Preliminaries of Structural Parameters Approximation Through Transcendence Equations for an ^{15}N Isotope Separation Column

Muresan V., Sas D., Clitan I., and Unguresan M.-L.

***Abstract*—The ^{15}N isotope separation column process presented in this article represents a space propagation process modeled by second-order quasi-linear equations with two independent variables. The new approach of Cohen's equation using a second-order differential equation in relation to time variable t and spatial variable s is presented. For this stage of development, for variables $F_{0T}(t)$ and $F_{0S}(s)$ there is a limitation of two time constants (T_1, T_2), or space constants (S_1, S_2). Also, $F_{0T}(t)$ and $F_{0S}(s)$ evolutions are exponentially increasing, resulting that the phenomenon is cumulative, both in relation to time and in relation to the propagation space. In this case, results a family of curves of the ^{15}N $y_{00}(t,s)$ concentration.**

***Index Terms*—Isotopic separation process, cohen's equation, transcendent equations, structural parameters approximation.**

I. Introduction

The space propagation process presented in this article represents an ^{15}N isotope separation column process which is modeled by second-order quasi-linear equations with two independent variables.

Using a second-order differential equation in relation with both time and space variables, a new approach of Cohen's equation is presented.

In the following equation, it is considered the overdamped version of approximating solutions associated with the isotopic separation phenomena [1]-[3]:

$$y_{00}(t,s) = \tilde{y}_{00} + F_{0T}(t) \cdot F_{0S}(s) \cdot (\tilde{y}_{ff} - \tilde{y}_{00}) \quad (1)$$

For this stage of development, for variables $F_{0T}(t)$ and $F_{0S}(s)$ there is a limitation of two time constants (T_1, T_2), or space constants (S_1, S_2). The evolution of $F_{0T}(t)$ and $F_{0S}(s)$ is represented in the following figure:

Also, $F_{0T}(t)$ and $F_{0S}(s)$ evolutions are exponentially increasing, resulting that the phenomenon is cumulative, both in relation to time and in relation to the propagation space. In this case, results a family of curves of the ^{15}N $y_{00}(t,s)$ concentration.

Considering the final values $F_{0T}(t) \rightarrow 1$ and $F_{0s}(s) \rightarrow 1$ [1]-[5] the ascending exponential functions are represented as follows:

$$F_{0T}(t) = 1 - \frac{T_1}{T_1 - T_2} \cdot \varepsilon^{-\frac{t}{T1}} - \frac{T_2}{T_2 - T_1} \cdot \varepsilon^{-\frac{t}{T2}} \quad (2)$$

$$F_{0S}(s) = 1 - \frac{S_1}{S_1 - S_2} \cdot \varepsilon^{-\frac{S}{S1}} - \frac{S_2}{S_2 - S_1} \cdot \varepsilon^{-\frac{S}{S2}} \quad (3)$$

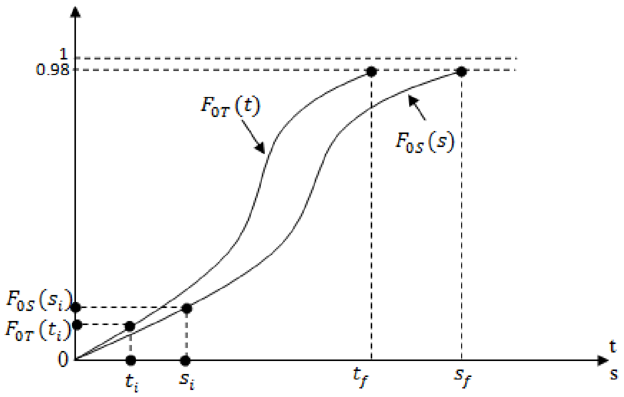

Fig. 1. Increasing evolution for $F_{0T}(t)$ and $F_{0s}(s)$ [3].

