Financial Accounting Measurement Model Based on Numerical Analysis of Rigid Normal Differential Equation and Rigid Functional Equation

Zhihua Yan¹, Bahjat Fakieh², Ragab Ibrahim Ismail³

¹ Wuxi Tourism and Commerce Branch of Jiangsu Union Technical Institute, Wuxi 214045, China
² Information System Department, Faculty of Computing and Information Technology, King Abdulaziz University, Jeddah, Saudi Arabia
³ Department of Accounting and Finance, Faculty of Administrative Sciences, Applied Science University, Al Eker, Kingdom of Bahrain

Abstract

The initial value problem of stiff functional differential equations often appears in many fields such as automatic control, economics and its theoretical and algorithmic research is of unquestionable importance. The paper proposes a rigid functional equation based on the integral process method of the financial accounting measurement model of numerical analysis. This method provides a unified theoretical basis for the stability analysis of the solution of the functional differential equation encountered in the integrodifferential equation and the financial accounting fair value measurement model of investment real estate.

Keywords: Rigid ordinary differential equation, accounting measurement, fair value measurement model, integration process, rigid differential equation, functional equation

AMS 2010 codes: 41A50

1 Introduction

At present, there are two follow-up measurement modes for investment in real estate in Chinese current accounting standards: one is the cost mode measurement, and the other is the fair value mode measurement. However, in recent years, the Chinese real estate market price is higher than the historical cost [1]. Therefore, if we adopt a different measurement model, it will impact its related financial indicators. Therefore, some companies will use the method of changing the measurement model of investment real estate to carry out earnings

¹Corresponding author.
Email address: zhihuayan214@163.com

doi:10.2478/amns.2021.2.00094
management and whitewash their performance, which will impact the company itself and investors.

We usually use differential equations to describe physical or chemical processes in practical problems in technical engineering fields such as chemical reactions, biological models, fluid and molecular dynamics, electronic networks and automatic control. These problems often involve many processes that interact but vary significantly in speed. This rigid phenomenon is reflected in the mathematical language. The differential equation itself contains both a fast-changing component that decays rapidly and a slow-changing component that changes very slowly. To ensure the stability of the numerical calculation and achieve a sure calculation accuracy, we limit the step size for the fast-changing component to be relatively small. When the fast-changing component decays sufficiently small, the problem enters the slow-changing stage [2]. At this stage, it takes a long time to approach the steady state. Therefore, more calculation steps are required. The increase in calculation results in the continuous accumulation of round-off errors and ultimately affects the numerical stability and calculation accuracy. If the problems mentioned above are solved using traditional differential equation numerical integration methods, difficulties will be encountered, and ideal numerical solutions cannot be obtained. However, the wide application of stiff differential equations in various practical fields makes it urgent to construct efficient numerical algorithms. In recent years, it has become a research hotspot in computational mathematics.

The Runge-Kutta (RK) method is a classic single-step method for solving severe problems. It has high accuracy and good stability. The disadvantage is that it requires a relatively large amount of calculation. The more commonly used RK methods include the single implicit RK method, diagonal implicit RK method, Rosenbrock method, etc. The Rosenbrock method is a kind of semi-implicit RK method based on the diagonal implicit RK method. Compared with the implicit RK method, there is no need to solve the nonlinear equations in the calculation process, significantly reducing the calculation workload [3]. Although the RK method has made many achievements in solving stiff differential equations, there are not many high-precision numerical calculations. Some scholars improve the algebraic accuracy of Rosenbrock’s method by choosing appropriate free parameter values. However, the order condition of the Rosenbrock method is a system of nonlinear equations about the parameters, which brings specific difficulties to the calculation of the parameters.

