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# Software Analysis for the Boring Plant Kinematics to extract the Boring Tools Steps

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## Abstract

*The item study a typical situation for manoeuvre of the boring tools for drilling of big depth. To they leverage concerns, from the viewpoint of actuation," the behavior to motion" aspectually of causality relation among forces and speeds, as well as the way in which this is reflected in the energetic conversions or in the parametric transformations of energy. For the structure identifiable through the lineal parameters, adequate with table, elasticity, internal dissipations and external dissipations, the equations motional deduced on energy path is similarly of the equations for conduction of the energy through the electric long lines. The item describes procedures wherewith is determined the temporally variation of the force what is applied of the structure, relatively inhomogeneous, for obtained optimal chart of speeds, the motion progressing successively through elastic elongation and through translation.*

**Key words**: *drive system in drilling rigs, optimization, efficiency.*

## Introduction

The researches effectuate of author considering the dynamics of the actuation system, have as the aim the motion behavior model elaboration, according to the physical reality of phenomenas which accompany the process of drill to big depth, holding the account, among anothers, of the spacial distribution for the physical parameters of boring tools. Is eliminated the current simplifications and the fashions and methods for identification of the physical parameters is built for those structures for which the spacial distribution of parameters do not can be neglect [1], following the realization for an concordant model for simulation with the conclusions and data what of the drilling practice offered. From the studies effectuate with their help, results the criterions thereto the productivity of the electric actuation systems can is improved [2]. The present paper he proposed to expatiate work with the model Kalvin – Voigt, the behavior model of motion for a the structure with spacial distribution of parameters

## The rheologycal model and the motional equations for the boring tools

Modelling of the boring tools, having longueurs of kilometers, as the rigid structures, subdued in the drill hole to unlubrificated frictions, he produces appreciable differences between the calculated efficiency and the accomplished efficiency of the swap system, for which the criterion of performance consists in the extraction steps of boring plant temporally minimum. The suggested model of we is the generalized model Kelvin - Voigt, presupposing that the boring plant rheology corresponds of a structures with viscoelasticity and lineal behavior and with the uniform distribution of parameters ( fig. 1 ). Utilizing the power method ( not single feasibly) the authors establish the system of the equations ( 1 ) what define completely the force and the speed in any section. The lineal parameters for the model, calculate just as show work [3], they have signification easy realizable in the figure 1.

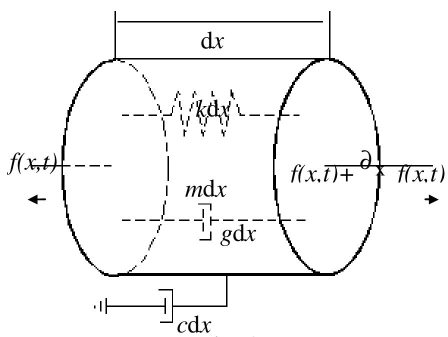

**Fig. 1.**

$$\begin{cases} \dfrac{\partial v}{\partial x} = gf + u\dfrac{\partial f}{\partial t}; \\ \dfrac{\partial f}{\partial x} = cv + m\dfrac{\partial v}{\partial t}. \end{cases} \tag{1}$$

The principal mission for swap system, in accordance to the model of optimum solution for the management of the process of drill, is decrease of the time for the extraction of steps of boring tools, He consists in the graphic optimization of speed for hook, from the viewpoint of productivity of the swap operation

## The determination of the model for variation temporally of the force to hook for desirable graphic of the speed.

He presupposes the determination of $f(t)$ function that satisfies the equations (1), in order to obtained a form of variation temporally for the speed to the crane hook, variation comfortable expressed through an serial segment Fourier . Confined to at least the specific errors of digital methods and their propagation, is searched the analytic solutions for suggested problem. The digital methods is used there where the analytic calculus becomes inoperative.

The harmonic solutions for the equations (1) is knowed. In the case of the baud of the longitudinal vibrations of $\omega$ pulsation, the force and the speed to the length x against of the receiver extremity have expressions $f = F_x \sin(\omega t - \xi)$, $v = V_x \sin(\omega t - \xi - \theta)$. The origin of the time tallies with the adhibition moment of excitation to hook.

