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METHOD OF AUTOMATIC MEASUREMENTS OF DRILLING MUD QUALITY PARAMETERS

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ABSTRACT

The quality of drilling muds is a most important characteristic of drilling technology. Sharp growth of requirements to measurements of the muds' parameters due to appearance of ever more sophisticated mud formulations, intended for various conditions of drilling. The wide spread manual method of taking measurements of drilling mud parameters cannot meat requirements of modern technologies any longer. A new principle of automatic measurements of the drilling mud parameters with transferring the results to display (like the values of other drilling practices) is proposed in the paper. The principle is illustrated by a scheme of automatic measurements of the mud's density (patented in Kazakhstan). Similar schemes are worked out for measurements of density, jell strength and filtration.

Key words: Drilling, Drilling muds, Measurements, Automatic measurements.

INTRODUCTION

The flushing system is a most important component of the drilling technology. Apart from removing the cuttings from the face of the hole, the flushing agent is performing a number of other functions. They are:

- Maintaining stability of the well bore,
- Preventing absorption of the liquid by permeable formations,
- Preventing outbreaks of formation fluids,
- Preventing drill pipe freezing in the well and helping to eliminate it,
- Reduction of friction forces between the well and the rotating drill string,
- Opposing destructive effect of chemically active fluids.

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The list of functions can be continued. All of the functions are executed by means of varying drilling mud's composition, while each composition is reflected in its own specific combination of quality parameters, obtained by measurements.

Specifically measurements of the drilling mud parameters are performed for the purposes as followed:

- Making sure that the required quality of the drilling mud at its preparing is achieved.
- Monitoring the changes of that quality in the drilling process due to consumption of the mud's ingredients.
- Determining the moment for taking measures on restoring the initial quality.
- Determining the moment for taking measures on adjusting the mud's quality in response to changing situation in the well bore.
- Assessing effectiveness of the taken measures.

Significant deviation of the measurements' results from those, planned for given conditions, can cause aggravation of situation (if not grave breakdowns) and bring about increase in the well's coast.

The principal section

The liable to measurement parameters of drilling mud are[1,2] its density, viscosity, filtration, filtration cake, gel strength, content of hydrogen ions, content of abrasive particles and some others.

For measurements of each of the listed parameters special technologies are worked out. The common feature of those technologies is the fact that the results of the measurements cannot be obtained at any desirable moment as it is, for example, the case with information on pressure on the mud pump, bit load, and a number of other indices of the drilling process. For their measurements special sensors are created, whose signals are constantly displayed on a signal panel. Unlike that, the measurement of any parameter of drilling mud quality is performed manually and represents a definite procedure, comprising a number of consecutive acts. Each particular measurement takes several minutes (sometimes even hours) to perform.

Besides time, spent on the measurement proper, each procedure includes also some supplementary time expenditures. They are:

- Time, spent on preparing to the measurement, such as taking sample of the mud from flushing system or making the measuring instruments ready.
- Time, spent on concluding operations, such as entering the results in the register book, cleaning the instruments from the mud traces and laying them in their cases. On some occasions, like measurements of the mud' viscosity (not the funnel viscosity), the result of the measurement cannot be obtained directly, but only after some additional mathematical processing.

Performing the measurements and assuring reliability of their results is only possible, if there is a personal available, possessing specific qualification. Therefore, due to significant expenditures of qualified labor time, the measurements are not performed continuously, but only when considered absolutely indispensable. As a result of balancing economical arguments on the one hand and the level of risk of break downs with grave consequences, – on the other, time intervals between the measurements are worked out as adduced in the table below[3].

Table 1: Intervals between measurements of drilling mud parameters, h

Well bore situation	Perametres				
	Density	**Viscosity**	**Filtration***	**Gel strength**	**Sand****
Normal	1	1	8	8	8
Aggravated	0.25	0.25	1	1	1

* According to existing technology the filter cake thickness measurements are performed in the process of filtration measurements

**A short for abrasive particles content

As it follows from the table, the intervals are established according to geological and technological situations in the well bore. The situations are subdivided into two classes: normal and aggravated. On the last occasion the intervals are reduced from 4 to 8 times.

