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Modeling Dynamic Motion of Structures Drilling Rigs with Topdrive

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ABSTRACT

Oil platforms with operators for top drive drill works on / off-shore drilling are structured according to actionarileutilizate. Their analysis focuses on finding new ways to strengthen ways to reduce energy consumption and increase performance reliability and technical risk reduction that can occur during operation. Optimization of drilling method depends on the operating system in connection with carrying out the functions required for the process. From this point of view, structural analysis aims at identifying how the electric system works. It depends on how the main and auxiliary systems of operation are grouped. In order to identify the models for simulating different working conditions using the methods of analysis of the structure of the system. Because of these methods can be carried out tests for a number of situations encountered in practice relevant.

INTRODUCTION

$$T_m = \frac{H}{V_r} + \frac{H}{l_p} \cdot \left(\frac{t_1 + t_3}{2} + t_4 \right)$$

Handling the drill stem is rather complex to conduct many operations necessary auxiliary entering both extraction operation as input and the load operation.

Operation of the drilling extraction consists in breaking them away from a certain length and store them on the stack.

Although mining operations of the drilling, as the input, take up a large proportion of the total handle, so operating rigs, they are themselves unproductive operations and the time that such an operation is conducted called auxiliary time (TA).

This resulted in major desire, which led to the drilling rig and modern intervention as auxiliary time is minimized, if possible zero, which means that the speed of maneuver will always have the maximum possible value dictated by the process served and resilience of the capability of the facility.

Starting from a general relation for overall machinery (TM) (ie the removal of the drilling depth H), [8], we can draw several conclusions:

Tm, is the total extraction maneuver;

H - maximum depth;
Vr - hook during steady speed;
t_{1} - time transient at startup;
t3 - time to stop transient;
t4 - duration auxiliary operations (the text is denoted TA);
lp - the length of a step.

The conclusion is that the optimal stride length LPO, resulting in a technical-economic calculation [8], which typically has a value of lpo = 27 m, the minimum total time during auxiliary maneuvering to obtain minimum.

Similarly, the study variance power (Pm) consumed to handle and speed hook during steady Vr, lead to similar conclusions about the value that you must have during AS.

In a unified approach emerges as a conclusion of importance that the total maneuver time Tm is minimum when the auxiliary is minimal (if possible zero). This condition influences correlated with lp, P, Vr show that it is possible to realize a facility dedicated drilling operation handy, efficient, small step lengths, the system powers maneuver relatively small, and handling task to be done with speed low values.

This is the evolution in terms of modernizing and even radical change IFI systems working worldwide with the ultimate in design and construction of systems with different structures of classical image [10].

THE MODERNIZATION OF THE MEDIA MATERIALIZE AND COMPLEX SYSTEMS

Development of unconventional drilling methods in which management processes is done by computer process using the structural variables described above, the elements or of the utmost importance (SG) (Figure 1.)

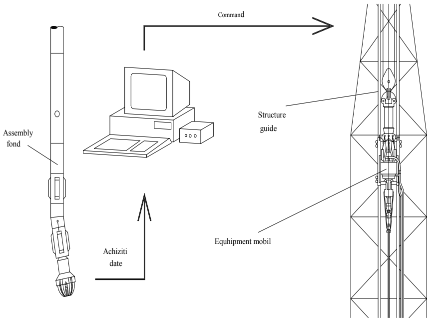

Figure. 1 drilling structure with automated guidance, for directional drilling

Increasing mechanization and automation of operations performed on the platform of the facility and the bridge ferryman by introducing a guiding structure (SG) cell assembly on which the motor hydraulic head (top drive) with the possibility of handling the up / down keeping coaxial hydraulic head spindle axis with the axis of the probe (Figure 2) and automation integrated operations / reverse threaded Add or place steps from / to stack with manipulators or robots;

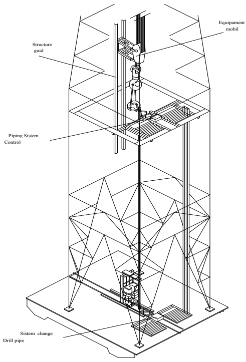

Figure 2 Schematic diagram of drilling rigs

Substantiation of new methods of drilling, for example drilling looming (COILED TUBING) where TA is zero, input or extraction maneuver continually making and lifting handle, ie lowering the head injector (I) achieving with the help of the guide structure of the movement (Figure 3.)