For complex values, solving the equations( 1 ), is obtained the solutions: $\underline{F} = \underline{M}e^{\underline{\gamma}x} + \underline{N}e^{-\underline{\gamma}x}$ and $\underline{V} = \dfrac{1}{\underline{Z}_c}(\underline{M}e^{\underline{\gamma}x} - \underline{N}e^{-\underline{\gamma}x})$, where $\underline{M}$ and $\underline{N}$ is the constants of integration that is determined after the conditions of baud of the mechanical energy. Is uses the notations $\underline{\gamma} = \sqrt{\underline{z}\,\underline{y}}$; $\underline{z} = c + jm\omega$; $\underline{y} = g + ju\omega$; $j^2 = -1$ and $\underline{Z}_c = \underline{z}/\underline{\gamma}$ (*mechanical characteristic impedance of the boring tools*)

The constants of integration $\underline{M}$ and $\underline{N}$ is determined after the conditions of operation to the receiver extremity ( $x = 0$ ): $\underline{F} = \underline{F}_2$ şi $\underline{V} = \underline{V}_2$, result in:

$$\begin{aligned} \underline{F} &= \underline{F}_2 \mathrm{ch}\underline{\gamma}x + \underline{Z}_c \underline{V}_2 \mathrm{sh}\underline{\gamma}x, \\ \underline{V} &= \frac{\underline{F}_2}{\underline{Z}_c}\mathrm{sh}\underline{\gamma}x + \underline{V}_2 \mathrm{ch}\underline{\gamma}x. \end{aligned} \tag{2}$$

Noting $\underline{Z}_s = \underline{F}_2 / \underline{V}_2$ the complex impedance of the task , is obtained the complex expression among the force and the speed in the section having the longitudinal coordinate $x$:

$$\underline{F} = \frac{\underline{Z}_s \text{ch}\underline{\gamma} x + \underline{Z}_c \text{sh}\underline{\gamma} x}{\frac{\underline{Z}_s}{\underline{Z}_c} \text{sh}\underline{\gamma} x + \text{ch}\underline{\gamma} x} \underline{V} . \tag{3}$$

With the notations $\underline{\gamma} = \alpha + j\beta$ ; $\underline{Z}_c = Z_c e^{j\psi}$ ; $\underline{Z}_s = Z_s e^{j\varphi}$ and taking $\underline{F}_2$ as origin of the phases is obtained the relation between the force and the speed in instantaneous values Writed for the extremity from hook ( $x = L$ ) and for the harmonica of order *k*, she is formal:

$$f_k(t) = \frac{Z_s F_1(t) + Z_c F_2(t)}{\frac{Z_s}{Z_c} F_3(t) + F_4(t)} v_k(t) , \tag{4}$$

where:

$$F_1(t) = \text{ch}(\alpha L)\cos(\beta L)\cos(k\omega t) - \text{sh}(\alpha L)\sin(\beta L)\sin(k\omega t);$$
$$F_2(t) = \text{sh}(\alpha L)\cos(\beta L)\cos(k\omega t + \varphi + \psi) - \text{ch}(\alpha L)\sin(\beta L)\sin(k\omega t + \varphi + \psi);$$
$$F_3(t) = \text{sh}(\alpha L)\cos(\beta L)\cos(k\omega t - \psi) - \text{ch}(\alpha L)\sin(\beta L)\sin(k\omega t - \psi);$$
$$F_4(t) = \text{ch}(\alpha L)\cos(\beta L)\cos(k\omega t + \varphi) - \text{sh}(\alpha L)\sin(\beta L)\sin(k\omega t + \varphi).$$