The approximating solution represented in relation (1) may be rewritten considering relations (2) and (3) such as [1]-[5]:

$$y_{00}(t,s) = \tilde{y}_{00} + \left(1 - \frac{T_1}{T_1 - T_2} \cdot \varepsilon^{-\frac{t}{T1}} - \frac{T_2}{T_2 - T_1} \cdot \varepsilon^{-\frac{t}{T2}}\right) \cdot \cdot \left(1 - \frac{S_1}{S_1 - S_2} \cdot \varepsilon^{-\frac{S}{S1}} - \frac{S_2}{S_2 - S_1} \cdot \varepsilon^{-\frac{S}{S2}}\right) \cdot (\tilde{y}_{ff} - \tilde{y}_{00}) \quad (4)$$

The inflection abscises correspond to the following relations [1]-[3], [5]-[7]:

$$t_i = \frac{T_1 \cdot T_2}{T_2 - T_1} \ln\left(\frac{T_2}{T_1}\right) \quad (5)$$

$$s_i = \frac{S_1 \cdot S_2}{S_2 - S_1} \ln\left(\frac{S_2}{S_1}\right) \quad (6)$$

In addition, it can also be shown that for the decreasing evolutions of $F_{0T}(t)$ and $F_{0S}(t)$ defined by the relations (7) and (8) and exemplified in figure 2, where $F_{0T}(t) \rightarrow 0$ and $F_{0S}(t) \rightarrow 0$, the inflection abscises t_i respectively s_i correspond to those defined in the relations (5) and (6) [1-2].

$$F_{0T}(t) = \frac{T_1}{T_1 - T_2} \cdot e^{-\frac{t}{T1}} + \frac{T_2}{T_2 - T_1} \cdot e^{-\frac{t}{T2}} \quad (7)$$

$$F_{0s}(s) = \frac{S_1}{S_1 - S_2} \cdot e^{-\frac{S}{S1}} + \frac{S_2}{S_2 - S_1} \cdot e^{-\frac{S}{S2}} \quad (8)$$

Further, in this paper it will be presented only the case for increasing evolution of the $F_{0T}(t)$ and $F_{0s}(s)$.

Manuscript received October 1, 2017; revised October 30, 2017.

Muresan Vlad, Diana Sas, and Iulia Clitan are with Automation Department from the Technical University of Cluj-Napoca, Romania (e-mail: sasdia@yahoo.com).

Mihaela Ligia Uniguresan is with Faculty of Materials and Environmental Engineering, Physics and Chemistry Department from the Technical University of Cluj-Napoca, Romania

DOI: 10.7763/IJMO.2017.V7.603

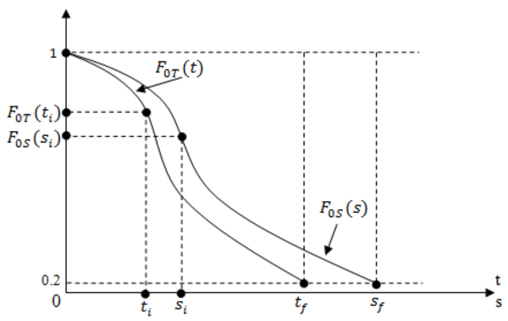

Fig. 2. Decreasing evolution for $F_{0T}(t)$ and $F_{0s}(s)$

II. Approximation of Structural Parameters by Transcendent Equations

Considering the relations (2), (3), (5) and (6) there are taken into consideration the following notations [1]-[3], [6]-[8]:

$$\lambda_T = \frac{T_2}{T_1} > 1 \tag{9}$$

$$\mu_T = \frac{t_f}{T_1+T_2} > 1 \tag{10}$$

$$\lambda_S = \frac{S_2}{S_1} > 1 \tag{11}$$

$$\mu_S = \frac{s_f}{S_1+S_2} > 1 \tag{12}$$

Based on knowing the abscises (t_i), (t_f) and ordinate $F_{0T}(t) \rightarrow 1$, but also the abscises (s_i), (s_f) and ordinate $F_{0S}(t) \rightarrow 1$ the aproximating parameters noted above determine the aproximation of both T_1 and T_2, respectively S_1 and S_2. It will be considered the following transcendent equation [1]-[3], [6], [7]:

