50 years University of Mining and Geology "St. Ivan Rilski"
Annual, vol. 46, part I, Geology and Geophysics, Sofia, 2003, pp.435-439

TECHNICAL EQUIPMENT FOR CEMENTING PROFSPECTING DRILL WELLS

Nikolay Tchervenakov

University of Mining and Geology "St. Ivan Rilsky", Sofia 1700, Bulgaria, E-mail: cherv@mgu.bg

ABSTRACT

Constructions and action of a set of technical equipments for cementing prospecting drill wells with small diameter (59 and 76 mm), consisted of cone and cylindrical packer, packer for horizontal drill holes, hydraulic mixer for grouting slurries and hydraulic dispersing device for grouts improving have been examined.

During prospecting wells drilling in an area, where underground mine workings exist, very often problems met are water loss in the upper part of the wells and water inflow in their lower part, especially for holes, drilled underground. The main reason for that is rock fissuration, caused by blasting in underground mines. Drill wells cementing by using common procedure of "face flooding" is not very efficient because the procedure goes at low pressure (1- 2 MPa) and grout can't penetrate into the rock fissures. Well known equipment in literature for preparation and forcing the grout into the drill holes are complex, expensive, with big dimensions and are not good enough for underground usage. For these reasons, in the period 1984 - 1988 for GORUBSO - Madan mine enterprise a scientific team from the University of Mining and Geology "St. Ivan Rilsky", Department of Drilling and Petroleum Engineering (V. Arisanov, N. Tchervenakov et al., 1985, 1986, 1988) elaborated a set of contrivances and corresponding technology for preparation of grouts and cementing drill holes with small diameter (59 and 76 mm).

During the process of elaboration, the main requirements of GORUBSO - Madan and the character of drilling conditions underground had been taken into account:

- small drill well diameters (59 and 76 mm);
- diamond core drilling in medium hardness rock (IX- X category);
- need of simple and highly reliable in their usage constructions, easy for transportation in underground mine conditions.

The set of contrivances consisted of:

- turbine flow meter;
- drillable cone and cylindrical packers;
- device for final high pressure grouting;
- hydro jet mixer for grout slurries preparation;
- hydraulic dispersing device for grouts amelioration.

Turbine flow meter is used for water inflow or water loss measuring. It is of classic type in which a sensing element a propeller with agate bearings is used. Turbine rotation frequency is proportional to flow speed i. e. to the quantity of liquid flow in corresponding part of the well. At every turbine turn the sensor of flow meter sends trough the cable an impulse to the counter at the mouth of drill well. Data received is used for designing well run - out record and from it parts of the drill hole are defined where there is water inflow or water loss.

Basic element of created equipment set are packers. They assure the possibility to produce pressure on cement slurry grout and this improve its penetration into the rock fissures during cementation process run. Two packer constructions were elaborated - cone packer (V. Arisanov, N. Tchervenakov, 1985) and cylindrical packer (N. Tchervenakov, V. Arisanov, 1986).

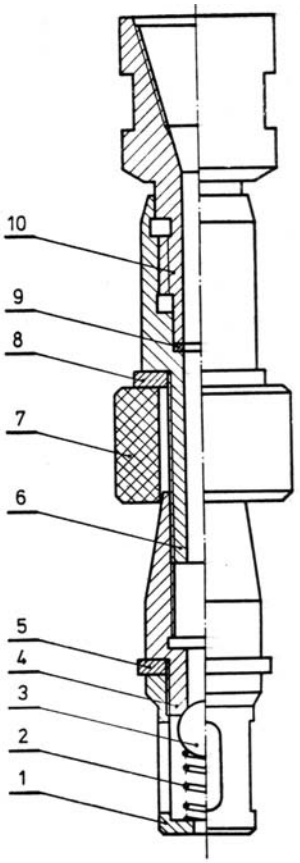

Figure 1. Cone packer

Cone packer is presented on fig 1. It is designated to insulate zone of grouting from upper drill well zones and by this way grout slurry can be forced at higher pressure. Packer consists of reverse valve pos. 1, 2, 3, cone body 4, stopping washer 5, screw- shaped spindle 6, elastic washer 7, pressing washer 8, washer 9 and combined safety adapter 10. Elastic washer 7 diameter is some bigger than hole diameter (60 mm for 59 mm hole diameter). Excluding washers 5 and 8 and upper adaptor 10, all other elements of the packer have smaller diameter than the well hole one and this permits to be taken out as a core from the well and by this way many times used.