The Chebyshev spectrum method is a high-precision method. If the solution of the original problem is sufficiently smooth, the calculation accuracy can reach exponential order convergence. The main objective of this method is to carry out the Chebyshev polynomial expansion of the unknown function and approximate the derivative of the unknown function in the equation through differentiation. We transform the original equations into linear algebraic equations satisfied by the expansion coefficients of Chebyshev polynomials. In recent years, the Chebyshev spectrum method has received more and more attention in many practical applications. Some scholars combined Chebyshev polynomials with stepwise regression statistical methods to effectively predict the precipitation in the southwestern region of China in the medium and long term. Some scholars use two-dimensional tidal wave equations to describe the tidal currents in the Daya Bay area, using Chebyshev polynomials as the basis functions, and using distributed pseudospectral methods for numerical simulations. Some scholars have solved the wave equation using the second type of Chebyshev wavelet method. Numerical experiments have established that this method gives a higher-precision numerical solution than some classical wavelet methods.

On the other hand, the Tau method is a unique Petrov-Galerkin method, different from the traditional Galerkin method. It does not require the basis function to satisfy the boundary conditions of the equation. Some scholars used the Chebyshev-Tau method and the Chebyshev-Galerkin method to perform high-precision numerical approximation to the boundary value problem of the two-dimensional Poisson equation, compared the convergence speed of the two methods, and analysed the calculation errors. In addition, some scholars have proposed a Chebyshev-Tau matrix method to solve Poisson-type equations with variable coefficients [4]. It should be pointed out that these methods are based on the numerical differentiation process, and the differentiation process is susceptible to a small error in the calculation. However, the sensitivity of numerical integration to errors is much smaller.

On the other hand, the condition number of the coefficient matrix obtained by the Chebyshev spectral method
discretisation based on the differential process increases rapidly with the increase in the number of unknowns. Significantly when solving large-scale and complex problems, the accumulation of round-off errors makes the spectral accuracy suffer a significant loss, and its calculation effect is not ideal. Therefore, some scholars have proposed that the numerical integration process’ difficulties can be effectively overcome instead of the differential process. Later, some scholars proposed a pseudospectral method based on the integral matrix and gave a relevant theoretical analysis on improving the condition number.

Inspired by the above research work, this paper proposes a Chebyshev-Tau method based on the integration process. This method opens up a brand-new idea for the high-precision numerical calculation of stiff differential equations. It starts from the highest order derivative term in the equation to perform Chebyshev polynomial expansion. Based on the indefinite integral formula of Chebyshev polynomial and its related operation properties, the polynomial approximation from the low-order derivative term of the equation to the unknown function is obtained from the integration process. Sufficient numerical experiments prove that the method proposed in this paper has certain advantages in solving stiff differential equations [5]. First, the integral constant introduced in the integration process can handle the boundary conditions flexibly. Secondly, compared with the classical Chebyshev spectrum method, the coefficient matrix obtained by the discrete one-dimensional problem is well formed. The condition number does not increase with the increase of the polynomial expansion order. In terms of calculation accuracy, both linear and nonlinear stiff differential equations have achieved exponential convergence accuracy. Compared with the classical differential equation numerical integration method, it consumes less calculation and obtains higher accuracy. And this method also shows good stability in long-term numerical calculations.

2 Stiff differential equations

Consider the following initial value problem:

\[
\begin{align*}
\frac{du(t)}{dt} &= f(u(t)), \quad a \leq t \leq b \\
\quad u(a) &= u_0 \\
\end{align*}
\]

(1)

Where \( u \) is the \( m \)-dimensional function vector defined on \([a, b]\). \( f : D = R^m \rightarrow R^m \) is the given sufficiently smooth map. \( R^m \) represents the \( m \)-dimensional Euclidean space.

If the eigenvalue \( \lambda_i(t), 1 \leq i \leq m \) of the Jacobian matrix \( \frac{\partial f}{\partial u} \) of \( f \) satisfies the following condition

\[ \max_{1 \leq i \leq m} |\text{Re}(\lambda_i(t))| \geq 1 \]

then problem (1) is called a system of stiff differential equations.