$$F_{0S}(s_f) - \left(1 + \frac{1}{\lambda_S - 1} \cdot \varepsilon^{coef1} - \frac{\lambda_S}{\lambda_S - 1}\varepsilon^{coef2}\right) = DIF \tag{13}$$

where:

$$coef1 = -\frac{\lambda_S \cdot ln\lambda_S}{\lambda_S - 1} \cdot \frac{s_f}{s_i} \tag{14}$$

$$coef2 = -\frac{ln\lambda_S}{\lambda_S - 1} \cdot \frac{s_f}{s_i} \tag{15}$$

Calculations start with $\lambda_S = 1 + \Delta\lambda_S$ for $\Delta\lambda_S = 10^{-2} \sim 10^{-4}$ providing iterative increasing for (λ_S) until the difference (DIF) changes its mark and (λ_S) fulfills to the solution of the transcendent equation.

The following relations corresponds to the approximation of space constants (S_1) and (S_2) with an error, as low as the step $(\Delta\lambda_S)$ is [1]-[3]:

$$\mu_S = \frac{\lambda_S ln\lambda_S}{\lambda_S^2 - 1} \cdot \frac{s_f}{s_i} \tag{16}$$

$$S_1 = \frac{s_f}{\mu_S(1+\lambda_S)} \tag{17}$$

$$S_2 = \lambda_S \cdot S_1 \tag{18}$$

At the same time, it can be shown that there is only one value (λ_S) for which the curve represented in the following figure passes simultaneously through the two points (i) and (f), where for (f) corresponds $F_{0S}(s) \rightarrow 1$, such as $F_{0S}(s) = 0.95 \div 0.99$.

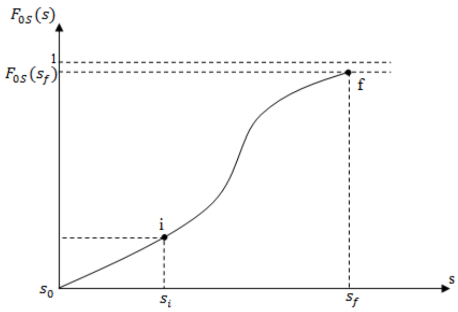

Fig. 3. Evolution of $F_{0s}(s)$

The transcendent equation calculates S_1 and S_2 from s_i, s_f, $F_{0S}(s_f)$ respectively F_{AS}, the value of the asymptote. The corresponding curves are shown in the figure below:

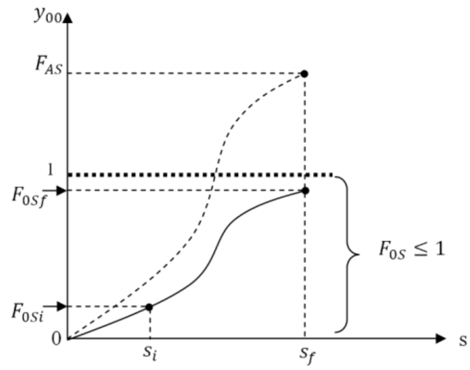

Fig. 4. Evolution of $F_{0Si}(s)$ and $F_{0Sf}(s)$ function of the value of the asymptote.

The program developed for the numerical integration of transcendental equations is presented in the following [1]-[3]:

L1: $\mathrm{s_f}$ = given, $\mathrm{F_{0Sf}}$ = given, $\mathrm{s_i}$ = given, $\mathrm{F_{AS}}$ = given, $\mathrm{F_{0Si}}$ = informative

L2: $\Delta\lambda = 0.001$, $\lambda = 1 + \Delta\lambda$, $\lambda_{max} = 20$

L3: $\mathrm{coef1} = -\frac{\lambda \ln\lambda}{\lambda - 1} \cdot \frac{s_f}{s_i}$ $\mathrm{coef2} = -\frac{\ln\lambda}{\lambda - 1} \cdot \frac{s_f}{s_i}$