Cone packer is turned on the lower part of the drill string and is lowered in the well without any rotation to the depth required. Because of the friction with hole walls, elastic washer 7 is in upper position. To put the packer into action, drill string must be slightly elevated and in the same time turned right. As a result of friction with well wall, washer 7 stays in rest and cone part of the body 4 penetrates into the hole of elastic washer 7, deforms it and press it with greater force to the well wall. Friction force between cone body 4 and elastic washer 7 tries to lift elastic washer 7, but friction force between elastic washer 7 and hole wall counteracts it and self wedging effect occurs. When cone angle is small enough, friction force between elastic washer and hole wall is always greater than the friction force between cone and elastic washer and washer rests immobilized to hole wall. When turning right screw spindle into the body 4 and by pressing washer 8 elastic washer 7 is deformed and tightened to hole wall. Stopping washer 5 prevents elastic washer 7 from dropping off. After putting the packer into action we force the slurry into the hole by a grout pump. When injection works are over, we take out drilling string out of the well and for the purpose we slowly turn it left and in the same time slightly lift it up. As a result of this manipulations safety adapter 10 is unscrewed from the screw spindle 6. We take out drilling string from the well together with adapter 10 of the packer and all other parts of the packer rest in the well until cement sets and hardens. All this prevents cement wash out and ensure high quality of grouting works. After cement setting and hardening we bring down drill string and drill again the grouted part of the hole with single core barrel. Because outer diameter of return valve pos. 1, 2, 3, body 4 and screw spindle 6 are smaller than diamond core bit inner diameter, we take them off from the well as a core and after cleaning them up we can use them again. Stopping washer 5, elastic washer 7 and washer 8, being made by easy to drill material are drilled by the diamond core bit.

In well known packer constructions the contact with hole wall and its wedging up is assured by using cone jaws. In as above described construction, this function is obtained by elastic element of the packer. For the purpose its outer diameter is greater than drill hole diameter and the effect of self wedging occur when cone stem gets into the elastic element. This makes packer construction very simple and in the same time avoiding cone jaws assures the possibility greater part of packer details to be worked out with enough small diameter just to use them as a drillable packer, i. e. to leave them into the well during cement of the grout slurry setting and hardening and after it to take them out of the hole as a core and use them again. Leaving the packer in the hole during the time of cement setting and hardening is very effective especially during grouting hole parts with great water inflows because this prevents grout wash out and its forcing out from the rock fissures. In the same time this construction possess some disadvantages and some of them are avoided in the next constructions. Its main disadvantage is: once placed, packer can't be moved up, turned or removed. Because of the small difference between hole diameter and the elastic sleeve, it can't be used in heavily broken rock and cavernous zones, where hole dimensions could be with great difference of hole diameter. In the same time we must say that isuch conditions during prospecting drilling in medium to hard rocks aren't too often.

The knowledge gained during experiments and application of cone packer was very useful with the start of cylindrical packer elaboration (fig. 2).

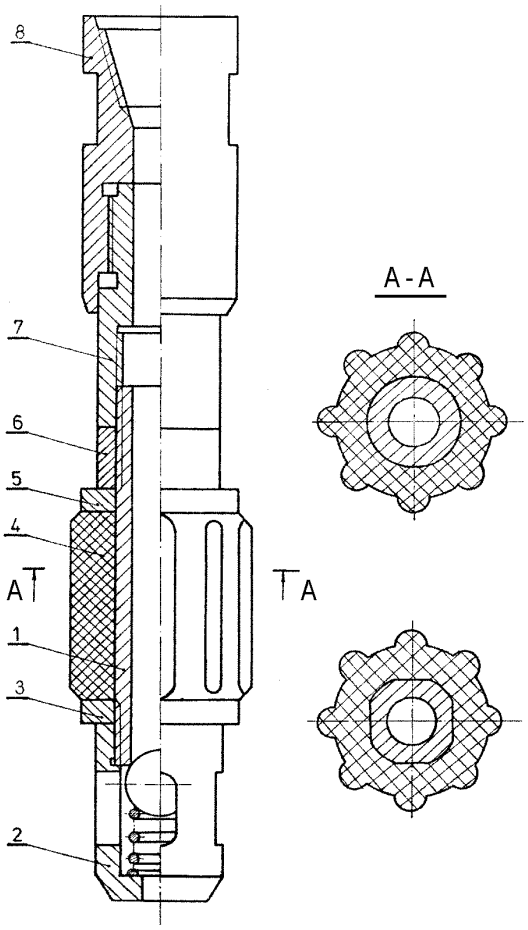

Figure 2. Cylindrical packer

Cylindrical packer consists of stem 1, reverse valve 2, lower washer 3, rubber pad 4, upper washer 5, sleeve 6, body 7 and upper adaptor 8. Rubber pad 4 has longitudinal ribs and their outer diameter is bigger than the hole well diameter, but rubber pad main diameter is smaller. The stem 1 and corresponding to it surface of rubber pad 4 could be with cylindrical or prismatic surfaces. Upper adapter 8 and body 7 are connected by easy dismountable flat double start thread.

