ABSTRACT

The doctoral thesis on the subject of “Research and development of coalbed methane extraction by feasible and technical means of selective hydraulic fracturing and horizontal hydrojet drilling” deals with the study of relevant objectives in the field of coalbed methane development and its commercial production in Kazakhstan. The paper consists of an introduction, five chapters, conclusion and references. As a target of research and a testing site Churubay-Nura region of Karaganda coal basin has been chosen.

The rationale of the research is to create conditions for the energy security of the Central and the Northern region, legislative support of methane recovery (Action Plan on arranging the exploration and coalbed methane production (Roadmap) of Ministry of Energy), during the course of geological prospecting and industrial experiment works on unconventional gas (coalbed methane) within the framework of the Geological Exploration Program in the Republic of Kazakhstan for 2015-2019 years and significant coalbed methane reserves (from 2 to 4 trillion cubic meters).

An effective method of forming the optimal system design, as well as increasing productivity in technologies development of methane recovery from coal seams are the application of methods of preferential hydrofracturing of solid and tough deposits and opening the productive strata in friable and semiconsolidated coal intervals by horizontal and horizontally-branched well bores in order to extend the filtration area.

The solution of these tasks requires a complex execution of works varying in methodological nature and structure. These include theoretical studies, experimental studies in the laboratory and at production site.

The paper examines complex of theoretical, experimental and methodological problems related to the development and introduction of the proposed theoretical and technological methodologies preferential hydraulic fracturing and horizontal-radial drilling into the production.

The aim of the thesis is a theoretical and experimental justification of gas extraction technology from seams based on the development of the application of the latest technical and technological means of interval hydraulic fracturing and radial hydrojet drilling for methane recovery.

The main objectives of the study are:

1. to analyze and determine the applicable scope of two study methods combination in order to enhance gas recovery;
2. to substantiate the theoretical principles of new modern technologies combining two methods in order to enhance gas recovery and determine the benefits for their effective use.
3. to conduct a pilot study under production conditions and on the basis of findings to make the presumable method of effective development of coalbed methane.
4. to assess the economical efficiency of theoretical studies and methods application in the proposed work.

Methods for the solution of objectives – to solve the assigned objectives a complex method of research has been adopted, including the compilation and analysis of the literature, the application to unconventional technical solutions while using standard equipment, digital methods of theoretical solutions, mathematical statistics and logic, value engineering, field observations and tests.

Scientific statements and results for the defense:

1. Increased coalbed methane permeability and intensification of methane recovery is achieved by means of integrated solutions and selection method of hydrofracturing in solid intervals and radial drilling of horizontal borehole in soft coal rocks.
2. The development of a mechanism of integrated solutions combining two study methods for gas recovery enhancement provides volume of methane removal to 9,2-14.1 m^3/t. and the well production rate up to 20-25 thousands m^3/ day.
3. Scientifically proven methodological recommendations on the selection of main technological solutions for the stratal degassing of high coal-bearing coal seams are based on the following key factors: predictive speed of coal seams gas recovery estimated at the stage of trial runs for determining the main feature and coal-gas bearing solid state (the value of stratal pressure, gas content, permeability and diffusion coefficients of coal, its sorption characteristics), float time for degassing, the value of the "gas barrier", as well as the results of field testing of certain technological solutions or trial injections.

The first chapter focuses on the survey of world experience in geotechnical coalbed methane production methods and methods of coal-bed degassing. The second chapter deals with Theoretical studies to develop and create hydro-impact on coal seam in the alternating force mode; geomechanical study of the decompression process and the disintegration of the coal seam. The third chapter is dedicated to the intensification of geotechnological process on methane recovery from underground headers through the borehole surface with determination of the critical parameters of the research object and the research on gas and hydrodynamic conditions and microstructural occurrence in seams of Karaganda and Dolin suites. The fourth chapter represents the procedure and findings of industrial tests under the investigation technologies of Karaganda and Dolin suites. The fifth chapter considers technical and economic efficiency of investigated technology of industrial production of coalbed methane.

Substantiation and reliability of scientific statements, summaries and recommendations are confirmed by:

- representative volume of borehole investigations;
- findings of field tests of the main technological solutions in the execution of work on the development of the interval hydraulic fracturing and horizontal (radial) hydrojet drilling technology for wells Karaganda and Dolin suites;
- successful results of industrial testing of the developed technological schemes on intensification of coalbed methane production rate.

Statements and conclusions of the study for the defense, as follows:

1. Extraction of methane in wells intensifies degassing of exploited coal seam that leads to an increase in mine safety with a high load on the working face.
2. Mining and geological conditions of the development of the coal seam solid and tough rocks of Karaganda suite have been determined on the basis of theoretical study of the coal seam gas permeability, coal volume deformation during adsorption or desorption of coal in the range of reservoir pressures of methane, coalbed methane mass transfer mechanisms.
3. Interval hydraulic fracturing has provided the conditions for non-aqueous extraction of methane by blocking underground fluid entering the well by the gas pressure in coal deposits,exceeding the value of the hydrostatic pressure of water in the surrounding rocks.
4. Parameters of interval hydraulic fracturing have been identified on the basis of the calculations which resulted the removal of methane reached at 9,2-14.1 m^3/t. In large-scale application of the method methane flow rate can reach up to 20-25 thousand m^3/day in the well with the additional equipment of high-performance pumping stations and durable binding wells.
5. Conducted calculation of strain and stress of Dolin suite soft rocks enabled to determine the most effective method of coalbed methane - radial hyfrojet drilling by using surface-active agents with a concentration of up to 0.1%.
6. Economical efficiency of commercial coalbed methane production shall be defined by a set of cost reduction on emissions, the use of methane as a fuel and raw material for the petrochemical industry, as an independent commercial product (in the future).

The findings of the study are recommended for the implementation in industrial production of coalbed methane in the Karaganda coal basin by the main operator Baker and Hughes International.