L4: $\mathrm{DIF1} = \left[F_{0S}(s_f) - \left(1 + \frac{1}{\lambda_S - 1} \cdot \varepsilon^{coef1} - \frac{\lambda_S}{\lambda_S - 1}\varepsilon^{coef2}\right)\right] \cdot F_{AS}$

L5: $\lambda = \lambda + \Delta\lambda$

L6: $\mathrm{coef1} = -\frac{\lambda \ln\lambda}{\lambda - 1} \cdot \frac{s_f}{s_i}$ $\mathrm{coef2} = -\frac{\ln\lambda}{\lambda - 1} \cdot \frac{s_f}{s_i}$

L7: $\mathrm{DIF2} = \left[F_{0S}(s_f) - \left(1 + \frac{1}{\lambda_S - 1} \cdot \varepsilon^{coef1} - \frac{\lambda_S}{\lambda_S - 1}\varepsilon^{coef2}\right)\right] \cdot F_{AS}$

L8: DIF = DIF1 · DIF2

L9: IF DIF < 0 *goto* L12

L10:If $\lambda \geq \lambda_{max}$ goto L16

L11:goto L3

L12: $\mu = \frac{\lambda \ln\lambda}{\lambda^2 - 1} \cdot \frac{s_f}{s_i}$, $S_1 = \frac{s_f}{\mu(1+\lambda)}$, $S_2 = \lambda \cdot S_1$

L13: $F_{0sf}(s) = 1 - \frac{S_1}{S_1 - S_2} \cdot \varepsilon^{-\frac{s_f}{S1}} - \frac{S_2}{S_2 - S_1} \cdot \varepsilon^{-\frac{s_f}{S2}}$

L14: $F_{0si}(s) = 1 - \frac{S_1}{S_1 - S_2} \cdot \varepsilon^{-\frac{s_i}{S1}} - \frac{S_2}{S_2 - S_1} \cdot \varepsilon^{-\frac{s_i}{S2}}$

L15: Print $\mu, S_1, S_2, F_{0sf}, F_{0si}$

L16: STOP

L17: $s = 0,\ \Delta s = s_f/10$

L18: $F_{0S}(s) = 1 - \frac{S_1}{S_1 - S_2} \cdot \varepsilon^{-\frac{s}{S1}} - \frac{S_2}{S_2 - S_1} \cdot \varepsilon^{-\frac{s}{S2}}$

L19: $y_{00} = F_{0S} \cdot F_{AS}$

L20: $F_{1S}(s) = \frac{1}{S_1 - S_2} \cdot \varepsilon^{-\frac{s}{S1}} - \frac{1}{S_2 - S_1} \cdot \varepsilon^{-\frac{s}{S2}}$

L21: $F_{2S}(s) = \frac{1}{S_1(S_1 - S_2)} \cdot \varepsilon^{-\frac{s}{S1}} - \frac{1}{S_1(S_2 - S_1)} \cdot \varepsilon^{-\frac{s}{S2}}$

L22: IF $s \geq s_f + \Delta s$ goto L25

L23: Print $s, F_{0S}, F_{1S}, F_{2S}, y_{00}$

L24: $s = s + \Delta s$ goto L18

L 25: STOP

L26: END

III. Approximation Preliminaries of Structural Parameters Through Transcendence Equations and Correction with Propagation Depth

In the simplified answer represented in the Fig. 5, it is considered a common case for which the measurement and knowledge possibilities are very limited.

For the same approximating solution, it can be experimentally raise only $y_{00}(t, s_f)$ for the interval $t = t_0$ and $t = t_{f\beta}$. [1]-[5]:

$$y_{00}(t,s) = \tilde{y}_{00} + F_{0T}(t) \cdot F_{0S}(s) \cdot (\tilde{y}_{ff} - \tilde{y}_{00}) \quad (19)$$

As a result, it can be established $\tilde{y}_{00} = y_{00}(t, s_f)$, $\tilde{y}_{ff} = y_{00}(t_{f\beta}, s_f)$ and the abscissa of inflection (t_i, s_f).