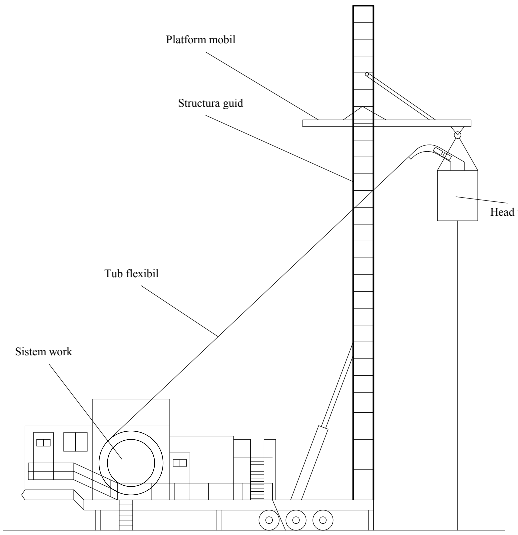

Figura 3 Schema de principiu a unei instalatii de foraj cu structură de ghidare destinată coiled tubing

The most spectacular, perhaps, of modern drilling rigs developments is the design and construction of facilities for drilling large diameter wells (IFDM), however, that these types of installations and constructive solution novelty is the introduction of the element guiding SG Movement assembly cell, it is the object of study [1].

This resulted in major desire, which led to the drilling rig and modern intervention as auxiliary time is minimized, if possible zero, which means that the speed of maneuver will always have the maximum possible value dictated by the process served and resilience of the capability of the facility.

The top drive is a hydraulic or electric motor suspended probe (mast) of a drilling rig, which provides force clockwise rotation to facilitate the drilling process. Using top drive system shown in (Figura4.) reduces the amount of manual work and risks that have traditionally accompanied this task.

Figure 4 The TOP DRIVE

MATHEMATICAL MODELING OF THE DYNAMIC BEHAVIOR STRUCTURE OF GUIDANCE SYSTEM TOPDRIVE

The structure of the guide means is a supporting structure shaped space „U" turned on the two runways are interlocked to ensure running parallel to the mobile device or the rails are interlocked directly to a mast structure or towers with changes both on the design requirements and the intended use of the system. From the point of view of mechanical path (CR) is a metal beam with different boundary conditions subject to the action of a mobile task variables.

The study found that system dynamics guiding structure behaves as an element of energy dissipation which is circulated in the energy flow of the operating system and the forces acting directly on it have a strong variability in terms of evolve over time and the position they occupy along the tread .

Accordingly, an influencing factor to be investigated is the speed of the mobile device that supports the drill string, and strongly influenced by the dynamics of the drive.

External actions due to wind, the exceptional or those caused by movement desynchronization topdrive platform can produce important applications tread.

Simultaneous effects of these actions can be analyzed theoretically using analytical calculation models, which by means of numerical simulation programs are operational and easy to use.

The models can be used for different types of queries on structures guide the movement of mobile equipment for land and marine drilling rigs or the type of drilling operation enforced (conventional drilling, inclined or directed) or from simple requests to the complex.

ROLLING STRUCTURE REQUESTED BY FORCE CONSTANT POINT MOBILE APPLICATION

To solve the problem the following assumptions are accepted:

- Deformation of the tread under the action of the constant force F, is produced only in the elastic range,
- Section and specific gravity are the same for the entire length;
- Moving speed v F = constant along the entire length.