The recommendations of the table are dated back to the end of the last century. Since that time the number of manufactured and offered on the market drilling mud compositions has increased very substantially. Correspondingly increased requirements for monitoring drilling mud quality in general and for greater frequency and precision of measurements of the quality parameters in particular.

At the technology of Drilling Department of the Kazakh National Satpaev Science and Technology University in cooperation with Volkovgeologia Joint stock company a method of automatic measurements of drilling mud quality parameters was worked out.

It should be pointed out here, that, what with the measurement procedure as such, – it was left intact, that is, it is carried out according to traditional technology. However to the traditional measuring instruments some supplementary elements were added, – for the purpose of performing the measurements without human interference, that is automatically.

Those elements in the facilities, intended for automatic measuring of various parameters of the drilling mud, have a number of common features. They are as follows:

- Each measuring unit is mounted upon a rotable table, whose turning is stopped and resumed by relays.
- The halts of turning are affected at some special positions, such as position of filling up the measuring capacities with mud; position of measuring proper, and position of washing up the measuring instruments to prepare them for the next measurement.
- In each particular position the measuring unit is coming in contact with some outward communications, such as ducts for mud or water delivery; trays for collecting and draining the worked-out mud and water; power feed lines and lines for leading out the measuring signal (voltage).
- As it was mentioned the results of the measurements are represented as electrical signals. The signals are supplied to an integrated circuit to convert them into digital form and subject to some necessary processing. Finally the results of the measurements are in proper measurement units shown on a display and remain there till the results of the next in turn measurement replace them. Besides, those results are preserved in a memory with a possibility to extract them, should the need appear.
- The measurement unit of each separate parameter of drilling mud is positioned upon its own rotable table, and all the tables rotate around a common axle. Thus a measuring aggregate is formed, which may be also provided with common systems of mud, water and energy supply, as well as a common signal panel.

The method under consideration has advantages as follows :

- Eliminates expenditures on special qualified personal for taking measurements,
- Increases the maximum possible frequency of measurements,
- Increases accuracy of the results,
- Guarantees permanent monitoring of the mud quality on the part of the drilling crew,
- Guarantees registering spontaneous changes of the mud quality and the time of their occurrence.

As an example of application of the structural principles, set forth above, a facility for executing automatic measurements of the drilling mud funnel viscosity[4-6] is presented below for more detailed consideration (Fig. 1).

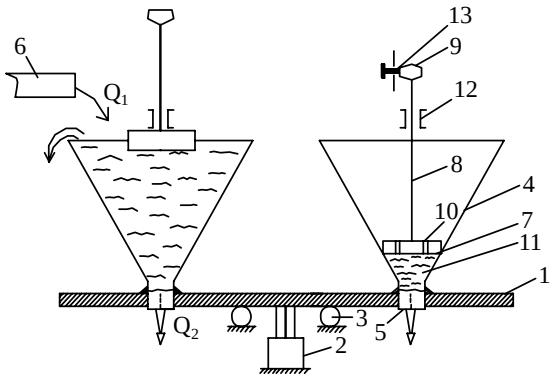

Fig. 1: A facility for automatic measurement of drilling mud funnel viscosity

1- Rotable table; 2- Electric motor; 3- Bearings; 4- Funnel: 5- Nipple; 6- Trough; 7- Float; 8- Rod; 9- Cap; 10- Hole; 11- Mud; 12- Guide; 13- Live contact

The round rotable Table 1 with the measuring funnel 4, mounted upon it, is revolved by a small electric motor. One revolution of the table corresponds to one separate measurement of the viscosity. Performing a revolution, the table passes three positions:

- Position I (not shown on the figure) is the position, in which the measuring unit is washed up with a stream of water,
- Position II (left on the picture) is intended for filling the funnel with drilling mud,
- Position III (right on the picture) is intended for taking measurement and transmitting its results to the integrated circuit.