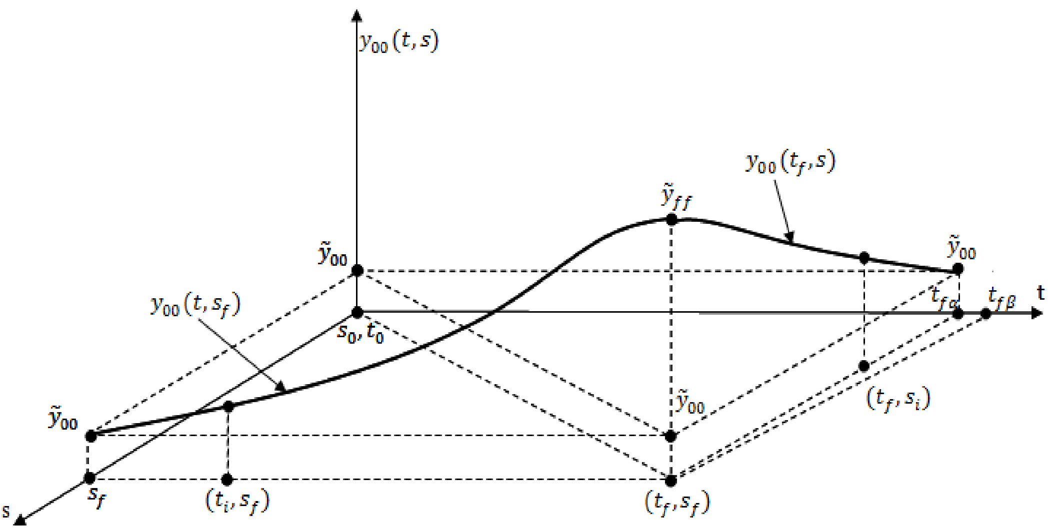

Fig. 5. Evolution of the approximating solution

With these known data, the time constants T_1 and T_2 are approximated by the transcendent equation method for which from $y_{00}(t, s_f)$ were obtained $[t_i, t_f, (\tilde{y}_{ff} - \tilde{y}_{00})]$.

This triplet of values represents the initial conditions for the dedicated program [1]-[3] from which it is obtained, in addition to the two time constants, the function $F_{0T}(t)$ with the remark that $F_{0S}(s_f) \to 1$ [1]-[5]:

$$y_{00}(t,s_f) = \tilde{y}_{00} + F_{0T}(t) \cdot F_{0S}(s_f) \cdot (\tilde{y}_{ff} - \tilde{y}_{00}) = \tilde{y}_{00} + F_{0T}(t) \cdot (\tilde{y}_{ff} - \tilde{y}_{00}) \quad (20)$$

Within this curve it is assumed to be valid the following proportion:

$$\frac{s_i}{s_f} = \frac{t_i}{t_{f\beta}} \quad (21)$$

where t_i and $t_{f\beta}$ correspond to the known ascending function $y_{00}(t, s_f)$.

As a result, the inflection abscissa together with s_f and $\tilde{y}_{ff}$ form the triplet of values $(s_i, s_f, \tilde{y}_{ff})$ that can be associated with the transcendent equation:

$$s_i = \frac{t_i}{t_{f\beta}} \cdot s_f \quad (22)$$

As in the previous case, with this data, the space constants S_1 and S_2 are approximated by the transcendent equation method for which from $y_{00}(t_f, s)$ were obtained $[s_i, s_f, (\tilde{y}_{ff} - \tilde{y}_{00})]$.

