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INTERFERENCE TESTS BY APPLYING PULSATION FOR DETERMINING THE HYDRAULIC PARAMETERS OF AQUIFERS ENDANGERING THE MINE SITES

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ABSTRACT

A hydrodynamical testing method based on pressure change measurement of high sensitivity is described. The authors present the application realised on a mine site of karst water danger; the scheme of the measuring method, it is development with noise filtration and the simulation model used for developing the measurements in heterogenous continuum. The applicability and the economical advantages are shown on the basis of experimental results.

1. Hydrodynamical tests by applying pulsation and pressure-change measurement of high sensitivity

The principle of the test is that pressure change is induced in an aquifer by means of production or injection of a well constructed properly. The pressure change is recorded by head-meters installed into one or more observation wells located at different points of the field. The flow and non-flow state of the pulsated well are changed periodically. The periodicity increases the rehability of the evolution. The specific trans-missibility and storage coefficient can be determined with accuracy depending on the density of the point measured and on the amount of other information. The accuracy of technique applied in Hungary is 0.1 mm water column. The static water level referring to the well head may range from minus 1oo meters up to 2oo bar over pressure. Interference tests by applying puls-ation of higher sensitivity require shorter inducing period and measuring time besides a lower stimulator capacity. The checking time of the measurement is proportional to the velocity of trans-mission. The shorter checking time provide information referring to smoller area.

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A measuring technique of high sensitivity is applied regularly for:

- determining the cave-volume
- determining the volume of aquifer with limited rechage
- measuring of the porosity by means of lunisolar effect registration
- detecting the water level changes in deep wells
- similar measurements in gas and oil fields.

2. The evaluation of the interference test based on pulastion by using the method of noise filtration with periodical summing up

Nowadays it has been proved that the interference test by applying pulsation including hydrodynamical test extends the list of useful methods and the information referring to underground reservoirs. The head meters of high sensitivity, however, detect numerous /natural and artifical/ noise components superimposed on the signals to be measured. The method presented below briefly was developed for the interpretation of higher reliability.

During the measuring process the pressure of a specified point of the field is induced and the pressure changing versus time is monitored at different points of the field. Since the parameters of the equations are in the explicite and implicit terms, therefore the solution must be a numerical mathematical method. The set of induction at a fixed point of the field, the set of pressure-changes at another point and the transmission equation are given. The task is to determine the constants /field parameters/ of the terms of the equation, but to take into consideration that the registered data are disturbed by noise of unknown quantity and intensity. Separation of the noise is realised by summing up the time-dependent signal of changes in several induction periods. In this case the signal-noise ratio increases by square root of the summed-up number of periods. The procedure is developed for analysing the early time transients and consequently the invariance of the time is also taken into account. The applied method is the curve-fitting approach with personal computer. Because of the fast convergence of the procedure manual calculation is possible in case of more simple transmissing equation and pulse-signal set. The interpreatation is very simple and fast in case of integral-exponential function given for unit the step of the put signal and square-low signal set of the stimulator function. In this case the evaluation can be carried out by using a table set precalculated. The presented one was developed for homogeneous field basicly. However, the method can be enlarged for different versions with exchange of the transmission equation.

About half of the measurements carried out in Hungary between 1976-1983 could be evaluated without the method of noise filtration. Seven percent of the measurements gave no new informat-

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ion with the method presented. Though the useful signal is 0.43 mm only and at the same time the background noise is 100 mm w.c. in order of magnitude, the procedure presented can provide an accurate evaluation of the useful signal.

3. Analogous simulation model of hydrodynamical tests for personal computers

The origine of the most part of the used hydrodynamical evaluating method is the analytical solution of the flow differential equation. Its field of application is limited by a lot of supposition. The inhomogenity causes difficulties when calculating rock parameters in case of smaller volume mainly in fissured karstic reservoirs.

There is a possibility for estimation by using location and measuring process variants fittire to the character of the reservoir and by selecting of the proper interpretation. But there is some chance of miscalculation.

The application of a model which can control the approximations of morphology and other heterogenity is highly necessary to increase the reliability and accuracy of the interpretation. This kind of special purpose program can be handled either in high number of variations or by using human intervening repeteadly. In both cases the running times are considerable even on computers of high capacity. This program is to be handled by an expert of hydrodynamics using personal computers with advantage.