This problem, the assumptions made, is described by the following differential equation:

$$\mathbf{E} \cdot \frac{\partial^4 v(x,t)}{\partial x^4} + m \cdot \frac{\partial^2 v(x,t)}{\partial t^2} + 2\mathit{fn} \cdot \frac{\partial v(x,t)}{\partial t} = \delta(x - ct) \cdot F \qquad (1)$$

Calculation scheme for this case is shown in Figure 1.

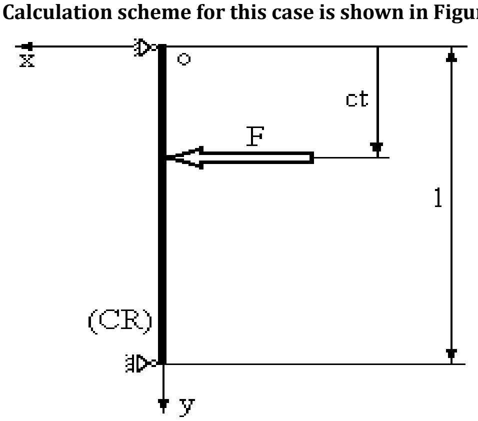

Figura 1. Schema de calcul pentru calea de rulare.

in which:

x is a current length along CR;

t - time, considering time t = 0 corresponding to the position of force F at the top of CR;

v (x, t) - deformed CR (arrow) at the distance x at time t;

E - modulus of elasticity of the material;

I - moment of inertia of the section geometric CR;

m - mass per unit length constant CR;

f - frequency damping;

δ (x) - Dirac distribution;

F-focused mobile force;

l - length of the CR;

c - at maneuvering speed constant, the force F is moved from one end to the other of the CR.

The boundary conditions of equation (1) are:

v(0,t) = 0; *v(1,t)* = 0

$$\left.\frac{\partial^2 v(x,t)}{\partial x^2}\right|_{x=0} = 0;\quad \left.\frac{\partial^2 v(x,t)}{\partial x^2}\right|_{x=l} = 0 \quad (2)$$

The initial conditions of equation (1) are:

v(*x*,0) = 0 (3)

$$\left.\frac{\partial v(x,t)}{\partial t}\right|_{t=0} = 0$$

By applying the finite Fourier sine transform integral (SF) with boundary conditions (2), taking into account the properties of the Dirac distribution has been operated after the multiplication of equation (6.1) by the factor sin (k π x / l), we obtain:

$$\left(\frac{k\pi}{l}\right)^4 \cdot EI \cdot V(k,t) + m\cdot \ddot{V}(k,t) + 2mf\cdot \dot{V}(k,t) = F\cdot \sin\left(\frac{k\pi c t}{1}\right) \quad (4)$$

in which:

$$V(k,t) = \int_0^1 v(x,t)\cdot \sin\left(\frac{k\delta x}{1}\right)\cdot dx,\ k = 1,2,3\ldots \quad (5)$$

$$v(x,t) = \frac{2}{1}\cdot \sum_{k=1}^{\infty} V(k,t)\cdot \sin\left(\frac{k\delta x}{1}\right) \quad (6)$$

V (k, t) represents the original image with SFs function v (x, t).

Notations:

$$\omega_{(k)}^2 = \left(\frac{k\pi}{1}\right)^4 \cdot \frac{E}{m} \quad (7)$$

ω(k) k is the angular frequency of vibration mode for CR simply supported.

$$f(k) = \frac{\omega_{(k)}}{2\pi} = \frac{k^2\cdot\pi}{2\cdot 1^2}\cdot\left(\frac{E}{m}\right)^{0,5} \quad (8)$$

Using this notation the equation (4) becomes

$$\ddot{V}(k,t) + 2f\cdot\dot{V}(k,t) + \omega_{(k)}^2\cdot V(k,t) = \frac{F}{m}\cdot\sin(k\omega t) \quad (9)$$

To solve this equation it is necessary to multiply (6.9) by the factor e-pt and applying Laplace integral transformation Carson (L).