Obtain the proper solution of constant term of the series is complicated and is resoluble with Laplace transformation. With the notations $f(x,t) = f$ ; $v(x,t) = v$ ; $f(x,0) = f_0$ ; $v(x,0) = v_0$ ; $(c + ms)(g + us) = \gamma^2$ ; $Z_c = (c + ms)/\gamma$ , holding the account as to the heads of the garniture have $x = L \rightarrow (\mathcal{L}f\ )_{x=L} = \mathcal{L}f_1$ şi $x = 0 \rightarrow (\mathcal{L}f\ )_{x=0} = \mathcal{L}f_2$ and noting $\mathcal{L}f_2 = Z_s \mathcal{L}v_2$ ( where $Z_s$ is operational impedance of the task and $\mathcal{L}v_2$ is he image of the speed at receiver end, for $\mathcal{L}v = C_0 / s$ ( he corresponds of the constant term) is established the relation:

$$\mathcal{L}f = \frac{C_0 (Z_c^2 \text{sh}\gamma L + Z_c Z_s \text{ch}\gamma L)}{s(Z_s \text{sh}\gamma L + Z_c \text{ch}\gamma L)} . \tag{5}$$

Considering that the task is the weight boring tools, having the $L_{pg}$ length, aproximated as the structure with viscoelasticity and lineal behavior and with the uniform distribution of $C, M, G, U$ parameters, equation( 5 ), rationalize in report with the physical lineal parameters, presents the forms from the table 1, accordingly with the evaluation of the mechanical impedance of load:

1. Extract step of boring tools is done through elastic elongation by the effect of weight of the garniture;

2. Extract step of boring tools is done through the translation of the garniture;

3. Extract the garniture is done through the extraction of weight boring tools.

Personalizing the complex expressions( 2 ) of the force and the speed, accordingly of these hypotheses, drives to next expressions for $\underline{Z}_s = \underline{F}_2 / \underline{V}_2$: 1. $\underline{Z}_{1s} = \underline{Z}_{c_{pg}} \coth(\underline{\gamma}_{pg} L_{pg})$; 2. $\underline{Z}_{2s} = \underline{Z}_{c_{pg}} th(\underline{\gamma}_{pg} L_{pg})$; 3. $\underline{Z}_{3s} = 0$. The index „*pg*” is adverted to garniture of weight boring tools, and with $X$ is noted the length at one time a garniture.

**Table 1**

| | $\mathcal{L}f = \dfrac{M(s)}{N(s)}$ |
|---|---|
| $Z_{c_{pg}}$ coth($\gamma_{pg} L_{pg}$ | $M(s) = C_0[(c+ms)\sqrt{G+Us}\cdot \mathrm{sh}\sqrt{(c+ms)(g+us)X^2}\cdot \mathrm{sh}\sqrt{(C+Ms)(G+Us)L_{pg}^2}\ +$<br>$+\sqrt{(c+ms)(g+us)(C+Ms)}\cdot \mathrm{ch}\sqrt{(c+ms)(g+us)X^2}\cdot \mathrm{ch}\sqrt{(C+Ms)(G+Us)L_{pg}^2}\ ]$<br>$N(s) = s[(g+us)\sqrt{C+Ms}\cdot \mathrm{sh}\sqrt{(c+ms)(g+us)X^2}\cdot \mathrm{ch}\sqrt{(C+Ms)(G+Us)L_{pg}^2}\ +$<br>$+\sqrt{(c+ms)(g+us)(G+Us)}\cdot \mathrm{ch}\sqrt{(c+ms)(g+us)X^2}\cdot \mathrm{sh}\sqrt{(C+Ms)(G+Us)L_{pg}^2}\ ]$<br>(6) |
| $Z_{c_{pg}}$ th($\underline{\gamma}_{pg} L_{pg}$); | $M(s) = C_0[(c+ms)\sqrt{G+Us}\cdot \mathrm{sh}\sqrt{(c+ms)(g+us)X^2}\cdot \mathrm{ch}\sqrt{(C+Ms)(G+Us)L_{pg}^2}\ +$<br>$+\sqrt{(c+ms)(g+us)(C+Ms)}\cdot \mathrm{ch}\sqrt{(c+ms)(g+us)X^2}\cdot \mathrm{sh}\sqrt{(C+Ms)(G+Us)L_{pg}^2}\ ]$<br>$N(s) = s[(g+us)\sqrt{C+Ms}\cdot \mathrm{sh}\sqrt{(c+ms)(g+us)X^2}\cdot \mathrm{sh}\sqrt{(C+Ms)(G+Us)L_{pg}^2}\ +$<br>$+\sqrt{(c+ms)(g+us)(G+Us)}\cdot \mathrm{ch}\sqrt{(c+ms)(g+us)X^2}\cdot \mathrm{ch}\sqrt{(C+Ms)(G+Us)L_{pg}^2}\ ]$<br>(7) |
| 0 | $M(s) = C_0\sqrt{C+Ms}\cdot \mathrm{sh}\sqrt{(C+Ms)(G+Us)X^2}$<br>$N(s) = s\sqrt{G+Us}\cdot \mathrm{ch}\sqrt{(C+Ms)(G+Us)X^2}$<br>(8) |