Upper adaptor 8 is screwed to the lower part of drilling string and packer Is descended down to well hole without any rotation of drilling string. When it reaches bottom of the well, pump for drilling fluid is turned on, all the slime gathered there is washed out, then the packer is lifted and positioned upper of the well zone, where the water inflow is registered. Packer positioning follows this order: drill string must be turned right. As a result of friction between rock and rubber pad 4, the last one rests immobile and retains immobile the stem 1. The body 7 is screwed on the stem 1 and by washer 5 presses rubber pad 4, it deforms and closes the well. During the screwing the friction force in the thread between body 7 and stem 1 tries to turn right stem 1 and rubber pad 4, but the friction force between rubber pad 4 and well wall is bigger and the pad rests immobile. In this position we start grout forcing. After injection finishing, drill string is removed following the order: we slightly lift and turn left drilling string. Unscrewing occurs in the thread between adaptor 8 and body 7 because it is easy to unscrew (flat double start thread). We take out of the well hole drilling string together with upper adaptor 8. Packer rests in the hole during cement setting and hardening and after that we drill the cement bridge with single core barrel and diamond core bit. Excluding rubber pad 4 and aluminum washers 3 and 5, outer diameter of all other parts of the packer are smaller than the inner diameter of diamond core bit and we take them out of the well as a core. After cleaning we can use them again.

In comparison with cone packer, construction of cylindrical one is more simple. It has many advantages and one of them is the special shape of rubber pad. As designed longitudinal ribs are more elastic in comparison with cylindrical pad and this make possible packer to be used in well holes with bigger dimensions than standard ones. The presence of gap between main diameter of pad and drill hole diameter permits washing up the drill well before grouting and to be used in heavy water inflows. Big advantage of this packer is that its putting into action is only by turning right without any lift of drill string, so this assures the possibility to be taken out from the hole when necessary.

Technology applied for bringing in and out of drilling string from horizontal holes includes its turning. Just to use this cylindrical packer construction in horizontal holes for Sofia Geological enterprise, a special adapter was elaborated (fig. 3). It is screwed between drilling string and packer and permits bringing the packer into the hole with rotation of the string. Adaptor consists of upper adaptor 1, stem 2, upper connector 3, body 4, lower connector 5 and lower adaptor 6. At the upper part of the upper adaptor 1 a standard female cone thread is cut and connection with drilling string is made trough it. At the lower part of lower adaptor 6 a standard male cone thread is cut to connect the cylindrical packer. On the upper connector 3 and lower connector 5 a left hand cone thread is cut. Adaptor is screwed between cylindrical packer and drilling string and in initial position upper connector 3 and lower connector 5 are in unscrewed position. During bringing into the hole of drilling string and the packer, elastic element of packer rubs to hole wall and make some resistance to drilling string bringing into the hole. Because of this friction force the stem 2 and lower adaptor 5 are in low position. When drilling string rotate the face of lower connector 5 rubs to lower adaptor 6, but the force between them is not enough to put the packer into action. When required depth is reached, drilling string is slightly elevated and slowly turned right. As a result upper adaptor 1, stem 2 and lower connector 5 are elevated and lower connector 5 is screwing into the upper connector 3. Drilling string rotation passes trough upper adaptor 1, stem 2, lower connector 5, upper connector 4, body 4 and lower adaptor 6 to packer and puts it into action. After finishing grouting works we release drilling string from the packer by turning left and slight elevation of drilling string. Unscrewing happens at the thread between the upper adaptor and the body of cylindrical packer, because there the connection is of a flat double start thread and friction force there is very small. All other elements of the packer are brought out of the hole as a core after cement setting and hardening.