Therefore the Laplace transform is:

$p^2 LV(k,p) + 2fpLV(k,p) + \omega^2(k)\, LV(k,p)$

$$= \frac{Fk\omega}{m}\cdot\frac{p}{p^2 + k^2\omega^2} \quad (10)$$

OPERATING ALGEBRAIC EQUATION ON THE PREVIOUS
Results are:

$$LV(k,p) = \frac{Fk\omega}{m}\cdot\frac{p}{p^2+k^2\omega^2}\cdot\frac{1}{p^2+2fp+\omega_{(k)}^2} \quad (11)$$

Notations: $\omega'^2_{(k)} = \omega^2_{(k)} - f^2$

$$\alpha = \frac{\omega}{\omega_{(1)}} = \frac{c}{2f_{(1)}\cdot l} = \frac{T_{(1)}}{2T} = \frac{c\cdot l}{\pi}\cdot\left(\frac{m}{E}\right)^{0,5} = \frac{c}{c_c} \quad (12)$$

$$\beta = \frac{f}{\omega_{(1)}} = \frac{f\cdot 1^2}{\pi^2}\cdot\left(\frac{m}{E}\right)^{0,5} = \frac{\nu}{2\pi} \quad (13)$$

in which:

α is the characteristic parameter of the effect of speed β - characteristic parameter of the effect of damping; *T*(1) - during the first vibration mode:; $T_{(1)} = \frac{1}{f_{(1)}}$;

T – while the path through F: $T = \frac{1}{c}$;

ccr – critical velocity: $c_c = 2f_{(1)}\cdot l = \frac{\partial}{l}\cdot\left(\frac{E}{m}\right)^{0,5}$;

$\nu = \frac{f}{f_{(1)}}$ logarithmic decrement of damping.

v0 – Maximum arrow mid runway: $v_0 = \frac{2F\cdot 1^3}{\pi^4\cdot E}$ (14)

Applying equation (11) L -1 and leater FS -1:is obtained and then the solution of and the process:

v(x,t) = FS -1 [L -1 [L*V(k*,p*)*]] =

$$= v_0\cdot\sum_{k=1}^{\infty}\frac{1}{k^2\left[k^2(k^2-\alpha^2)^2+4\alpha^2\beta^2\right]}\cdot\left[k^2(k^2-\alpha^2)\cdot\sin(k\omega t) - \frac{k\alpha\left[k^2(k^2-\alpha^2)-2\beta^2\right]}{(k^4-\beta^2)^{0,5}}\cdot e^{-f}\cdot\sin(\omega'_{(k)}t) - 2k\alpha\beta\cdot\left[\cos(k\omega t) - \frac{\cos(\omega'_{(k)}t)}{e^f}\right]\right]\cdot\sin\left(\frac{k\pi x}{1}\right). \quad (15)$$

The bending moment M (x, t) and the shear force T (x, t) follows:

$$M(x,t) = -E\cdot\frac{\partial^2 v(x,t)}{\partial x^2} = \quad (16)$$

$$= M_0\cdot\sum_{k=1}^{\infty}\frac{8k^2}{\pi^2}\cdot\sin\left(\frac{k\pi x}{1}\right)\cdot\frac{1}{k^2\cdot\left[k^2(k^2-\alpha^2)^2+4\alpha^2\beta^2\right]}\cdot\left\{k^2(k^2-\alpha^2)\cdot\sin(k\omega t) - \frac{k\alpha\cdot\left[k^2(k^2-\alpha^2)-2\beta^2\right]}{(k^4-\beta^2)^{0,5}}\cdot e^{-f}\cdot\sin(\omega'_{(k)}t) - 2k\alpha\beta\cdot\left[\cos(k\omega t) - e^{-f}\cdot\cos(\omega'_{(k)}t)\right]\right\};$$