The principle of the model construction was to apply less mathematical abstraction, with the aim at allowing the users to define a comprehensive physical scheme. The built in functions are mass transport equations at present, but the turbulent and heat flow and diffusion equations can be added easily.

The physical field is transformed with square-shaped nodes, the center of which represents the storage capacity and the inhomogeneous hydraulic transmissibility is represented on the interfaces perpendicularly. Besides these three parameters the potential of each nodal point is stored in the computer memory.

The basic logic of calculation is, that the five nodal points connected with each-other tend to eliminate their different initial pressure. The change of the potential within a time step is calculated for each nodal point repeatedly.

The size of nodes is arbitrary, but the increase in the number of elements effects the running time exponentially, because the time step must be reduced proportionally.

The initial potential values are set by code as input data for each node. However, there is a possibility to load an optional potential field and stored in the memory at each start of the program.

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Different boundary conditions are produced with different sub-routins. For example, the node with infinitive volume can be produce with resetting the initial pressure at the boundaries of a fairly large area being modelled in each time cycle. The system requires no special manipulations for reservoirs of closed boundaries.

The model was verified with simulation of simple homogeneous flow systems published in the literature. At least four nodal points were needed for simulation between the simulated and observed points to reach the accuracy, which matches the results obtained by field tests.

4. Results of tests carried out in the Ajka-II coal field

The common interpretation of the interference tests by applying pulsation known from references are valid merely for homogeneous rocks, and for cases with simple inhomogeneity.

This approximation can not be allowed for the Ajka-II region generally. The tectonic map shows, that the significant sizes of the tectonic blocks can sometimes be larger than the distances applied between wells investigated in the course of the test. This statement can be proved by results of the simplified evaluation, while the deviation rate of the calculated parameters is over 1:10. Extremely high pressure change velocity was detected between two wells, where no fault was signed on the tectonic maps. This calculated value can be supposed only for channels with high transmissibility.

For the mentioned reasons a new interpretation of the meassured data was carried out. The registered curves of pressure change was analised with functions suitable for different flow systems /radial, linear, double radial/. In spite of the high noise-disturbances of the measurements the analysis could be realized by means of the noise filtration method of summing up periodically. This method reflects the characters of the measured curves. On the basis of the investigations the measurements and evaluation method suitable for determining the hydrodynamic parameters of the separated regions were selected. The flow systems applied for interpretation are as follows: linear flow, homogeneous field drained with horizontal line source, radial flow in homogeneous field. In order to determine the storage parameters care was taken of between the time section of the measurement and the applied method.

As a result, the transmissibility of the tectonic lines, the hydraulic conductivity and the storage parameters of the compact tectonic blocks and the equivalent parameters of the widespread units of limestone reservoir could be determined and verified.

The reliability of the parameters obtained must be checked. It is only rough approximation that the early time period of detected curves gives information only for a closer area.

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The suitable method, however, was selected on the basis of qualitative information. The analogous simulation flow model developed for personal computer is used for checking and correcting if necessary.
The model construction was as follows:

- On the area undisturbed by tectonic lines: parameters specified for this formations were adapted /average value/

- The conductivity terms of the tectonic zones were modelled as follows:
parallel with the tectonic lines the real conductivity was applied;
perpendicular to it the average one.
The average storage parameters were connected with estimation of the volume ratio of the tectonic zones.
The data had to be recalculated by using the model-laws, because of the scale errors between the nodal volume and the natural scale of the tectonic lines.

- For the model construction the boundary effect has no influence on the inner, modelled phenomena. Closed boundary conditions are considered. The applied noise filtration method is not sensitiv to the monotonous changes and effects of different period.

The real conditions which had characterised the measurements were simulated and the potential change were detected on the observation wells.

Since the measurements are influenced by disturbances and the modelling has its own special errors, the measured and modelled results were not compared directly. The modelled results were compared with the apparent parameters which could be calculated by using simple, routine interpretation of noise filtration.

Having performed the necessary modifications, one can state that the parameters of the constructed tectonical model meet the natural conditions even in details, and the natural phenomena will take place similarly to the modelled ones.

The distances between the induced and observation wells ranged from 390 to 1790 meters. Water volume of 2200 cubic meters was pulsated with a maximal yield of 1200 h/min. The test lasted 5 days. An amplitude of 100 mm-s should have been produced at the measuring points to get data comparable to the traditional well-tests. This value could be reached by multiplying
- the water yield by 13 or
- the investigation time by 8.

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