3 Chebyshev-Tau method based on the integration process

3.1 Preliminary knowledge

For \( \forall t \in [-1, 1] \), the polynomial \( \{ T_i(t) \} \) satisfies the following recurrence relation:

\[
\begin{align*}
T_0(t) &= 1, T_1(t) = t \\
T_{k+1}(t) &= 2T_k(t) - T_{k-1}(t), k \geq 1
\end{align*}
\]

(2)

Indefinite integral formula

\[
\begin{align*}
\int T_0(t)dx &= T_1(t) \\
\int T_1(x)dx &= \frac{1}{4}T_2(t) + \frac{1}{4}T_0(t) \\
\int T_i(x)dx &= \frac{1}{2(t+1)}T_{i+1}(t) - \frac{1}{2(t-1)}T_{i-1}(t), i \geq 2
\end{align*}
\]

(3)
3.2 Equation discrete

Consider the numerical discretisation of the following one-dimensional model problem

\[
\begin{align*}
    u(t) + h(t)u(t) &= g(t), \quad -1 \leq t \leq 1 \\
    u(-1) &= u_0
\end{align*}
\]

(4)

Suppose the unknown functions \(u(t)\) and \(u'(t)\) have the following truncated Chebyshev polynomial expansion

\[
\begin{align*}
    u'(t) &\simeq \sum_{i=0}^{N} a_i T_i(t), u(t) &\simeq \sum_{i=0}^{N} b_i T_i(t)
\end{align*}
\]

(5)

If the function value on the node is given in advance, the expansion coefficient in the expression can be obtained by the fast Fourier transform [6]. The calculated amount is \(O(N \log N)\). Derived from the indefinite integral formula (3)

\[
\begin{align*}
    u(t) &\simeq \sum_{i=0}^{N} a_i \int T_i(x)dx \simeq b_0 + (a_0 - \frac{a_2}{2}) T_1(t) + \sum_{i=2}^{N-1} \left( \frac{a_{i-1} - a_{i+1}}{2i} \right) T_i(t) + \frac{a_{N-1}}{2N} T_N(t)
\end{align*}
\]

Remember the coefficient vectors \(a = [a_0, a_1, \ldots, a_N]^T\), \(b = [b_0, b_1, \ldots, b_N]^T\) and \(U = [b_0, a_0, \ldots, a_N]^T\), then the relationship satisfied between \(a, b, U\) can be expressed by the operation form of a matrix and vector as

\[
a = H_0 U, \quad b = H_1 U
\]

(6)

Where \(H_0, H_1\) is the \((N+1) \times (N+2)\) order integral matrix

\[
H_0 = \begin{bmatrix}
0 & 1 & 0 & \cdots & 0 \\
\vdots & 0 & 1 & \vdots & \vdots \\
\vdots & \vdots & \ddots & \vdots & \vdots \\
\vdots & \vdots & \cdots & 0 & \vdots \\
0 & 0 & \cdots & 1 & 1
\end{bmatrix}
\]

\[
H_1 = \begin{bmatrix}
1 & 0 & 0 & \cdots & 0 \\
1 & 0 & -\frac{1}{2} & \cdots & 0 \\
\frac{1}{4} & 0 & \frac{1}{4} & \cdots & 0 \\
\vdots & \vdots & \vdots & \cdots & \vdots \\
\frac{1}{2(N-1)} & \cdots & \frac{1}{2(N-1)}
\end{bmatrix}
\]

Further by the operational properties of matrices and vectors, there are

\[
\begin{align*}
    u'(t) &\simeq [T_0(t), \cdots, T_N(t)]H_0 U \\
    u(t) &\simeq [T_0(t), \cdots, T_N(t)]H_1 U
\end{align*}
\]

(7)

For the variable coefficient term \(V(t) = h(t)u(t)\) in the control equation, it is necessary to investigate the Chebyshev polynomial expansion of the product of the two functions for processing.

