DEVELOPMENT OF A SIMULATION-OPTIMIZATION MODEL FOR THE METHANE EXTRACTION FROM THE SUBSURFACE

- APPLICATION TO AN ABANDONED COAL MINING SITE IN THE RUHR, GERMANY -

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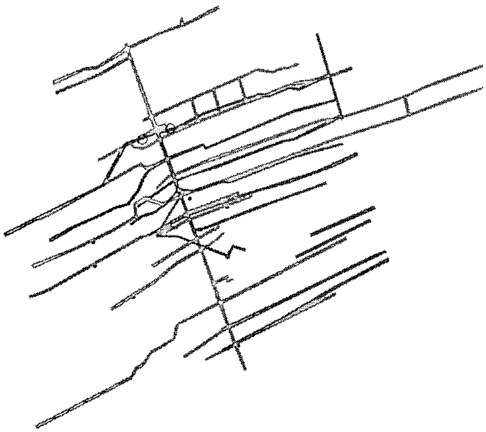
Author carried out a joint research with a German coal mining company, Deutsch Montane Technology (DMT) GmbH, intended to develop a specifically tailored simulation-optimization model to control the migration of the methane continuously desorbed from coal seams in an abandoned coal mining site, the Ruhr, Germany (see Figure 1). The primary purpose of the overall research work is to know how to install the so-called passive extraction wells over the site (see Figure 2). For this purpose, an optimization model, Simulated Annealing (SA), is coupled with a multiphase flow simulator MUFTE-UG (MUltiphase Flow, Transport and Energy - Unstructured Grid) (henceforth, MUFTE-SA). A two-phase (gas,water)/ three-component (air, methane and water) model, additionally embedded in the simulator, is selected for the simulations of the methane-migration. MUFTE-SA is then applied to examine how to locate the passive extraction wells to the places where a maximal methane extraction is obtained. Applying the simulation-optimization techniques with a multiphase model is yet very limited especially concerning the real world problems as the handling of the multiphase model especially in the real world simulation is very difficult and often expensive in terms of the computational time. Thus, some new attempts are made in due course. For instance, the total time requirement is equal to the computational time of each simulation multiplied by the number of iterations required by the optimization algorithm. This total time was expected to be enormous as the computational time for each real-world simulation is huge, nevertheless the SA requires generally hundreds, thousands of iterations as its nature. Thus, a parallelization design of the optimization procedure is proposed (see Figure 3). This attempt succeeded in reducing the total computational time, almost linearly to the number of processors of a parallel computer. This contribution briefly outlines the progress of the joint research and demonstrates in the end the general rule for the installation as well as the specific answers for this application (see Figure 4). The insights obtained in this contribution are expected to be linked to the guiding principle for the coal-mining operation.

REFERENCES

Kobayashi, K., Hinkelmann, P. and Helmig, R (2003): Comparison of Different Model Concepts for Gas-Water Processes in the Subsurface, In XXX IAHR Congress 24-29 AUGUST 2003 (CD-ROM), Thessaloniki, Greece.

Kobayashi, K (2004): Optimization Methods for Multiphase Systems in the Subsurface – Application to Methane Migration in Coal Mining Areas– Ph.D. dissertation, Institute fuer Wasserbau, Universitaet Stuttgart, Germany.



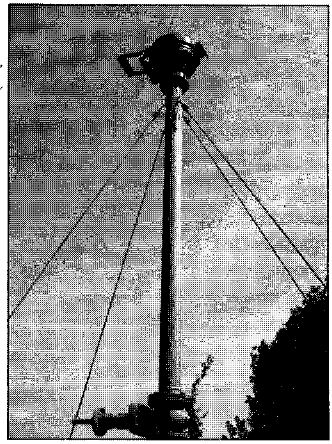


Fig. 1. A plan view of the coal mining site, in the Ruhr, Germany. The dots indicate where the passive extraction wells are installed. The roadways of the former coal working at a depth of 40 m are represented with the darker gray color in the plan, while the lighter gray color represents the coal working at a depth of 60 m (left).

Fig. 2 A passive extraction well at the site (right).

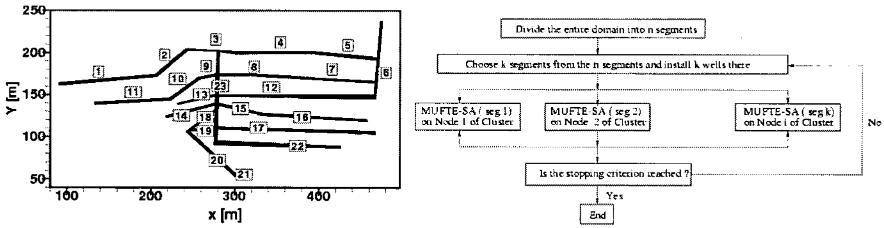


Fig. 3 Parallelization strategy by means of a domain decomposition. Decomposed domain (left) and the chart of the parallelization procedure (right).

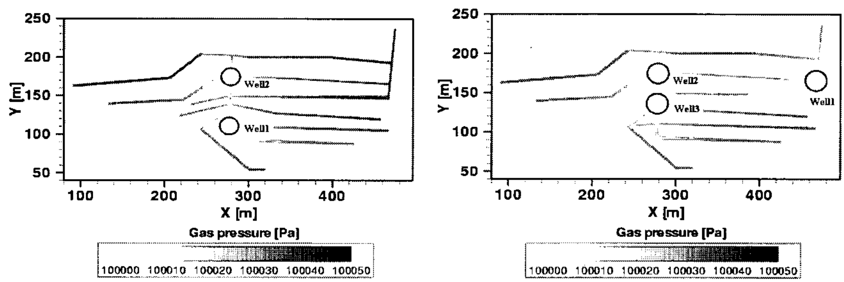


Fig. 4 The pressure field when the best extraction is observed. The circles in the figure show where the passive extraction wells are installed (left: two-well case, right: three-well case).