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Parameters Control Systems in a Plant for Drilling Wells

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Abstract

Development of oil and gas industry requires the realization and use of advanced automated equipment to replace human activity and ensure the fastest execution, with superior performance and complete safety, of the entire specific activity of drilling wells.

In this paper, one has studied automatic advance systems and controlled parameters for drilling wells. During the drilling operation, the pressing is done by the partial weight of the drill pipes and, therefore, the automatic advance of the screed must be done very precisely, depending on the yield of that process, on the verticality of the borehole and considering accident avoiding. The paper presents and describes several types of systems that aim to control the parameters of drilling wells equipment.

Key words: *well control equipment, well control methods, drilling automation.*

Introduction

The diversity of operations that are necessary to drill a hole, the size of the masses in motion and developed energy by various units to drive, the difficult operating conditions on the sole dig wells and drilling depth increases and the expansion of the offshore drilling are only a few underlying factors that prove the complexity of the drilling process and the need for increased automation.

Through automation, one ensures a shortened probe trenching and expenditure for this purpose, avoiding costly damage and reducing the physical effort of operators, while creating the possibility of applying efficient process optimization.

Automating the drilling process relates mainly to:

- adjust the bit advance by maintaining a constant value (inferred based on an optimization criterion) of a technological parameter with important role in the deployment of the rock;
- automation of shunting operations;
- automation of cementing operation;
- automation of the operation of preparation of the drilling mud;
- automating pumping mud into the well.

The Automatic Advance of the Drill Bit

Because during the drilling operation the pressing on bit is performed by the partial weight of the drill pipe, the advance of screed must be done with great precision, considering the fact that the process efficiency, the verticality of the borehole and avoiding accidents depend on it.[2]

These considerations, plus those related to growth drilling depth and expansion of offshore drilling, are those that formed the basis of the urgent need to automate the process of advance of the drilling bit.

The automatic advance of the drilling bit realizes the control of a technical parameter at a constant value, considered optimal, which conditions the advance operation by convenient changing the descent speed of the upper end of the drill string, i.e. speed hook, noted V_C.

In general, there are several possibilities for adjusting the parameter chosen, but now only the automatically system with the load on dig control can be used at the three variants of rotary drilling.

There are automated systems that perform rotational speed control of the bit, but especially at drilling turbine, where the influence of the moment resistance of the bit on rotational speed is higher, as well as the control system of rotational power of bit.

Theoretically, there can be made automatic systems with resistant torque control, but they are not used in practice because of the difficulties in measuring of the moment and transmission at the surface of the measurement results.[4]

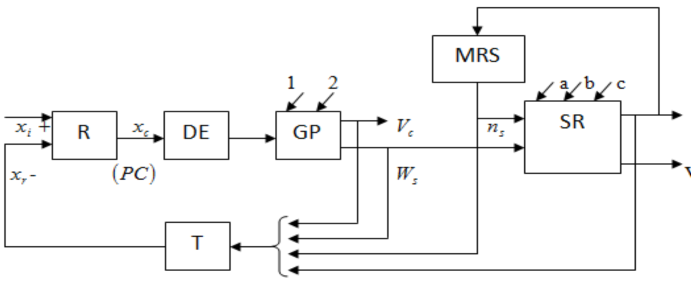

Fig. 1. Block diagram of the automatic advance of the bit
R – controller; DE – execution device; GP – drill pipe; 1 – weight, length and elasticity of drill pipe; 2 – friction between the gasket and the drilling fluid/friction between the gasket and the drill hole walls; SR – hoe-rock subsystem; a – rock characteristics; b – drilling bit features; c – drilling fluid flow and quality; MRS – submersible rotary engine; PC – pressure control; M_S – drilling bit resistance torque; V_S – advancing speed of drilling bit; n_S – rotation speed of drilling bit; W_S – down force on drilling bit; W_C – the force on hook; V_C – the speed on hook.

DE aims to change the speed of the descent of the drilling pipe in accordance with the control signal generated by the pneumatic controller. Used DE can be:

- devices with brake, band or clogs;
- with brake with magnetic powder;
- with brake rotary positive displacement pump type;
- with brake planetary differential device with two electric motors type.

Depending on the parameter that adjusts, the automated systems are as follows:

- automated advance systems with axial load control drill bits;

- automated advance systems with rotation speed control on drill bits;
- automated advance systems with resistant torque control on drill bits;
- automated advance systems with rotation power control of drill bits.

Brake systems, with band or with clogs, work in two versions: with continuous or discontinuous operations. Because of the nonlinear character and variation of tasks hook in wide holes, continuously operating systems have a DE made as automatic systems with negative reaction after speed of the hook drilling pipe.

