the Soham transform of the function f(t) by q(v) then we define inverse Soham transform as

* 1. **Properties of Soham Transform:**

We state some useful properties of Soham integral transform in this subsection [ 1].

1. **Linearity property**: If 𝑓1 (t) and 𝑓2(t) are two functions of t and c1 and c2 are any two constants then

2. **Transform of derivative**: Let P(v) be the Soham transform of the function f(t) i.e . [S[f(t)] = P(v)] then

# Soham Transform of Elementary Functions:

“For t ≥ 0 the function f(t) is piecewise continuous and is of exponential order” , these are the sufficient conditions for the existence of Soham transform. If these conditions are not satisfied then Soham transform of that function may or may not exist.

In this section we state Soham transform of some elementary functions.

Table: Soham transform of some functions

|  |  |  |
| --- | --- | --- |
| Sr. No. | f(t) |  |
| 1 | 1 |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |
| 6 |  |  |
| 7 |  |  |
| 8 |  |  |
| 9 |  |  |

1. **CONVOLUTION THEOREM:**

Now we state and prove convolution theorem.

The convolution of two function f(t) and g(t) is defined as. ,

**Theorem:** If f(t) and g(t) are two functions such that and ,

then

**Proof:** Applying Soham transform.

Change order of integration and put

Thus the convolution theorem forintegral transform ( Soham transform);

is proved.

1. **SOHAM TRANSFORM FOR CONVOLUTION TYPE 2ND KIND LINEAR VOLTERRA INTEGRAL EQUATIONS**

In this study, the kernel will be assumed to be a difference kernel, as described by the difference(y-t).The 2nd kind of Volterra integral equation can thus expressed as:

…..(1)

The Soham integral transform method is applied to both sides of (1), yielding

…..(2)

Now we use convolution theorem of Soham integral transform on both sides of the equation (2), we have

Inverting the Soham integral transform on equation (3), We obtain:

Equation (4) is the required solution of equation (1)

**5. NUMERICAL APPLICATIONS**

Some applications are presented in this part to show the unity of Soham integral transform for solving Volterra integral equation of the 2nd kind. Now we solve following Volterra integral equations of second kind.

1. Consider the Volterra integral equation of the 2nd kind :

The Soham transform is applied to both sides of equation (5), yielding,

Now using the Soham transform convolution theorem on equation (6), we have,

S{(y)}=+vs{siny}.s{(y)}

s{(y)}[1−] =

s{(y)}= ….. (7)

We obtained required solution (5) by applying the inverse Soham transformation of both sides of (7)

(y) = 1 . It is required solution.

1. Consider Volterra integral equation

=y+y-t)dt ….…(8)

We apply Soham transform on both sides of equation (8), and obttain,

s{= s{y}+s{y-t)dt}

s{}=s{y}+s{siny\*} …….(9)

By using convolution theorem of Soham transformation,

By applying inverse Soham transformation to both sides of equation (10),

(y)={ +{

(y)= t +

It is the required solution.

1. Now consider the Volterra integral equation of the 2nd kind:

Applying Soham transform on both sides,

By using convolution theorem of Soham transform,

S{(y)}=+ v.s{}. S{(y)}

+

Applying inverse Soham transform,

It is the required solution.

(D)Take the Volterra integral equation of 2nd kind:

(y)=-cosy -2(t).dt ..……..(12)

Applying Soham transform on both sides, we get

Using convolution theorem,

We apply the inverse Soham transform to above equation.

It is the required solution.

1. Consider the Volterra integral equation of the 2nd kind:

Applying Soham transform, on both side we get,

By using convolution theorem of Soham transform

S{(y)}=v s{1}.s{(g)}

By using inverse Soham transform

}

is the required solution.

1. **CONCLUSION:** We applied Soham integral transform to solve the problems on Volterra integral transform successfully. Answers obtained are same as obtained by other methods.

**REFERENCES:**

1. 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
2. Dinkar P. Patil , Savita S. Khakale, The New Integral Transforms “Soham Transform”, International Journal of Advances in Engineering and Management, Vol.3, issue 10, Oct. 2021.
3. Dinkar P. Patil , Yashashri S. Suryawanshi , Mohini D. Nehete , Applications 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) .
4. 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.
5. 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.
6. 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.
7. 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.
8. Dinkar P. Patil, Yashashri S. Suryawanshi and Mohini D Nehete, Applications of SohamTransform 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.