$$T(x,t) = T_0\cdot\sum_{k=1}^{\infty}\frac{2k^3}{\pi}\cdot\cos\left(\frac{k\pi x}{1}\right)\cdot\frac{1}{k^2\left[k^2(k^2-\alpha^2)^2+4\alpha^2\beta^2\right]}\cdot\left\{k^2(k^2-\alpha^2)\cdot\sin(k\omega t) - \frac{k\alpha\left[k^2(k^2-\alpha^2)-2\beta^2\right]}{(k^4-\beta^2)^{0,5}}\cdot e^{-f}\cdot\sin(\omega'_{(k)}t) - 2k\alpha\beta\cdot\left[\cos(k\omega t) - e^{-f}\cdot\cos(\omega'_{(k)}t)\right]\right\}; \quad (17)$$

$$M_0 = \frac{F\cdot l}{4} \quad (18)$$

T0 = F (19)

Note: The Series (15) which is deformed CR, converges very similar rapid convergence of the series

$$\sum_{k=1}^{\infty}\frac{1}{k^4}.$$

Series (16), (17) have a slower convergence, similar convergence series:

$$\sum_{k=1}^{\infty}\frac{1}{k^2},\ \text{respectively}\ \sum_{k=1}^{\infty}\frac{1}{k}.$$

ANALYSIS OF POSSIBLE CASES

– *The static* case (c = 0; α = 0) relation (6.15) for α = 0, is:

$$v(x,t) = v_0 \cdot \sum_{k=1}^{\infty} \left(\frac{1}{k^4}\right) \cdot \sin\left(\frac{k\pi x}{l}\right) \cdot \sin(k\omega t) \tag{20}$$

This case shows deformation (arrow) CR when they act on a concentrated force F at distance l = ct.

If the CR oscillating without damping (f = 0; β =0):

In (15) FOR β =0, f = 0 result:

$$v(x,t) = v_0 \cdot \sum_{k=1}^{\infty} \sin\left(\frac{k\pi x}{l}\right) \cdot \frac{1}{k^2 \cdot (k^2 - \alpha^2)} \cdot \left[\sin(k\omega t) - \frac{\alpha}{k} \cdot \sin(\omega_{(k)} t)\right] \quad (21)$$

– *Case wich* β << 1

$$v(x\ t) \approx v_0 \cdot \sum_{k=1}^{\infty} \sin\left(\frac{k\pi x}{l}\right) \cdot \frac{1}{k^2 \cdot (k^2 - \alpha^2)} \cdot \left[\sin(k\omega t) - \frac{\alpha}{k} \cdot e^{-f} \cdot \sin(\omega_{(k)} t)\right] \quad (22)$$

– *Case wich* β = βcr = *n*2

In this case the critical value of depreciation is,

$$f = \omega(n) = \omega_{(1)} n^2 \quad (23)$$

$$\beta_{cr} = \frac{f}{\omega_{(1)}} = n^2;$$

$$v(x\ t) = v_0 \cdot \frac{1}{n^2 \cdot (n^2 + \alpha^2)^2} \cdot \left\{ (n^2 - \alpha^2) \cdot \sin(n\omega t) - 2n \cdot \alpha \cdot \cos(n\omega t) + \right. \quad (24)$$
$$\left. + e^{-f} \cdot \left[(n^2 + \alpha^2) \cdot n\omega t + 2n \cdot \alpha\right] \right\} \cdot \sin\left(\frac{n\pi x}{l}\right).$$