Obtain \(V(t) \simeq h(t) \sum_{j=0}^{N} b_j T_j(t)\) from Equation (5), and we write it as \(u_j(t) = h(t)T_j(t)\). At the same time, we assume \(h(t) \simeq \sum_{i=0}^{N} h_i T_i(t)\), then the following formula \(u_j(t) \simeq \sum_{i=0}^{N} h_i T_i(t) T_j(t)\) is obtained. On the other hand,
we assume \( v_j(t) \simeq \sum_{i=0}^{N} v_{j,i} T_i(t) \), and use the relation \( T_i(t) T_j(t) = \frac{T_{i,j}(t) + T_{j,i}(t)}{2} \) to obtain the coefficient vector \( v_j(t) = [v_{j,0}, \ldots, v_{j,N}]^T \) and \( h = [h_0, \ldots, h_N]^T \) satisfying \( v_j = M_j h \).

\[
M_j = \frac{1}{2} \begin{pmatrix}
1 & \cdots & 1 \\
\vdots & \ddots & \vdots \\
1 & \cdots & 1
\end{pmatrix}_{(N+1) \times (N+1)}
\]

Element 1 in row 1 is in the column \( j+1 \), and element 2 in column 1 is in a row \( j+1 \). We assume that \( V(t) \simeq \sum_{i=0}^{N} V_i T_i(t) \) can be expressed as the coefficient vector \( V = [V_0, \ldots, V_N]^T \) by the above derivation process

\[
V = M_h b = M_h H_1 U
\]

Where \( M_h = [M_0 h, M_1 h, \ldots, M_N h] \). So far, the discrete form of the governing equation in question (4) is

\[
(H_0 + M_k H_1) U = g
\]

Where \( g \) is the Chebyshev polynomial expansion coefficient vector of the correct term \( g(t) \). If there is a nonlinear term in the control equation, we can transform the original problem into a variable coefficient equation for discretisation by establishing an iterative format [7].

3.3 Boundary condition processing

We use Equation (7) to establish the following discrete for boundary condition \( u(-1) = u_0 \)

\[
[T_0(-1), \ldots, T_N(-1)] H_1 U = u_0
\]

From the above formula \( b_0 \) can be expressed by \( a \) as

\[
b_0 = Q a + u_0
\]

Among them \( Q = I - \overline{H}_1, I^- = [1, -1, 1, \cdots]_{(N+1)\times(N+1)} \overline{H}_1 = H_1 (2N + 2) \).

We will use Equation (10) on behalf of the person in Equation (9). We assume \( L = H_0 + M_k H_1, L_1 = L(:,1), L_2 = L(:,2:N+2) \), then Equation (9) is finally transformed into a linear algebraic equation system satisfied by the coefficient vector \( a \)

\[
(L_1 Q + L_2) a = g - L_1 u_0
\]

Among them \( L_1 Q + L_2 \) is a square matrix of order \( N + 1 \). From the above-mentioned discrete process, it can be found that the integral constant introduced by the integral enables the boundary conditions to be handled flexibly.

4 Overview of investment real estate and subsequent measurement models

4.1 Overview of investment real estate

The accounting treatment of investment real estate that uses the cost model for subsequent measurement is similar to fixed assets and intangible assets, with monthly depreciation and amortisation. Most of the listed companies in China adopt the cost model. The cost model has strong practicability [8]. This model can fully consider the various consumption of assets, but it is difficult to accurately calculate various depreciation and appreciation, which leads to insufficient authenticity of the data. Under the fair value model, no depreciation and amortisation are provided.
4.2 Accounting treatment of investment real estate’s subsequent measurement mode conversion under the current standards

4.2.1 Handling of changes

The change in the subsequent measurement mode of investment in real estate should be treated as a change in accounting policy. There will be a certain difference between the fair value and the book value when the measurement model changes. We will adjust the difference to the retained earnings at the beginning of the period [9]. The enterprise makes changes to the investment in real estate measurement model, which complies with the provisions of the accounting standards on investment in real estate.