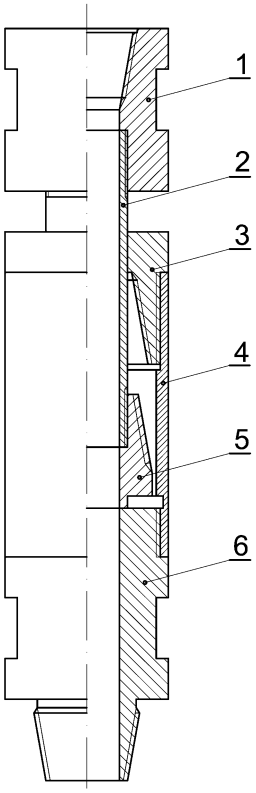

Figure 3. Adaptor for horizontal drill holes

Additional increase of pressure during grout forcing could be obtained by using the device, shown on fig. 4 (V. Arisanov, N. Tchervenakov, 1985). It is a piston pump, screwed on before the packer and consists of lower adaptor 1, plunger case 2, reverse valve 3, 4 and 5, piston 6 and 7, piston stem 8, end piece 9 and upper adaptor 10. For rotation transmission from drilling string to packer, the surfaces of upper adaptor 10, end piece 9 and body of the piston 6 are prepared as face connectors. The set of packer and device for additional grouting pressure is lowered to the predetermined level and packer is fixed as explained above. We are forcing the grout slurry by means of the mud pump and at the same time trough the spindle of drilling device we produce reciprocating motion of drilling string about 40- 50 cm to and fro. Movement up of

drilling string in the working chamber of cylinder 2 creates vacuum, which closes the packer valve, opens the valve 3, 4, 5 of additional grouting pressure device and cement slurry trough longitudinal hole of piston stem 8 enters into the working chamber of cylinder 2. Drilling string motion down creates pressure in the working chamber 2, which closes valve pos. 3, 4, 5 of the device for additional grouting pressure, opens the packer valve and piston 7 under high pressure forces grouting slurry into the drill hole. Advantages of the construction is its simplicity, high pressure and possibility for smooth regulation of pressure and flow by axial pressure and speed of drilling string movement.

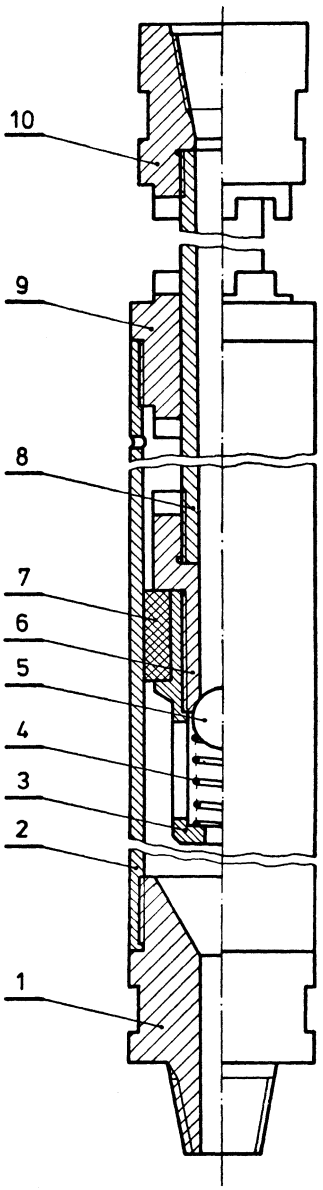

Figure 4. Device for additional grouting pressure

For cement grouting slurry preparation in field conditions propeller type clay mixing machines are used. Their big dimensions make them not worthy for underground conditions. That why for the purpose a hydro jet type mixer was created, presented on fig. 5. (V. Arisanov, N. Tchervenakov and all, 1989). Trough the hose 1 mixer is connected to washing pump, which pumps 80- 120 dm^3/min water into the mixer. Water gets out from the nozzle 4 with a very high speed and as a result makes vacuum 0.8 - 0.9 MPa in the working chamber of the body 6. Under the vacuum action in the working chamber trough the entering pipe connection hose and suction moth, connected to it (they can't be seen on the drawing) cement is sucked from the cement bag. In the working chamber it mixes with getting into water. So obtained cement slurry trough diffuser 8 enters into slurry reservoir. Device functions using energy from forced by slurry pump liquid. By this way outer dimensions of the device are much smaller than common clay mixers ones. High speed of the current in working chamber assures very good dispersing and mixing of cement slurry.