The fonction( 5 ), rationalize in report with the physical lineal parameters, are presented below a complicated form, such that for determination of her genesis is due to to appeal of digital methods. Is necessary, firstly, a testing the situation of the poles in the z-plane.

Utilizing the theorem of the argument, knowed from the theory of the functions with the complex variables, find if the zeros of the function $N(j\omega)$ obtained through substitution of $s$ with $j\omega$ , is inclusive in the left semiplane. In this case, with monotonous breed of $\omega$ from 0 to $\infty$, the argument of $N(j\omega)$ shall breed monotonous, anti-clockwise, with $n\pi/2$ again his module shall breed to $\infty$ when $\omega \to 0$. The original of the function ( 5 ) is easy of finded with help of the Fourier transformation, making after feature of frequency: puting equation( 5 ) in the likeness of $\mathcal{L}f = \dfrac{Y(s)}{s}$, the Fourier transformation of $f$ is $F(j\omega) = Y(j\omega)\cdot 1(j\omega)$ and noting $Y(j\omega) = U(\omega) + jV(\omega)$ result $f = \dfrac{2}{\pi}\int_0^\infty U(\omega)\dfrac{\sin\omega t}{\omega}\,d\omega$, the integration is done digital.

If function( 5 ) he has the poles in the right semiplane, they shall be searched through the digital methods and the theorem of development shall be applied, $f$ function resulting in the likeness of $f(t) = \dfrac{M(0)}{N(0)} + \sum_{i=2}^{m}\dfrac{M(s_i)}{N'(s_i)}e^{s_i t}$ .

## The digital simulation procedures

The primary data in relation with the boring tools structure is entered through the construction programs of the derrick ,in accordance to which is determine the component of the garniture: the length of the garniture of weight boring tools, the maxim length of the garniture, the length of the step of boring tools.

A prime module calculate the static tasks to hook to the of a extraction step, the ideal durations of extraction of the respective tasks and the calculus of the optimal elements of graphic of speed to the extraction of the step

The stage of the extraction of the garniture is established comparing the number of extracted steps with the initially length of the garniture. For the settlement of the conditions of the motion is calculated: the elongation below the own load of suspended garniture, $\Delta l_i$, elongation of garniture, when exercises about the hoe the pressure $F_w$ and the supplementary elongation $\Delta l_{si} = \Delta l_i - \Delta l_{1i}$. Comparing the length extracted with $\Delta l_{si}$ is chosen the adding variant from the table 1.

If the function ( 5 ) realize the necessary conditions for determination the original with the help of the integral Fourier, the duration of processing is considerable reduced. This is established through testings according to theorem of the argument, verifying if function image has all poles in the left semiplane and follow the alternation of signs of the real and the imaginary parts to the denominator of the expression $Y(j\omega)$.

But that is can followed the path showed, is passed to the search of the poles of the function in the sight adhibition of the theorem of the development. They have signification except poles existent astarboard of abscissa $\min\left\{-\frac{c}{m}, -\frac{g}{u}, -\frac{C}{M}, -\frac{G}{U}\right\}$, because the operational solutions of the telegraphic equations are unique for $\mathrm{Re}\{\gamma > 0\}$ and $arg\,\gamma \in \left[-\frac{\pi}{2}, +\frac{\pi}{2}\right]$. Is no signification for the negative values for the constant of phase, ecause the garniture don't enters elastic energy in system and therefore $\gamma \to \left[0, -\frac{\pi}{2}\right]$. Therefore, because $\gamma(s)$ is formal $\gamma = \sqrt{(A+Bs)\cdot(C+Ds)}$, and for $s = x + \mathrm{j}y$ we have $\gamma = \sqrt{\varepsilon + \mathrm{j}\tau}$ where $\varepsilon = (A+Bx)(C+Dx) - BDy^2$ and $\tau = 2yBD\left[x + \frac{1}{2}\left(\frac{A}{B} + \frac{C}{D}\right)\right]$. He results that, for the condition $\arg\gamma = \frac{1}{2}\operatorname{arc\,tg}\frac{\tau}{\varepsilon} > 0$ $\varepsilon$ and $\tau$ be due to has same sign.