– Case wich β > βcr

If the damping is supercritical, it results:

$$f^2 > \omega_{(k)}^2 = k^4 \cdot \omega_{(1)}^2 \quad (25)$$

accordingly,

$$\beta = \frac{f}{\omega_{(1)}} > n^2 \quad \beta \geq 0 \quad (26)$$

In this case the pols for expresion (11) is (±*k*iω) and

$$\left(-f \pm \omega'_{(k)}\right)$$

By applying transformations L -1 and FS -1 to expresion (11) rezult:

$$v(x,t) = v_0 \cdot \sum_{k=1}^{\infty} \frac{1}{k^2 \cdot \left[k^2 \cdot (k^2 - \alpha^2)^2 + 4\alpha^2 \cdot \beta^2\right]} \cdot \left\{ k^2 \cdot (k^2 - \alpha^2) \cdot \sin(k\omega t) - \right. \quad (27)$$
$$- 2k\beta \cdot \cos(k\omega t) + \frac{k \cdot \alpha \cdot e^{-f}}{2 \cdot (\beta^2 - k^4)^{0,5}} \cdot \left\{ \left[2\beta^2 - k^2 \cdot (k^2 - \alpha^2) + 2\beta \cdot (\beta^2 - k^4)^{0,5}\right] \cdot e^{\omega'_{(k)} t} - \right.$$
$$\left.\left. - \left[2\beta^2 - k^2 \cdot (k^2 - \alpha^2) - 2\beta \cdot (\beta^2 - k^4)^{0,5}\right] \cdot e^{-\omega'_{(k)} t} \right\}\right\} \cdot \sin\left(\frac{k\pi x}{l}\right).$$

WORK RATE EFFECT

For subcritical speeds $\alpha = \frac{c}{c_{cr}} < 1$ (c < ccr),

The maximum curvature occurs at mid-span beam during passage through CR (fig.2.) and the supercritical speeds $\alpha \geq 1$ The

maximum curvature at mid-span beam occurs when F reaches the opposite end of the starting point (Fig. 2). In (Figure 3) is the variation of arrow maximum at mid-span beam by parameter α for damping values β = 0; 0,1; 0,3; βcr = 1;2.

From this plot it is noted that the maximum curvature occurs within the range α ≅ (0,5...0,7); and for large values of factor α strain value is almost equal to the static deflection of the beam under its own weight.For α << 1 can give an approximate expressi

$$v(x,t) = v_0 \cdot \sin(\omega t) \cdot \sin\left(\frac{\pi x}{l}\right) = v_0 \cdot \sin\left(\frac{\omega c t}{l}\right) \cdot \sin\left(\frac{\pi x}{l}\right) \quad (28)$$

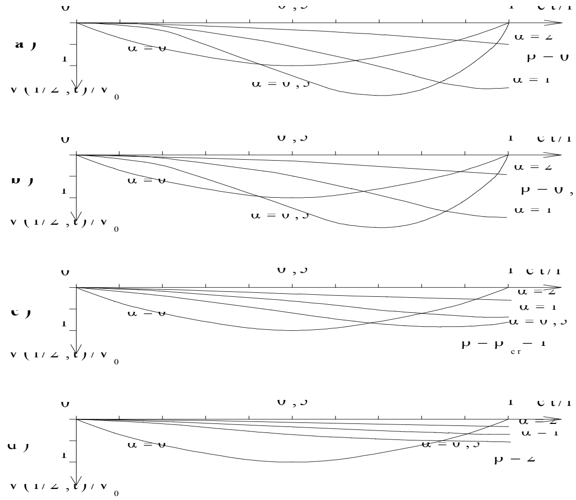

Figure 2. parameter v(l/2,t)/v0 for different values of the coefficient α ºi β

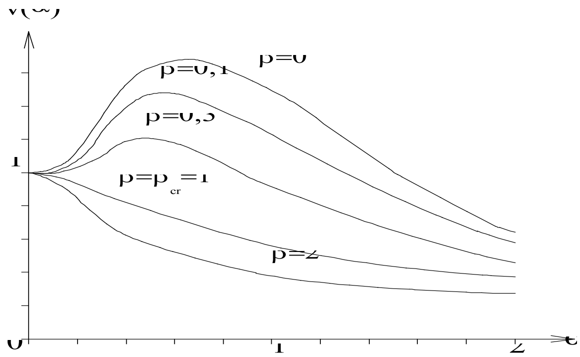

Figure 3. The maximum v(α)=v(l/2,t)/v0 according to the α ºi β

CONCLUSIONS

The evolution of drilling rigs in the last years is actually spectacular and includes the full range of installations for the drilling process.