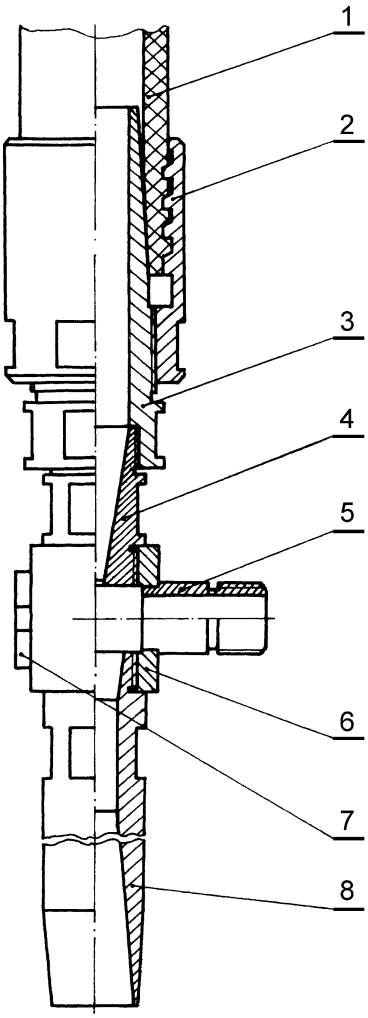

Figure 5. Hydro jet mixer

For improving of cement slurry parameters a hydraulic disperser, presented on fig 6 is used (N. Tchervenakov, V. Arisanov 1989). In the cone stem 4 mutually crossing each other helical channels are cut. Their cross section in the outset is bigger and diminishes to their end. The smallest cross section is at the point of crossing. Stem 4 is in the body 5 and to it is connected entering pipe connector. To pipe connector 3 by the nut 2 is connected hose 1. Cement slurry, forced by mud pump trough hose 1 enters with high speed into the entering pipe connector 3, where it parts to two currents and enters helical channels of cone stem 4. At crossing points the two currents collide each other at high speed and this finely

disperse cement particles and improves its rheologic properties. Because of the stem cone shape at its end cross section of channels diminishes, current speed grows up and this leads to fine dispersion.

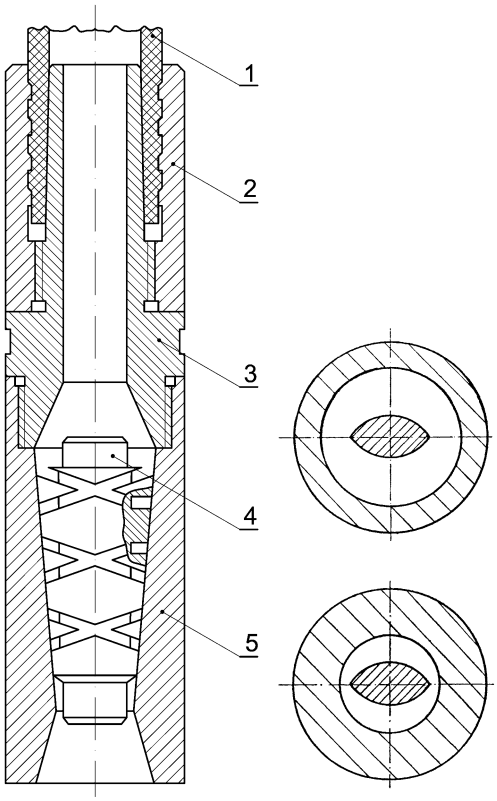

Figure 6. Hydraulic disperser

So described device for additional grouting pressure, hydro jet type mixer and hydraulic disperser replace a very expensive and with much bigger outer dimensions set of devices of Heny enterprise for preparation and forcing under high pressure cement grouting slurry. Together with packers and flow meter they cover all technological cycle of operations for liquidation of high water inflows or losses. Its simple construction, reliable work and small outer dimensions make them very suitable for underground operations.

REFERENCES

Аризанов, В., Червенаков, Н. 1985. Тампонажно устройство. Авт. свидетелство №39591/22.03.1985 кл. Е 21 В 33/13.

Аризанов, В., Червенаков, Н. 1985. Тампонажно устройство за геологопроучвателни сондажи. – *Научнопрактическа конференция по техника и технология на сондирането, 30- 31 май, Асеновград.*

Аризанов, В., Червенаков Н. Цанев В. 1986 Тампониране под високо налягане на геологопроучвателни сондажи. – *Годишник на Минно-геоложкия университет, XXXII,* св. IV, 185-193.

Аризанов, В., Червенаков, Н., Цанев, В., Златанов, В. 1988. Комплекс технически средства и технология за борба с усложненията при диамантеното сондиране в ГОРУБСО. – *Годишник на Минно-геоложкия университет, XXXIV,* св. III, 147- 152.

Аризанов, В., Червенаков, Н., Златанов, В. 1989. Хидроежекторен миксер. – *Конференция по проблемите на проучвателното сондиране, 6-7 юни, Асеновград.*

Червенаков, Н., Аризанов, В. 1986. Сондируем пакер. Авт. свидетелство № 43280/ 29.05.1986 кл. Е 21 В 33/13

Червенаков, Н., Аризанов, В. 1988. Смесител за течности. Авт. свидетелство № 46438/ 29.09.1988 кл. В 01F 3/8.

Recommended for publication by Department 0f , Faculty of Geology