This triplet of values represents the initial conditions for the dedicated program from which it is obtained, in addition to the two time constants, the function $F_{0S}(s)$ with the remark that $F_{0T}(t_{f\beta}) \to 1$ [1]-[5]:

$$y_{00}(t_{f\beta},s) = \tilde{y}_{00} + F_{0T}(t_{f\beta}) \cdot F_{0S}(s) \cdot (\tilde{y}_{ff} - \tilde{y}_{00}) = \tilde{y}_{00} + F_{0S}(s) \cdot (\tilde{y}_{ff} - \tilde{y}_{00}) \quad (23)$$

The correction of the time constants T_1 and T_2 in relation to the propagation depth s becomes variable also in this case due to the fact that from Fig. 5 it is observed that the evolution of the approximating solution $y_{00}(t, s_f)$ presents a delay from the final moment $t_{f\alpha}$ to the final moment $t_{f\beta}$.

Since $t_{f\beta} > t_{f\alpha}$ is due to the progressive increase of time constants T_1 and T_2 in relation to propagation depth s, it is justified to use corrections.

IV. Approximation of Structure Parameters by Tabular Method

The tabular method may be considered an ideal method whenever experimentally can be completed tables such as the one below, both from t_0 to t_f and from s_0 to s_f, either for a real process or for an approximating solution, which corresponds, for example, with the relation (23) associated with figure 5, respectively [1]-[5]:

$$y_{00}(t,s) = \tilde{y}_{00} + F_{0T}(t) \cdot F_{0S}(s) \cdot (\tilde{y}_{ff} - \tilde{y}_{00}) \qquad (23)$$

TABLE I: Structural Parameters in Tabular Form

$s \backslash t$	t_0	...	t_k	...	t_f
s_0	y_{00}	...	y_{k0}	...	y_{f0}
...	...	...	...	...	...
s_j	y_{0j}	...	y_{kj}	...	y_{fj}
...	...	...	...	...	...
s_f	y_{0f}	...	y_{kf}	...	y_{ff}

From Table I, for the line $j = constant$ the following curve could be represented [4], [5]:

$$y_{00}(t,s_j) = \tilde{y}_{00} + F_{0T}(t) \cdot F_{0S}(s_j) \cdot (\tilde{y}_{ff} - \tilde{y}_{00}) \qquad (24)$$

Also, for column $k = constant$ the following curve could be represented [4], [5]:

$$y_{00}(t_k,s) = \tilde{y}_{00} + F_{0T}(t_k) \cdot F_{0S}(s) \cdot (\tilde{y}_{ff} - \tilde{y}_{00}) \qquad (25)$$

where $\tilde{y}_{00} = y_{00}(t_0, s_0)$ and $\tilde{y}_{ff} = y_{00}(t_f, s_f)$

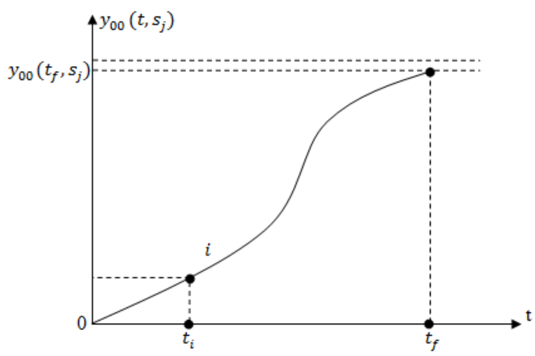

Fig. 6. Evolution of the approximating solution.

Thus, it can be observed that from the relations (24) and (25) the following figures may be represented. From Fig. 6 result time contants $T_1(s_j)$ and $T_2(s_j)$ meanwhile from Fig. 7 result space constants $S_1(t_k)$ and $S_2(t_k)$ but also $y_{00}(t_k, s_j)$.