In the case in which in lieu of DE having lowering speed as output parameter is used an DE with output parameters which is an operating brake lever, the automated advance systems may be interpreted as a control system of a parameter (or V_C, n_S, W_S) in cascade with speed control of the hook. The advantage is that it is the most used and completely eliminates the influence of nonlinearity of breaking system and load hook.

In the case of advance systems with discontinuous operations, the movement of the upper end of the drill pipe is performed in successive steps by loosening the brake when the actuator of the brake lever control receives proper pulse duration and intensity. This system is used for drilling in small depth or medium [4].

Control of the Load on the Drill Bit

Controlling drill bit load is done by appropriately modifying the descent speed of the hook, i.e. the upper end of the drill pipe gasket. The elastic properties of the material they are made of is an essential element in understanding how, from the surface, one may ensure the desired loading on the drill bit.

To establish a steady advancement of the drill bit, the lowering speed of the hook V_C must be equal to the forward speed of the drill bit V_S. If the hook speed is higher than the forward speed of the drill bit, the drill rod assembly is compressed (as a spring elastic), increases the load on the drill bit and the advance speed of the hook increases until equals the speed on hook.

The execution device of the load drill bit control system consists of the braking device DF, the drilling drum wiring T, the crown-block G, the crane M and the hook C (fig. 2).

If the drilling drum would be left free, then the lowering speed of the hook would become increasingly higher and the drill road assembly would be destroyed under its own weight. The breaking device can be of several types: with metal tape, hydraulic brake type, with magnetic powder, etc.

Typically, the breaking device is coupled to the drum shaft through a planetary reduction, with a large transmission factor n_t (hundreds).

In this way, the speed of rotation of the brake shaft is n_t times larger than that of the drum shaft, and the braking torque of the brake shaft is n_t times lower than that of the drum shaft.

Measurement of load on the drill bit is made at the surface by assessing the mechanical tension of the fixed end (dead) of drilling cable, which is proportional to hook load G_C :

$$G_f = \frac{G_C}{2m} \tag{1}$$

where m is the number of rollers of the drilling crane. The load on drill bit G_S is equal to the variation of the load on hook ΔG_C of the drilling string crossing from freely suspended state (with rotating gasket and drill bit a few centimeters above the role probe) in the normal working condition.

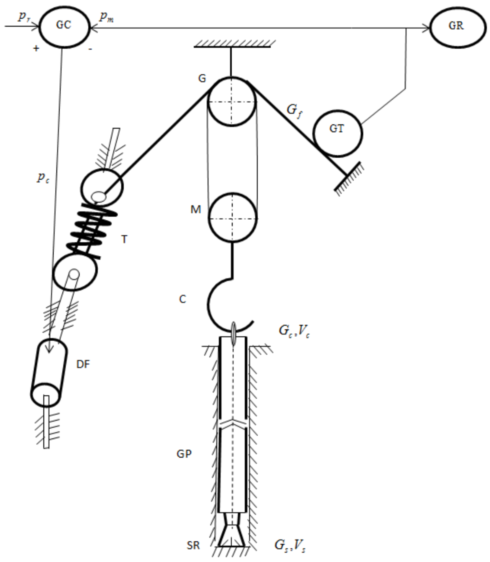

Fig. 2. Scheme of the down hole control system.

Therefore, control of a load drill bit to a constant value is equivalent to control at a constant value, conveniently chosen, of the load on cable drilling. In most drilling rigs, load controller (effort) is of a pneumatic type P or PI (with very weak integral component) [3].

Axial Load Control on Drill Bit

Automatic advance systems with the axial load control on drill bit are divided into two classes: automatic advance systems with the proper control of axial load on drill bit and automatic advance systems with load control on the crane hook rig.

On the assumption of neglecting the friction and possible attaching of gasket of the borehole walls, the variations of two loads compared to steady state values are equal. Although automatic advance systems from the first class can achieve superior performance to those of the second class, they have not received an extension on an industrial scale because of the difficulties encountered in directly measuring the axial load drill bit [1].

The system shown in Figure 3 serves to automatically control the load on the hook by means of a hydraulic nonlinear controller that operates on the principle of general comparisons between the reaction parameter W_r and the input and output values (A_{r1} and A_{r2}).

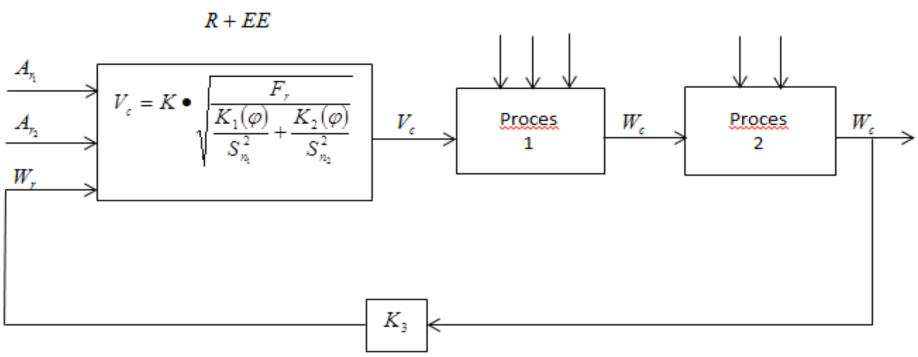

Fig. 3. System for automatic control of the load hook by means of a hydraulic nonlinear controller.