When the funnel 4, with the rotable Table 1, arrives at some particular position, a special cam on the table meets a live (closed) contact in the feeding line of the motor. The cam breaks the line, stopping the motor and the table itself.

All the procedure is controlled by a time rely. It represents a disk with a number of cams. The disc is rotating at a constant frequency by a synchronous electric motor. Thus, after a predetermined period of staying in the given position has elapsed, the rotable disk of the time relay brings its cam to a dead (open) contact, closes it and restarts the table's turning so that the funnel should come to the next position. There another cam of the table halts its motion again by breaking the live contact.

Let us assume, that the rotable table is staying in the position I, so, that the funnel is held under a stream of water, removing traces of mud from the funnel 4, the nipple 5, and the float 7. After the time period, necessary for intensive cleaning has terminated, the cam of the time relay closes a dead contact of the starting relay. That last closes two dead contacts: the contact in the feeding line of the motor and another one, which continues to feed the starting relay itself, after the cam of the time relay has gone past.

The rotable table starts turning and brings the funnel in position II, where it stops under the trough 6 and its stream of mud. (The mud is taken from the mud pump's receiving tank, that is, after having undergone all the settling and screening procedures). Since the incoming from the trough 6 flow rates Q_1 is supposed to be greater, than the flow rate Q_2, issuing from the nipple 5, the funnel is being filled with drilling mud, and the float 7 is rising with its level. When the upper end of the funnel is reached (as on the figure), the mud starts over the edge to be collected in a tray below the rotable table and led out into the pump's receiving tank.

At the end of the fixed time period, the time relay resumes the table's turning, carrying the funnel away from under the trough 6. At the moment, when the stream of mud stops hitting into the funnel, the outgoing flow rate Q_2 stops being recompensed with the incoming flow rate Q_1, and the mud level in the funnel begins to com down. At that very moment a special cam on the table switches on another starting relay, supplying power to the circuit of an impulse generator, whose calibrated impulses are supplied to a counter. The process of viscosity measurement starts.

In the meantime the table reaches position III and stops there. The mud continues to drain out of the nipple 5, and accordingly the float 7 continues to sink, carrying with itself the float 7 with its rod 8 and cap 9. When the predetermined volume of mud has left the funnel, the cap 9, on its way down, meets the live contact 13 and discontinues the line,

feeding the impulse generator. The generator stops supplying impulses, and the total sum of the counter (the number of impulses, converted into seconds), appears on the signal panel, being simultaneously registered in the memory block. Thus the measurement of the funnel viscosity is effected.

Sometime later the time relay returns the table to position I for washing up. The working cycle is completed, and the facility is ready for the next cycle of measurement, as well as for all the other consecutive cycles, as long, as the need for drilling mud viscosity measuring has not terminated (for example, when drilling process is replaced by pulling up the drill pipes).

The time of one measurement cycle can be varied in accordance with requirements of the situation. That can be achieved, if a motor with adjustable frequency of rotations is applied as a drive for the time relay.

On the described funnel viscosity measuring facility a patent of Kazakhstan Republic was issued[4]. The same general principles were taken advantage of for designing facilities for automatic measurements of other drilling mud quality parameters, namely for measuring density, gel strength and filtration.

CONCLUSIONS

(i) The quality of drilling mud plays a key role in bringing down the costs of well construction,

(ii) With the drilling mud compositions becoming ever more sophisticated, requirements for measurements of their parameters become more and more exacting,

(iii) Meeting those requirements in a traditional way that is by taking the measurements manually, are going to be ineffective and too embarrassing,

(iv) The only way to solve the problem is to perform all the required measurements automatically,

(v) The paper here suggests some general principles of transition from manual method of taking measurements of drilling mud parameters to an automatic one,

(vi) The method is demonstrated by the example of the funnel viscosity measuring facility and

(vii) Also worked out are practical schemes of facilities for automatic measurements of several other drilling mud parameters.

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