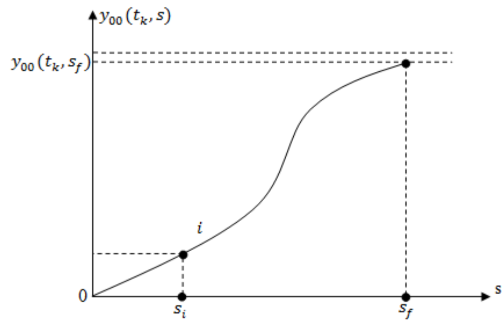

Fig. 7. Evolution of the approximating solution

Due to the fact that from both figures was obtained the triplet of values $[t_i, t_f, (\tilde{y}_{ff} - \tilde{y}_{00})]$ and $[s_i, s_f, (\tilde{y}_{ff} - \tilde{y}_{00})]$ in the following it is still possible to use the transcendent equation method for ascending evolutions.

As a result, from $[t_i, t_f, (\tilde{y}_{ff} - \tilde{y}_{00})]$ are obtain $T_1(s_j)$ and $T_2(s_j)$ and from $[s_i, s_f, (\tilde{y}_{ff} - \tilde{y}_{00})]$ are obtain $S_1(t_k)$ and $S_2(t_k)$. Finally, an analytical solution or approximating solution can be obtained in the vicinity of the point (t_k, s_j) such as [1]-[5]:

$$y_{00}(t,s) = \tilde{y}_{00} + \left(1 - \frac{T_1}{T_1 - T_2} \cdot \varepsilon^{-\frac{t}{T_1}} - \frac{T_2}{T_2 - T_1} \cdot \varepsilon^{-\frac{t}{T_2}}\right) \cdot \left(1 - \frac{S_1}{S_1 - S_2} \cdot \varepsilon^{-\frac{s}{S_1}} - \frac{S_2}{S_2 - S_1} \cdot \varepsilon^{-\frac{s}{S_2}}\right) \cdot (\tilde{y}_{ff} - \tilde{y}_{00}) \qquad (26)$$

where $T_1 = T_1(s_j)$, $T_2 = T_2(s_j)$, $S_1 = S_1(t_k)$, $S_2 = S_2(t_k)$.

Considering the figures 6 and 7, from $t_i = 0$ days to $t_f = 14$ days, and from $s_i = 0$ to $s_f = 7$ meters, both $F_{0T}(t)$ and $F_{0S}(s)$ evolutions are exponentially increasing, resulting that the phenomenon is cumulative, both in relation to time and in relation to the propagation space.

It should be mentioned the fact that for possible corrections, the expressions $F_{0T}(t)$ and $F_{0S}(s)$ can be completed with formally identical components $\frac{t_i}{t_i - t_{i-1}} \varepsilon$ respectively $\frac{s_i}{s_i - s_{i-1}} \varepsilon$, of a number of times, so the final evolution $y_0(t,s)$ to become almost overlay on the rigorous evolution investigated in the literature.

V. Conclusion

A space propagation process is modeled by second-order quasi-linear equations with two independent variables, one in relation to time t and the other one in relation to propagation space s.

By using Cohen's equation with a new approach, more precisely using a second-order differential equation in relation to time variable t and spatial variable s, it is modeled an $^{15}\boldsymbol{N}$ isotope separation column process.

For both $\boldsymbol{F_{0T}(t)}$ and $\boldsymbol{F_{0S}(s)}$ is a limitation of two time constants $(\boldsymbol{T_1}, \boldsymbol{T_2})$, or space constants $(\boldsymbol{S_1}, \boldsymbol{S_2})$, at this stage of development. For possible corrections, both expressions $\boldsymbol{F_{0T}(t)}$ and $\boldsymbol{F_{0S}(s)}$ should be fulfilled with formally identical components $\frac{t_i}{t_i - t_{i-1}} \boldsymbol{\varepsilon}$ respectively $\frac{s_i}{s_i - s_{i-1}} \boldsymbol{\varepsilon}$, so the final evolution $\boldsymbol{y_0(t,s)}$ to achieve a better accuracy.

Also, $\boldsymbol{F_{0T}(t)}$ and $\boldsymbol{F_{0S}(s)}$ evolutions are exponentially increasing, resulting a family of curves of the $\boldsymbol{^{15}N\ y_{00}(t,s)}$ concentration, taking into consideration the fact that the phenomenon is cumulative, both in relation to time and in relation to the propagation space.