The search of the complex poles is done through the double section method. The calculus of the components of original function, accordingly with these poles, he requires the derivation of the denominator Derivative is can calculated through any from the expressions

$$f'(z) = \frac{\partial u}{\partial x} + \mathrm{j}\frac{\partial v}{\partial x} = \frac{1}{\mathrm{j}}\left(\frac{\partial u}{\partial y} + \mathrm{j}\frac{\partial v}{\partial y}\right). \tag{9}$$

Is calculated, for each complex pole $s_i = x_i + \mathrm{j}y_i$, the derivates of the denominator $N(s) = U(x,y) + \mathrm{j}V(x,y)$:

$$\left[\frac{\partial U(x, y_i)}{\partial x}\right]_{x=x_i} \text{ and } \left[\frac{\partial V(x, y_i)}{\partial x}\right]_{x=x_i} \tag{10}$$

Taking the complex conjugated poles is obtained formally terms:

$$2e^{x_i t}\left|K_i\right|\cos(y_i t+\Phi_i)\,, \tag{11}$$

where $K_i=\left\lfloor M(s_i)/N'(s_i)\right\rfloor_{s_i=x_i+y_i}$ and $\Phi_i=\text{arc tg}\,(\mathscr{Im}[K_i]/\mathscr{Re}[K_i])$.

Real poles from the $\mathcal{L}f$ function, expressed through the relations ( 6 ) or( 7 ) from the table 1, its can be in the aisle:

$$\left[\min\left(-\frac{c}{m},-\frac{g}{u},-\frac{C}{M},-\frac{G}{U}\right),\max\left(-\frac{c}{m},-\frac{g}{u},-\frac{C}{M},-\frac{G}{U}\right)\right].$$

In the aisles among roots, $\mathcal{L}f$ have different forms. They were described for the associative programming of the calculus, as follows:

- they noted: $a=c+ms; b=g+us; A=C+Ms; B=G+Us;$
- they entered depending on s:

$$\begin{aligned}
&\alpha_1=\sin\sqrt{|ab|}X\cdot\text{sh}\sqrt{|AB|}L_{pg}\,;\ \alpha_2=\sin\sqrt{|ab|}X\cdot\text{ch}\sqrt{|AB|}L_{pg}\,;\\
&\alpha_3=\text{sh}\sqrt{|ab|}X\cdot\sin\sqrt{|AB|}L_{pg}\,;\ \alpha_4=\text{sh}\sqrt{|ab|}X\cdot\cos\sqrt{|AB|}L_{pg}\,;\\
&\alpha_5=\sin\sqrt{|ab|}X\cdot\sin\sqrt{|AB|}L_{pg}\,;\ \alpha_6=\cos\sqrt{|ab|}X\cdot\cos\sqrt{|AB|}L_{pg}\,;\\
&\alpha_7=\cos\sqrt{|ab|}X\cdot\text{sh}\sqrt{|AB|}L_{pg}\,;\ \alpha_8=\cos\sqrt{|ab|}X\cdot\text{ch}\sqrt{|AB|}L_{pg}\,;\\
&\alpha_9=\text{ch}\sqrt{|ab|}X\cdot\sin\sqrt{|AB|}L_{pg}\,;\ \alpha_{10}=\text{ch}\sqrt{|ab|}X\cdot\cos\sqrt{|AB|}L_{pg}\,;\\
&\alpha_{11}=\sin\sqrt{|ab|}X\cdot\cos\sqrt{|AB|}L_{pg}\,;\ \alpha_{12}=\cos\sqrt{|ab|}X\cdot\sin\sqrt{|AB|}L_{pg}\,;
\end{aligned}\tag{12}$$

