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TECHNIQUE OF FLOWMETERING INVESTIGATIONS AT INTERVALS IN GROUT HOLES

O. Ju. Lushnikova, C Sc Min. Eng.
STG Specialized Association
7a Petrovski St., Antratsit
Voroshilovgrad Region, USSR

ABSTRACT

The paper presents a technique of flowmetering tests at intervals that has been developed at STG association with regard to various geological conditions of grouting in water bearing strata. This technique enables, for the first time in grouting experience, testing at intervals each aquifer separately irrespective of strata pressure and rock permeability, and without casing the boreholes up to a depth of 2000 m.

INTRODUCTION

At present in the field of hydrodynamic investigations there is no equipment that provides obtaining an interval-spaced flowmetering chart without borehole casing to detect liquid discharge (loss) within the strata thickness, and for accurate determination of the filtration parameters and rock fissuring.

It is notorious that the drill stem models available enable only the average evaluation of aquifer filtration properties and can not define either aquifer filtration inhomogeneity or spacing and size of fissures, and what is more, the water yeild from each fissure.

Potentialities of flowmetering technique enable testing the aquifer in a detailed and comprehensive manner. However, while employing a flometer without a packer, and when the borehole is disturbed by pumping-out or pumping-in, one can not reveal and study at intervals each layer separately.

The numerous attempts to combine a packer with a flometer in order to eliminate the disadvantages of both methods were unsuccessful since they were based on a rigid design arrangement of the packer with the flowmeter. The shortcomings of such an approach are obvious. First, during each packer anchoring one can measure the discharge of liquid only at one point of the seam. And for testing a 1000-m deep hole, suppose, at least at 10 m intervals, it is necessary to anchor and remove the packer 100 times. It is obvious that using this pattern one can not obtain detailed information on the seam, to attain it one should have a continuous record of liquid discharge alterations within the whole strata thickness. Second, having a rigid design arrangement of the flowmeter with the packer, one has to carry out each measurement at various degrees of the seam opening. Besides, using this method, it seems impossible to measure accurately the water make from each zone because it will require to wait for a stable filtration regime for a long time during each packer anchoring. And the last thing, in an open borehole it is impossible to anchor the packer at any desirable point, and what is more, at every 0.1÷0.2 m that is needed for a detailed seam testing.

It is evident that to eliminate the above mentioned shortcomings of available instruments, one has to develop such a design which will enable anchoring the packer in the roof of a tested zone, and the flowmeter should travel in a down-packer space. With all this, the instrument must have small dimensions, and its diameter must be close to a borehole diameter to provide an accurate flowmetering record for the liquid discharge.

INSTRUMENT DESIGN

The design of the developed STG-3P instrument for flowmetering at intervals is illustrated in Fig.1. It consists of three main units: a packer 3, a flowmeter 6 and a connector 4. Prior to the commencement of investigations the flowmeter is fastened with the packer by means of a special connector. In such an assembly the device is run down the hole on a string of drill pipes up to the roof of a tested zone 8. The borehole is sealed by compressing the rubber element of the packer while pulling the string upwards. Then the cable 1 is run down the pipes, it has a special cap piece 5 to contact the flowmeter. On getting the contact with the cable, the flowmeter disconnects with the packer and can move in any directions in the down-packer space. Investigations can be carried out both during overflow from the hole and during pumping-in and pumping-out. Monitoring the rotation velocity of the impeller 7 is performed via a surface transducer. On the completion of investigations the flowmeter is run upwards up to the moment when it contacts the connector. The cable is automatically disconnected with the instrument. First, the cable is raised, and then the packer with the connector and flowmeter are removed from the hole.

The instrument has several modifications for borehole testing in the range of 0.059 to 0.25 m. Specifications of the flowmeter are enlisted in Table 1.

TECHNIQUE OF INVESTIGATIONS

Depending on the character of strata disturbance the process schemes are as follows:

a. during water outflow;
b. by pouring-out water through an open borehole collar;
c. by pumping-in water at a sealed borehole collar;
d. by pumping-out by means of airlift;
e. by pumping-out by means of a submersible pump.

