

on the capital investments in the system. With the decrease in oil prices on the markets, the operating costs and the rentability of oil and gas fields comes to focus. By optimizing the formation water injection prices, the gains regarding the exploitation fields can be increased, even with lesser prices regarding the production of a 1 m<sup>3</sup> of the equivalent of oil. This means that the field becomes more rentable and its lifespan is directly extended. According to the remaining hydrocarbon reserves mentioned in chapter 3, with the rationalization and optimization of the injection system, larger quantities of oil can economically be gained, which consequently increases the ultimate recovery of mature fields.

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## 8. References

- Arnold, K.E. (1987): Surface Facilities for Waterflooding and Saltwater Disposal. Bradley, H. B. (ed.): Petroleum engineering handbook, Richardson, 34 p.
- Bendeković, J., Bendeković, D., Brozović, T., Jančin, T. & Lasić, V. (2007): Priprema i ocjena investicijskih projekata (Preparation and evaluation of investment projects), FOIP 1974. d.o.o., (in Croatian), 442 p. Dunn-Norman, S. & May, E.A. (1997): An Overview of Injection Design, SPE Production Operations Symposium, 1997. March 9-11, Oklahoma City.
- Fakhru'l-Razi, A., Alireza, P., Luqman Chuah, A., Dayang Radiah, A.B., Sayed Siavash, M., Zurina Zainal, A. (2009): Review of technologies for oil and gas produced water treatment, Journal of Hazardous Materials 170, 530-551, Elsevier.
- Gas Processors Suppliers Association (2004): Engineering data book, GPSA, 822 p.
- Igunnu, E.T. & Chen G.Z. (2012): Produced water treatment technologies, International Journal of Low-Carbon Technologies, 1-21. Ivšinić, J. & Dekanić, I. (2015): The Basic of Model for Marginal Testing Of Costs for Disposal of Extracted Formation Water, The Mining-Geology-Petroleum Engineering Bulletin, 85-100.
- Newman, K., Woolsey, G., McCosh, K., Hand, E & Boodhai, M. (2009): Multistage Centrifugal Pumps for Drilling and Production Waste Injection Operations, SPE Asia Pacific Health Safety, Security, and Environment Conference and Exhibition, 2009. August 4-6, Jakarta.
- Ochi, J. & Hofsaess, T. (2015): Role of Well Completion in PWRI design, SPE European Formation Damage Conference and Exhibition, 2015. June 3-5, Budapest.
- Palsson, B., Davies, D. R., Todd, A.C. & Somerville, J.M. (2003): Water Injection Optimized with Statistical Methods, SPE Annual Technical Conference and Exhibition, 2003. October 5-8, Denver.
- Patton, C.C. (1990): Injection-Water Quality, The Journal of Petroleum Technology, 1238-1240.
- Pedenaud, P. (2006): TOTAL Experience To Reduce Discharge of Hydrocarbons Through Produced Water, SPE International Conference of Health Safety, and Environment in Oil and Gas Exploration and Production, 2006. April 2-4, Abu Dhabi.
- Sečen, J. (2006): Metode povećanja iscrpka nafte (Methods of enhanced oil recovery), INA, Industrija nafte d.d., (in Croatian), 608 p.
- Velić, J., Malvić, T. & Cvetković, M. (2015): Geologija i istraživanje ležišta ugljikovodika (Geology and exploration of hydrocarbons reservoir), University of Zagreb, Faculty of Mining, Geology and Petroleum Engineering, Zagreb, (in Croatian).
- Velić, J., Malvić, T., Cvetković, M. & Vrbnac B. (2012): Reservoir geology, hydrocarbon reserves and production in the Croatian part of the Pannonian Basin System, Geologia Croatica 65/1, 91-101.

## SAŽETAK

### Analiza utisnog sustava vode u pješčenjačka ležišta ugljikovodika, primjer iz zapadnog dijela Savske depresije

Utiskivanje slojne vode sastavni je dio proizvodnoga ciklusa ugljikovodika u sekundarnoj fazi pridobivanja. Utisni sustavi mogu se podijeliti na središnji i pojedinačni. U radu su opisani troškovi utiskivanja slojne vode na primjerima polja A (središnji utisni sustav) i B (pojedinačni utisni sustav) koji se nalaze u zapadnome dijelu Savske depresije. Ležišne su stijene naftno-plinskih polja A i B sitnozrnati do srednjezrnati pijesci i kvarcno-tinjčasti pješčenjaci donjopontske starosti. Srednja poroznost u polju A iznosi 15 – 35 %, a u polju B 10 – 31 %, ovisno o dubini i postotku cementacije. Za obrađena naftno-plinska polja u ovome radu napravljena je usporedba troškova i analiza osjetljivosti utisnoga sustava te moguća optimizacija i racionalizacija troškova utisnih sustava.

### Ključne riječi

utisno-vodni sustavi, analiza osjetljivosti, ekonomika utisnih sustava, Savska depresija, pješčenjaci