4.2.2 Accounting treatment of investment in real estate measured by fair value model after the change

No depreciation, amortisation, and asset impairment provisions are accrued for investment in real estate measured under the fair value model [10]. The accounting entries are as follows:

1. Rising prices of investment in real estate
   Borrow: Investment in real estate-changes in fair value
   Loan: gains and losses from changes in fair value

2. Falling investment in real estate prices
   Borrow: gains and losses from changes in fair value
   Loan: Investment in real estate-changes in fair value

5 Analysis of the financial impact of the change in the subsequent measurement mode of a commercial investment in real estate

5.1 Impact on the balance sheet

Investment real estate is a non-current asset. Therefore, the total assets of a company will change as its book value changes. Figure 1 shows the fair value model. Over the past 10 years, Chinese real estate has continued to increase in value. Under normal circumstances, the book value of the investment in real estate under the fair value model is much greater than the book value under the cost model [11]. Therefore, after the change in the measurement model, the scale of the company’s book assets will increase substantially. In addition, when the measurement model is changed, there will be an individual difference in the book value of the investment in real estate under the two models. This will affect the company’s undistributed profits and other subjects. After a Commercial investment changed the subsequent measurement model of investment in real estate to a fair value model in 2015, the book value of the investment in real estate has increased significantly. This proportion of total assets has also increased, as shown in Table 1.

| Table 1 | Overview of A Commercial Investment Real Estate from 2013 to 2018 (Unit: 10,000 Yuan) |
|---------|--------------------------------------|
| 2013    | 10,909.5                             | 4.72                   |
| 2014    | 18,061.45                            | 7.82                   |
| 2015 cost model | 27,097.76                         | 9.4                    |
| 2015 fairness model | 1,43,177.44                       | 22.47                  |
| 2016 fair model | 1,41,718.47                        | 8.95                   |
| 2017 fair model | 4,99,262.35                        | 28.1                   |
| 2018 fair model | 6,15,962.14                       | 31.65                  |
According to the data in Table 1, it can be concluded that the book value of a Commercial’s investment in real estate has been rising from 2013 to 2015. In 2015, the book value of investment in real estate under the cost model measurement model was RMB 270,9776 million [12]. This is 5.28 times the cost model measurement, increasing its share of total assets to 22.47%. The real estate downturn in 2016 led to a decrease in fair value, and its share in total assets also declined. In 2017, the real estate market rebounded, and the fair value increased. By 2018, investment real estate accounted for 31.65% of total assets.

According to Table 2, we can get the follow-up measurement model of a commercial change investment in real estate in 2015. The difference between the book value under the two measurement models increased the company’s other comprehensive income of 875,669,800 Yuan. Since 2016, the company’s other comprehensive income has been on the rise. On the whole, the fair value model has increased the deferred income tax liabilities of a commercial investment real estate. Still, the undistributed profits and other comprehensive income have also increased substantially. Therefore, it is better for the development of the enterprise than for the cost measurement model.

| Table 2 2015–2018 A List of Book Values of Commercial Investment In Real Estate (Unit: 10,000 Yuan) |
|---------------------|---------------------|---------------------|---------------------|
|                     | Deferred income tax liabilities | Undistributed profit | Other comprehensive income |
| 2015 (cost model)   | 888.92               | 53,406.9            | 306.52              |
| 2015 (fair value model) | 29,908.84          | 1,27,237.6         | 87,873.5          |
| 2016 (fair value model) | 1,24,272.29        | 60,857.81          | 94,527.9          |
| 2017 (fair value model) | 1,51,115.59        | 1,05,498.82        | 1,64,747.42       |
| 2018 (fair value model) | 1,73,403.97        | 1,63,336.31        | 2,09,963.95       |

5.2 Impact on the income statement

There is an overall upward trend, with a fair value higher than the book balance. When the gains and losses from changes in fair value increase, the enterprise’s profits will increase accordingly, which can enhance the enterprise’s profitability. According to the data in Table 3, it can be concluded that depreciation and amortisation, and other cost-related items are not accrued under the fair value measurement mode. Therefore, if housing prices continue to increase and the depreciation and amortisation in the cost measurement model decrease, the enterprise’s profits will increase substantially [13]. Since 2017, the gains and losses from changes in the fair
value of investment real estate have been positive, and the book value has increased. By 2018, the proportion of gains and losses from changes in fair value in operating profits has increased to 6.56%.