All these schemes are important during tests in grout holes

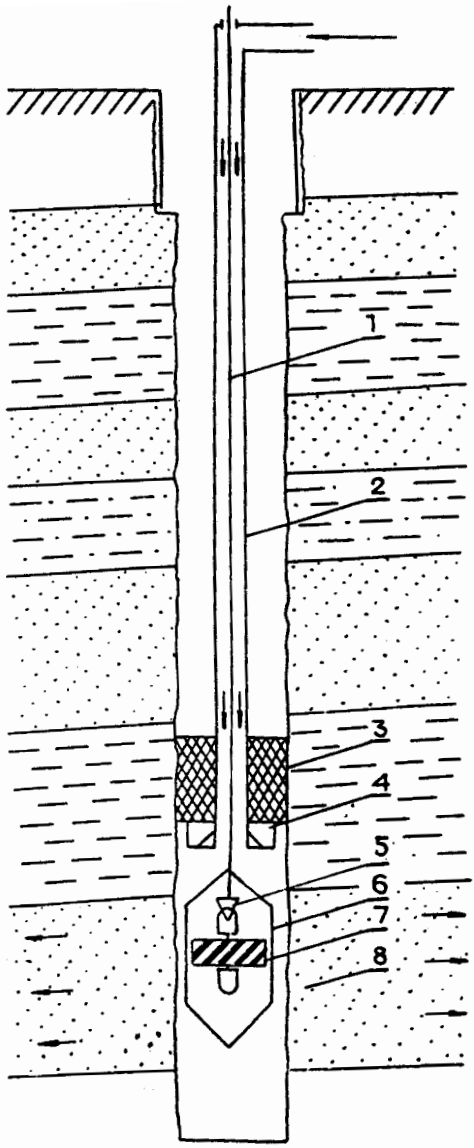

Figure 1 Process scheme for flowmetering at intervals

1 - cable; 2 - drill pipes; 3 - packer; 4 - connector; 5 - cap piece; 6 - flowmeter; 7 - impeller; 8 - tested water bearing strata.

Table 1 Specifications of STG-3P flowmeters for testing boreholes at intervals

Parameters	Unit	Models							
		STG-3P--57	STG-3P--73	STG-3P--89	STG-3P--108	STG-3P--127	STG-3P--146	STG-3P--168	STG-3P--194
Measurable flow range	10^{-3} m^3/s	0.001-20.0	0.01-20.0	0.01-20.0	0.01-20.0	0.01-20.0	0.01-20.0	0.01-20.0	0.01-20.0
Measuring accuracy	%	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Borehole depth	m	1000	1500	1500	1500	2000	2000	2000	2000
Allowable mineralization	kg/m^3	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Tested liquid		water, clay slurry, oil, mineralized water, brines							
Hole diameter range		59+80	76+100	93+120	112+140	132+160	152+185	172+200	200+250
Maximum hydrostatic pressure	MPa	20	20	20	20	20	20	25	25
Instrument diameter	m	0.057	0.073	0.089	0.108	0.127	0.146	0.168	0.194
Battery voltage	v	12	12	12	12	12	12	12	12

drilled to shut off water inflows into the mine workings. Irrespective of the process scheme the flowmetering is carried out at not less than 3 stationary regimes of borehole disturbance. It is necessitated by the need to obtain indicatory relationships of the flow of liquid versus pressure differential for each fissure. On the basis of these relationships the size of fissures is determined, and it will contribute to more complete detection of all water-permeable intervals. On the completion of flowmetering tests at each stationary regime of pumping-in or pumping-out, the process of strata pressure recovery is monitored keeping the packer and flowmeter down the hole. It is executed by the use of pressure gauges and electric levelmeters.

SCHEME 'A'

This process scheme is used when the static level in an aquifer exceeds the level of a borehole collar. As a rule, it occurs during drilling from the shaft bottom or other underground excavations. The borehole collar is equipped with a preventer to carry out tests.

SCHEME 'B'

This process scheme is used to study relatively high-permeable aquifers with intensive fissuring and the strata pressure below a borehole collar.

SCHEME 'C'

When the pressure diferential formed by increasing the water level in a borehole is insufficient to detect aquiferous zones, pumping-in is carried out at a sealed borehole collar. The borehole collar is equipped with a special sealing device.

SCHEME 'D','E'

These process schemes are used, as a rule, during tests in proving boreholes. For carrying out investigations the string has an increased diameter in the upper part to enable lowering the airlift or submersible pump. The length of the upper

piping depends on the designed water level lowering. The piping accomodating the packer serves for water transportation.

SUMMARY

The developed STG-3P flowmeter device makes it posiible:

- to test each aquifer at intervals both during pumping-out and pumping-in at stationary and unstationary filtration regimes;
- to eliminate large diameter drilling and casing with multi-stage columns since no casing is needed for testing at intervals;
- to reveal and test all aquifers irrespective of their permeability, strata pressure and bedding depth;
- to determine at intervals all filtration parameters and strata fissuring characteristics: permeability coefficient, static level, location and number of fissures, karstic zones, their size and water inflow from them.

Thus, the developed STG-3P instruments solve technical problems of borehole testing at intervals, and contribute to the development of a new stage in the flowmetering technique.