This trend is launched in two main directions:

- A first course in the modernization of drilling is the introduction of economical and reliable drive systems of which corresponding current level of technological accessibility, it highlights the drives with three-phase asynchronous motors.

- A second solution is manifested by the increase in the degree of mechanization and automation of specific operations work systems, especially the overall duration of the total time to handle, which means minimizing (even to zero), the auxiliary times .

Corresponding to the two essential requirements set forth above are found, and the development machine oil is dramatic in some cases radically changing the image of "classical" structure have on the system. It appears that changes have been made to the resistance of the system by allowing for guiding mobile equipment in order to meet both requirements mentioned above, changes which often are major, and the structure can be named after the function that fulfill, guiding structure.Equally drives and working bodies have changed, the objectives are related to computer-aided process control and reduce energy consumption in terms of increasing the reliability and safety in operation.

In conclusion, the appearance of the structure of the guide member guiding the movement of the mobile assembly comprising a mobile platform on which is fixed to the head of hydraulic motor driven by three-phase asynchronous electric motor, becomes the new element in the system configuration of the computer and is driven drilling designed to provide precision position moving parts, control its speed of travel, taking the reaction forces and moments, etc.. necessary drilling operations automation and increase shunting operation to reduce the auxiliary time.

In a unified approach emerges as a conclusion of importance that the total maneuver time is minimum when the auxiliary is minimal (if possible zero). This condition shows that it is possible to realize a facility dedicated drilling operation handy, efficient, small step lengths, the power system relatively small maneuvering and handling task to be done with speed lows.

This is the evolution in terms of modernizing and even radical change working systems worldwide rig with the ultimate in design and construction of systems with different structures of image classes.

REFERENCE

[1] Boyadief G.J.,1986, SPE Drilling Engineering An overview of topdrive drilling system applications and Experience., | [2] Bourgoyne Jr. A.T., Millheim K.K., Chenevert M.E. and Young Jr. F.S. (1991). Applied Drilling Engineering. Richardson, TX 75083-3836, USA: Society of Petroleum Engineers. | [3] Cavanaugh J.M. & Adams D.M., Top drive Drilling System Evaluation. SPE, Drilling Engineering 1988. | [4] Grangr P., Side drive reduces overheads. The Oilman. 1987/3. | [5] General Catalogue Maritime Hydraulics Drilling Equipment Division. 1996-97. | [6] Gerwick Jr. B.C. (1986). Construction of Offshore Structures. Baffins Lane, Chichester, Sussex PO19 1UD,UK: John Wiley & Sons. | [7] Stan M., Metode avansate de proiectare a utilajului petrolier- ed.UPG,2005 | [8] SzostakL., & Chrzaszcz W., Rigs with Upper Drive System of Drilling Cable Column. Mining, Quarterly of Mining and Metallurgy Academy in Kraków. | [9] http://www.Klockner Moeller , Programming instructions | [10] Gavris A.S., Munteanu R.jr., Zagar B., Iudean M.D., Munteanu M., Popovici D., Controlling a DC and AC Motor, Editura november 2008, Cluj-Napoca, Romania | [11] Vladareanu L., Controlul în timp real cu automate programabile . Studii şi cercetari aplicative, Ed. Bren, ISBN 973-648-432-7, pp.207, Bucuresti, 2005 | [12] Popovici D., Podea Z., Velea L. M., Automatic Systems with PLC, annual Symposium of the Institute of Solid Mechanics SISOM 2009, 2009 May 28-29, Bucharest | [13] Velea L.M., Popovici D., Popovici O., Podea Z., Measurement and Control Systems with Programmable SMC- PLC Automation Systems, Conference Proceedings of The National Symposium of Theoretical Electrical Engineering SNET 09, Bucharest, 2009 | [14] .http://www.varco.com, Top drive drilling system |