Table 3  A summary of the impact on the income statement after the measurement mode change

|                  | Depreciation and amortisation | Changes in fair value gains and losses | Depreciation and amortization as a percentage of operating profit | Proportion of gains and losses from changes in fair value (%) | Operating profit |
|------------------|-------------------------------|----------------------------------------|---------------------------------------------------------------|------------------------------------------------------------|-----------------|
| 2015 (cost model) | 3,787.19                      | -                                      | 36.86%                                                        | -                                                          | 10,274.53       |
| 2015 (fair value model) | -                             | -921.93                               | -                                                             | 1.07                                                       | 86,461.68       |
| 2016 (Fair Value Model) | -                             | -1,458.97                             | -                                                             | 1.75                                                       | 83,403.03       |
| 2017 (Fair Value Model) | -                             | 782.95                                | -                                                             | 0.52                                                       | 1,50,484.6      |
| 2018 (Fair Value Model) | -                             | 11,819.79                             | -                                                             | 6.56                                                       | 1,80,280.9      |

5.3 Impact on financial indicators

The financial indicators of listed companies mainly include three aspects: solvency, profitability, and operating ability. Based on the basic situation, this article mainly calculates and analyses the company’s debt-to-asset ratio, return on net assets, net sales interest rate, and total asset turnover rate. According to the various values in Table 4, it can be concluded that the financial indicators of the enterprise in the year (2015) have been significantly improved when the business of a business changed the investment in real estate measurement model (2015) [14]. However, the improvement of financial indicators in the following years is relatively small. The asset-liability ratio dropped significantly when it was changed in 2015. The asset-liability ratio fluctuated in 2016–2018. It can be seen that our use of the fair value model to measure investment in real estate will not necessarily continue to reduce the company’s debt-to-asset ratio, and the fair value of the real estate will also decline. However, under the fair value measurement model, the company’s book profits will increase, and the rate of return on net assets will increase.

Table 4 List of impacts of changes in measurement mode on financial indicators

|                  | Solvency | Profitability | Operating capacity |
|------------------|----------|---------------|--------------------|
|                  | Assets and liabilities | Return on net assets | Sales margin | A turnover rate of total assets |
| 2015 (cost model) (%)_ | 54.35 | 5.92 | 4.00 | 73.52 |
| 2015 (fair value model) (%)_ | 45.20 | 44.57 | 10.38 | 143.43 |
| 2016 (fair value model) (%)_ | 71.84 | 12.82 | 6.07 | 59.44 |
| 2017 (fair value model) (%)_ | 65.44 | 17.70 | 9.24 | 66.18 |
| 2018 (fair value model) (%)_ | 65.88 | 19.67 | 9.97 | 67.34 |

6 Conclusion

To achieve high-precision numerical calculation of stiff differential equations, this paper proposes an improved Chebyshev-Tau method. Based on the indefinite integral formula of Chebyshev polynomial, the numerical integration process replaces the differential process. This makes the condition number of the discrete matrix significantly improved, thereby effectively controlling the rounding error. From the data, it can be seen that the
profits and debt capacity of real estate under fair value have increased significantly. However, the current market environment in China is not mature enough to apply fair value widely. Therefore, it is necessary to strengthen the construction and regulation of Chinese investment in the real estate market.

Acknowledgements.
Project of Jiangsu Education Science in the 13th 5 year plan in 2018: Research on innovation path of quality evaluation mechanism in Vocational Colleges from the perspective of “made in China 2025” (No.: D/2018/03/50).