- is the $\mathcal{L}f$ function expressed except with positive arguments below radicals, in the forms grouped in the table 2

**Table 2**

| | $Z_s(s)=Z_0(s)\coth[\gamma_{pg}(s)\cdot L_{pg}]$ | $Z_s(s)=Z_0(s)\text{th}[\gamma_{pg}(s)\cdot L_{pg}]$ |
|---|---|---|
| $a>0$<br>$b<0$<br>$A<0$<br>$B<0$ | $\mathcal{L}f=\dfrac{C_0[a\sqrt{\|B\|}\alpha_1-\sqrt{\|abA\|}\alpha_8]}{s\sqrt{\|b\|}[\sqrt{\|Ab\|}\alpha_2+\sqrt{\|aB\|}\alpha_7]}$ | $\mathcal{L}f=\dfrac{C_0[a\sqrt{\|B\|}\alpha_2-\sqrt{\|abA\|}\alpha_7]}{s\sqrt{\|b\|}[\sqrt{\|Ab\|}\alpha_1+\sqrt{\|aB\|}\alpha_8]}$ |
| $a>0$ $a<0$<br>$b>0$ $b<0$<br>$A>0$ $A>0$<br>$B<0$ $B>0$ | $\mathcal{L}f=\dfrac{C_0[-a\sqrt{\|B\|}\alpha_3+\sqrt{\|Aba\|}\alpha_{10}]}{s\sqrt{\|b\|}[\sqrt{\|AB\|}\alpha_4-\sqrt{\|aB\|}\alpha_9]}$ | $\mathcal{L}f=\dfrac{C_0[a\sqrt{\|B\|}\alpha_4+\sqrt{\|abA\|}\alpha_9]}{s\sqrt{\|b\|}[\sqrt{\|Ab\|}\alpha_3+\sqrt{\|aB\|}\alpha_{10}]}$ |
| $a>0$<br>$b>0$<br>$A<0$<br>$B>0$ | $\mathcal{L}f=\dfrac{C_0[a\sqrt{\|B\|}\alpha_3+\sqrt{\|abA\|}\alpha_{10}]}{s\sqrt{\|b\|}[\sqrt{\|Ab\|}\alpha_4+\sqrt{\|aB\|}\alpha_9]}$ | $\mathcal{L}f=\dfrac{C_0[a\sqrt{\|B\|}\alpha_4-\sqrt{\|abA\|}\alpha_9]}{s\sqrt{\|b\|}[-\sqrt{\|Ab\|}\alpha_3+\sqrt{\|aB\|}\alpha_{10}]}$ |
| $a>0$ $a>0$<br>$b<0$ $b<0$<br>$A<0$ $A>0$<br>$B>0$ $B<0$ | $\mathcal{L}f=\dfrac{C_0[-a\sqrt{\|B\|}\alpha_5+\sqrt{\|abA\|}\alpha_6]}{s\sqrt{\|b\|}[-\sqrt{\|Ab\|}\alpha_{11}-\sqrt{\|aB\|}\alpha_{12}]}$ | $\mathcal{L}f=\dfrac{C_0[-a\sqrt{\|B\|}\alpha_{11}-\sqrt{\|abA\|}\alpha_{12}]}{s\sqrt{\|b\|}[\sqrt{\|Ab\|}\alpha_5-\sqrt{\|aB\|}\alpha 6]}$ |
| $A<0$ $a<0$<br>$b<0$ $b>0$<br>$A>0$ $A<0$<br>$B>0$ $B<0$ | $\mathcal{L}f=\dfrac{C_0[a\sqrt{\|B\|}\alpha_1+\sqrt{\|abA\|}\alpha_8]}{s\sqrt{\|b\|}[-\sqrt{\|Ab\|}\alpha_2+\sqrt{\|aB\|}\alpha_7]}$ | $\mathcal{L}f=\dfrac{C_0[a\sqrt{\|B\|}\alpha_2+\sqrt{\|abA\|}\alpha_7]}{s\sqrt{\|b\|}[-\sqrt{\|Ab\|}\alpha_1+\sqrt{\|aB\|}\alpha_8]}$ |