The winch cable tension W_r, is acting on the crankshaft of a hydraulic motor consisting of two spherical-cylinder double-acting, whose rods are connected to the crankshaft.

Each cylinder room situated on both sides of the piston is filled with oil and linked together by one pipe on which are two adjustable valves with passage sections S_{r1}, S_{r2}, respectively.

The speed of the gasket movement at hook is proportional with the crankshaft speed that depends on the voltage W_r of the wire winch and on the sections A_{r1} and A_{r2} of valves:

$$V_c = K\sqrt{\frac{W_r}{\frac{K_1(\varphi)}{A_{r1}^2}+\frac{K_2(\varphi)}{A_{r2}^2}}} \tag{2}$$

Dependence of factors K_1 and K_2 to the rotation angle φ of the crankshaft produces variations of advance speed of gasket V_C, even if the cable tension W_r at winch is constant.

For $A_{r1} = A_{r2} = A_r$, one may obtain at a complete rotation of the crankshaft a degree of irregularity of feed rate:

$$V_c = K^1(\varphi)A_r\sqrt{W_r} \tag{3}$$

in exces of 20%.

The automation device has the disadvantage that does not stop the advance of the drill string at the occurrence of accidental overloads, but only decreases the feed rate. Stopping can be achieved only by closing the valves on the pipes that connect the cylinder chambers.

The system shown in figure 4 performs *the automatic control of the hook load*, through direct drive on the winch brake lever. The reaction force W_r, proportional to the pressure P at the output of the “bedpan” type drilling measuring device is compared to the force W_i produced by the tension of an elastic element.

Depending on the differential signal, a relay generates electrical signals corresponding to controlling two electromagnetic valves, which permit the passage of the steam (or compressed air) in the active chamber of a cylinder, which acts through the piston rod, by force W_a, on the brake lever, to finally obtain the winch drum braking force W_f.[1]

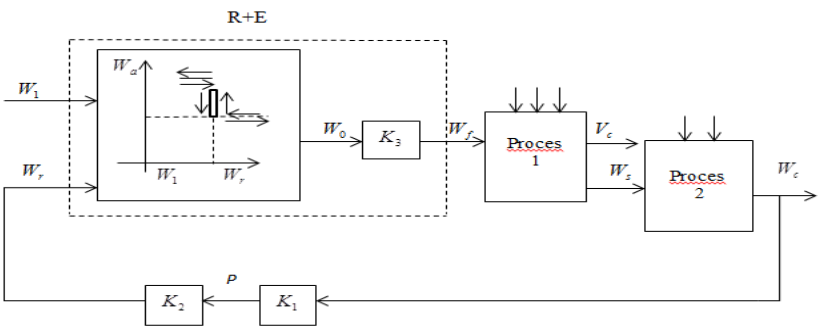

Fig. 4. Automatic control of the load hook by operating directly on winch brake lever.

The value of the proportionality factor depends on the friction coefficient between the band and the metal asbestos and varies at the transition from the static to the dynamic regime. Operation of the automatic control is discontinuous, the drilling operation being performed by repeated stopping and starting of the whole train set.

Conclusion

Most automatic drill bit advance systems work on the principle of maintaining constant the hoe load around the optimal value, dependent on the nature and strength of the rocks it traverses, the type of hoe and drilling fluid flow and pressure, depth drilling. Thus, if the load on hoe is small, then the dislocation of rocks is shallow and it is characterized by a high vibration, rapid wear and low speed advancement hoe. When the load on the hoe is too big, there is a danger of drill gasket breakage, damage of hoe, or packing hoe (when drilling fluid fails to bring to the surface the entire amount of detritus resulting from the dislocation of the rock).

This paper presents some advance automatic systems and their associated parameters for drilling rig wells, many of them in current use.

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Sisteme de reglare a parametrilor specifici într-o instalație de foraj a sondelor

Rezumat

Lucrarea prezinta diverse sisteme de reglare a parametrilor specifici unei instalatii de foraj a sondelor. Reglarea acestor parametri are un rol esential in realizarea corecta a avansului sapei de foraj, avans care trebuie facut cu mare precizie, deoarece de acesta depinde randamentul procesului, verticalitatea gaurii de sonda, precum si evitarea accidentelor.