References
[1] Urreta, H., Aguirre, G., Kuzhir, P., & Lopez de Lacalle, L. N. Actively lubricated hybrid journal bearings based on magnetic fluids for high-precision spindles of machine tools. Journal of intelligent material systems and structures., 2019. 30(15): 2257-2271
[2] Mehmood, A., Zameer, A., Ling, S. H., ur Rehman, A., & Raja, M. A. Z. Integrated computational intelligent paradigm for nonlinear electric circuit models using neural networks, genetic algorithms and sequential quadratic programming. Neural Computing and Applications., 2020. 32(14): 10337-10357
[3] Colly, A., Marquette, C., & Courtial, E. J. Poloxamer/Poly (ethylene glycol) Self-Healing Hydrogel for High-Precision Freeform Reversible Embedding of Suspended Hydrogel. Langmuir., 2021. 43(7): 3903-3913
[4] Robichaud, A., Deslandes, D., Cicek, P. V., & Nabki, F. Electromechanical tuning of piecewise stiffness and damping for long-range and high-precision piezoelectric ultrasonic transducers. Journal of Microelectromechanical Systems., 2020. 29(5): 1189-1198
[5] Khaghani, A., & Cheng, K. Investigation on multi-body dynamics based approach to the toolpath generation for ultra-precision machining of freeform surfaces. Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture., 2020. 234(3): 571-583
[6] Stejskal, T., Melko, J., Rjabušin, A., Fedorko, G., Hatala, M., & Molnár, V. Specific principles of work area stiffness measurement applied to a modern three-axis milling machine. The International Journal of Advanced Manufacturing Technology., 2019. 102(5): 2541-2554
[7] Alonso-Mallo, I., Cano, B., & Reguera, N. Comparison of efficiency among different techniques to avoid order reduction with Strang splitting. Numerical Methods for Partial Differential Equations., 2021. 37(1): 854-873
[8] Chen, Y. M., Chen, Y. X., & Liu, J. K. Transforming linear FDEs with rational orders into ODEs by modified differential operator multiplication method. Journal of Vibration and Control., 2020. 42(4): 840-853
[9] Krishna, G., Sreenadh, S. & Srinivas, A. Entropy Generation in Couette Flow Through a Deformable Porous Channel. Applied Mathematics and Nonlinear Sciences., 2019. 4(2): 575-590
[10] Sanz-Serna, J. & Zhu, B. Word series high-order averaging of highly oscillatory differential equations with delay. Applied Mathematics and Nonlinear Sciences., 2019. 4(2): 445-454
[11] Chakraverty, S., Rezazadeh, H., & Domiri Ganji, D. On the solution of time-fractional dynamical model of Brusselator reaction-diffusion system arising in chemical reactions. Mathematical Methods in the Applied Sciences., 2020. 43(7): 3903-3913
[12] Robichaud, A., Deslandes, D., Cicek, P. V., & Nabki, F. Electromechanical tuning of piecewise stiffness and damping for long-range and high-precision piezoelectric ultrasonic transducers. Journal of Microelectromechanical Systems., 2020. 29(5): 1189-1198
[13] Khaghani, A., & Cheng, K. Investigation on multi-body dynamics based approach to the toolpath generation for ultra-precision machining of freeform surfaces. Proceedings of the Institution of Mechanical Engineers, Part B: Journal of Engineering Manufacture., 2020. 234(3): 571-583
[14] Stejskal, T., Melko, J., Rjabušin, A., Fedorko, G., Hatala, M., & Molnár, V. Specific principles of work area stiffness measurement applied to a modern three-axis milling machine. The International Journal of Advanced Manufacturing Technology., 2019. 102(5): 2541-2554
[15] Alonso-Mallo, I., Cano, B., & Reguera, N. Comparison of efficiency among different techniques to avoid order reduction with Strang splitting. Numerical Methods for Partial Differential Equations., 2021. 37(1): 854-873
[16] Chen, Y. M., Chen, Y. X., & Liu, J. K. Transforming linear FDEs with rational orders into ODEs by modified differential operator multiplication method. Journal of Vibration and Control., 2019. 42(4): 840-853