| | $Z_s(s)=Z_0(s)\coth[\gamma_{pg}(s)\cdot L_{pg}]$ | $Z_s(s)=Z_0(s)\text{th}[\gamma_{pg}(s)\cdot L_{pg}]$ |
|---|---|---|
| $a<0$ <br> $b>0$ <br> $A>0$ <br> $B<0$ | $\mathcal{L}f=\dfrac{C_0[a\sqrt{\lvert B\rvert}\alpha_5+\sqrt{\lvert abA\rvert}\alpha_6]}{s\sqrt{\lvert b\rvert}[\sqrt{\lvert Ab\rvert}\alpha_{11}+\sqrt{\lvert aB\rvert}\alpha_{12}]}$ | $\mathcal{L}f=\dfrac{C_0[a\sqrt{\lvert B\rvert}\alpha_{11}-\sqrt{\lvert abA\rvert}\alpha_{12}]}{s\sqrt{\lvert b\rvert}[-\sqrt{\lvert Ab\rvert}\alpha_5+\sqrt{\lvert aB\rvert}\alpha 6]}$ |
| $a<0$ <br> $b>0$ <br> $A>0$ <br> $B>0$ | $\mathcal{L}f=\dfrac{C_0[-a\sqrt{\lvert B\rvert}\alpha_1+\sqrt{\lvert abA\rvert}\alpha_8]}{s\sqrt{\lvert b\rvert}[\sqrt{\lvert Ab\rvert}\alpha_2+\sqrt{\lvert aB\rvert}\alpha_7]}$ | $\mathcal{L}f=\dfrac{C_0[-a\sqrt{\lvert B\rvert}\alpha_2+\sqrt{\lvert abA\rvert}\alpha_7]}{s\sqrt{\lvert b\rvert}[\sqrt{\lvert Ab\rvert}\alpha_1+\sqrt{\lvert aB\rvert}\alpha_8]}$ |
| $a<0$ <br> $b>0$ <br> $A<0$ <br> $B>0$ | $\mathcal{L}f=\dfrac{C_0[a\sqrt{\lvert B\rvert}\alpha_5+\sqrt{\lvert abA\rvert}\alpha_6]}{s\sqrt{\lvert b\rvert}[-\sqrt{\lvert Ab\rvert}\alpha_{11}-\sqrt{\lvert aB\rvert}\alpha_{12}]}$ | $\mathcal{L}f=\dfrac{C_0[-a\sqrt{\lvert B\rvert}\alpha_{11}+\sqrt{\lvert abA\rvert}\alpha_{12}]}{s\sqrt{\lvert b\rvert}[-\sqrt{\lvert Ab\rvert}\alpha_5+\sqrt{\lvert aB\rvert}\alpha 6]}$ |
| $a<0$ <br> $b<0$ <br> $A>0$ <br> $B<0$ | $\mathcal{L}f=\dfrac{C_0[a\sqrt{\lvert B\rvert}\alpha_3+\sqrt{\lvert Aba\rvert}\alpha_{10}]}{s\sqrt{\lvert b\rvert}[-\sqrt{\lvert AB\rvert}\alpha_4-\sqrt{\lvert aB\rvert}\alpha_9]}$ | $\mathcal{L}f=\dfrac{C_0[-a\sqrt{\lvert B\rvert}\alpha_4+\sqrt{\lvert abA\rvert}\alpha_9]}{s\sqrt{\lvert b\rvert}[-\sqrt{\lvert Ab\rvert}\alpha_3+\sqrt{\lvert aB\rvert}\alpha_{10}]}$ |

The program establishes the order for values of the roots $-\dfrac{c}{m},-\dfrac{g}{u},-\dfrac{C}{M},-\dfrac{G}{U}$ and he appeals, accordingly, the functions from the table 2

