Ph. D. Thesis

Self-organisation in an underground storage of hydrogen

Abstract :

The thesis objective is to perform the hydrodynamic analysis of the processes observed during the underground storage of Hydrogen in the form of mixtures with other gases, especially with CO2, in an aquifer. Hydrogen is considered as the renewable energy, the underground storage is estimated as the best method of storing large volumes of gas. The behaviour of such mixtures in presence of some additional species produces intensive chemical reactions catalyzed by reservoir methanogenic bacteria. Being superposed with a high diffusivity of H2, they form a natural underground reactor functioning in a nonlinear oscillating regime. The oscillations lead to a fluctuating dynamic structure with creation of large-scale zones of hydrogen alternated with the zones sursaturated by methane. The forecast of the dynamics of these zones and their chemical composition has an industrial importance.

The mathematical part of the thesis will consist in developing an appropriate kinetic model of chemical activity and kinetics model of the population dynamics. The preliminary results show that the simplest model of the process reduces to the Turing oscillator known in the theory of dynamic systems. The qualitative analysis of the process, the bifurcation analysis and detection of various scenarios of evolution, the 3D-reservoir simulation based on the developed model will be also the objective of the thesis. A short experimental part devoted to bacterium kinetics will be performed under the guidance of the Laboratory of microbiology.

The last part of the thesis will be devoted to the applications of the developed theory to the following engineering problems: simulating a field case, evaluating the mixing between H2 and CO2, evaluating the geometry and dynamics of the dynamic zones, optimisation of gas recovery and injection.

Profile of candidates:

Differential Equations. Dynamic systems, Numerical methods and programming.

Thesis direction:

Michel Panfilov, professor, INPL Nancy

Start:

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Laboratory:

LEMTA

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