REFERENCES

[1] T. Coloşi, M. L. Ungureşan, E. H. Dulf, and R. C. Cordoş, "Introduction to analogical modeling and numerical simulation with (Mpdx) and taylor series distributed parameters processes," *Editura Galaxia Gutenberg*, Cluj-Napoca, Romania, 2009

[2] T. Coloşi, M. Abrudean, M. L. Ungureşan, and V. Mureşan, "Numerical simulation of distributed parameters processes," Springer, 2013

[3] D. Sas, I. Clitan, M.-L. Unguresan, and V. Muresan, "Analytical modeling of an ^{15}N isotope separation column by second-order quasi-linear equations with two independent variables," in *Porc. International Conference on Aerospace, Robotics, Biomechanics, Neurorehabilitation, Mechanical Engineering and Manufacturing Systems (ICMERA) 2017*, Bucuresti, Romania

[4] D. Sas and Z. Kovendi, "Preliminaries in (Mpdx) method associated with cohen equations," in *Porc. 2016 IEEE International Conference on Automation, Quality and Testing*, Robotics (AQTR) Cluj-Napoca, Romania.

[5] T. Coloşi, M. Abrudean, M. L. Ungureşan, and V. Mureşan, "PID Control of distributed parameter processes through the (M_{pdx}) method with approximating solutions," in *Porc. Conference of Information Technologies and Control Methods with Power Systems*, Cluj-Napoca, Romania, 2013

[6] D. Sas and M. Secara, "Preliminaries in numerical simulation of isotope separation closed-loop processes," in *Porc. 2015 International Conference on Engineering of Modern Electric Systems (EMES) Oradea*, Romania.

[7] T. Colosi, E. Dulf, and M. Abrudean, "Modeling and numerical simulation of PDE using the (Mdpx) matrix, associated to taylor series,", in *Porc. 2006 IEEE International Conference on Automation, Quality and Testing, Robotics*, vol. 1, May 2006.

[8] I. Clitan, V. Muresan, T. Colosi, and M. Unguresan, "Control structure design for an 18 O isotope separation column," in *Porc. 20th International Conference on Automation, Quality and Testing*.

Muresan Vlad graduated at the Automation and Computer Science Faculty and completed her master's degree of advanced process control at the Technical University of Cluj-Napoca, Romania. He received his doctorate in systems engineering at the same University.

His research interests are industrial process control, modeling and simulation of physical-chemical processes and neural networks. He is currently an associate professor at the Automation Department from the Technical University of Cluj-Napoca.

Diana Sas graduated at the Automation and Computer Science Faculty and completed her master's degree of advanced process control at the Technical University of Cluj-Napoca, Romania. Her research interests are industrial process control, modeling and simulation of physical-chemical processes and neural networks. She is currently a PhD student at the Automation Department from the Technical University of Cluj-Napoca.

Iulia Clitan graduated at the automation and computer science faculty and completed her master's degree of advanced process control at the Technical University of Cluj-Napoca, Romania. She received her doctorate in systems engineering at the same University.

Her research interests are industrial process control and biomedical engineering. She is currently a lecturer at the Automation Department from the Technical University of Cluj-Napoca.

Mihaela Ligia Uniguresan has a bachelor of science in physical-chemistry, she graduated at Babes-Bolyai University and completed her master's degree of applied electrochemistry at the Same University. She received her doctorate in physical chemistry, chemical Kinetics at babes-Bolyai University.

Her research interests are chemical kinetics of rapid reactions, modeling and simulation of physical-chemical processes, synthesis of chemical compound marked with stable isotopes, physical-chemical and isotopic analyses (mass spectrometry, gas chromatography), modeling of the processes occurring at the interface electrode - electrolyte. She is currently an associate professor at Faculty of Materials and Environmental Engineering, Physics and Chemistry Department from the Technical University of Cluj-Napoca.