## Results obtained

Assuming a tachogram model, defined in the interval corresponding to with drawing cycle of drill pipe stands trough a Fourier series segment as shown in figure 2, it was determined the model of hook force time vatiation by integration of equation system (1) for the terms of series:

$$v(t)=C_0+\sum_{k=1}^{25}B_k\cos k\frac{2\pi}{t_c}t \tag{13}$$

Function (14) is calculated step by step using numerical methods. In continuation it is determined the model of time variation of the torque on live shaft, using the known equations of kinematics and dynamics of crane-crown blok mechanism and hoisting drum. Results obtained in relative figures (related to normal hook load) for a drilling string of 4.1/2 in, having 1800 m length, are shown in table 3 and and in figure 3.

$$f(t)=\sum_k\frac{Z_sF_1(t)+Z_cF_2(t)}{\dfrac{Z_s}{Z_c}F_3(t)+F_4(t)}v_k(t)+\sum_i\frac{M(s_i)}{s_iN'(s_i)}\cdot e^{s_it}+\frac{M(0)}{N(0)} \tag{14}$$

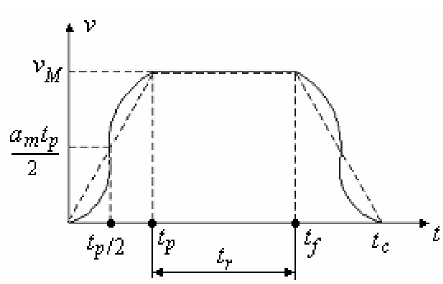


**Fig. 2.**

**Table 3**

| | | | | | | |
|---|---|---|---|---|---|---|
| t[s] | 0,00 | 0,25 | 0,50 | 0,75 | 1,00 | 1,25 |
| M/Mn | 1,256 | 1,083 | 0,997 | 0,812 | 1,001 | 1.199 |
| t[s] | 1,50 | 1,75 | 2,00 | 2,25 | 2,50 | 2,75 |
| M/Mn | 0,975 | 0,875 | 0,793 | 1,157 | 0,996 | 0,887 |
| t[s] | 3,00 | 3,25 | 3,50 | 3,75 | 4,00 | 4,25 |
| M/Mn | 0,775 | 0,855 | 1,200 | 1,011 | 0,808 | 0,761 |
| t[s] | 4,50 | 4,75 | 5,00 | 5,25 | 5,50 | 5,75 |
| M/Mn | 1,174 | 1,001 | 0,932 | 0,926 | 0,801 | 1,243 |

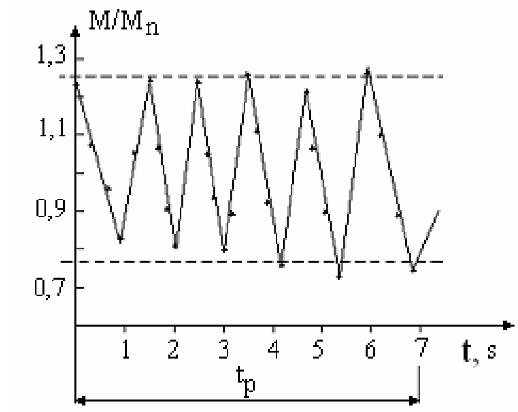


**Fig. 3.**

It is easily noticed that dependence $M(t)$ can be assimilated with a variation in saw-teeth, corresponding to a gradual starting by rheostat or a gradual (in more steps) control of rectifier ignition angle.

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# Analiza software a cinematicii troliului de foraj la extragrea garniturii de prăjini

## Rezumat

*Articolul se ocupă de o situaţie tipică pentru garnitura de foraj a instalaţiei pentru forări de mare adâncime, la manevrarea căreia interesează, din punctul de vedere al acţionării, "comportarea la mişcare" sub aspectul relaţiei de cauzalitate dintre forţe şi viteze, precum şi modul în care se reflectă aceasta în cadrul conversiilor sau transformărilor parametrice ale energiei. Pentru structura identificată prin parametrii lineici corespunzători masei, elasticităţii şi disipărilor înterne şi exterioare, ecuaţiile de mişcare deduse pe cale energetică sunt similare acelora ale transmiterii energiei prin liniile electrice lungi. Articolul descrie procedeele prin care se determină variaţia în timp a forţei aplicată structurii, relativ neomogene, pentru a obţine tahograma de viteze considerată optimă, mişcarea producându-se succesiv prin alungire elastică şi prin translaţie.*