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Subsurface expertise and joint research - the DGMK recipe for a successful transformation of energy storage

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Abstract

The use of hydrogen will play a central role in all sectors in achieving Germany's climate targets. There is general political consensus on this. The storage of hydrogen is not only the basic prerequisite for sector coupling. Energy storage in underground storage facilities is the method of choice for the secure and long-term storage of hydrogen. Due to the highly variable production of hydrogen from different sources and the equally expected highly fluctuating demand, underground gas storage facilities will play a key role in the future energy system.

The conversion of today's underground gas storage facilities to hydrogen or the construction of new storage facilities is by no means trivial, but is highly demanding for machines, materials and processes.

In order to provide technical and scientific support for the transformation of the storage market, the DGMK has established a dedicated working group focussing on energy storage (AK Energiespeicher), a lively platform for the technical exchange of experts from both operators and the associated service industry.

In addition, the DGMK has already initiated several projects on the hydrogen compatibility of steels, cements (in preparation) and special components in recent years and is carrying these out in interdisciplinary research consortia. The necessary conversion measures of existing underground gas storage facilities for the storage of hydrogen in accordance with DVGW G260 5th gas family or for the storage of natural gas-hydrogen mixtures of the 2nd gas family are placing special demands on the technical equipment.

DGMK offers, among other things, a comprehensive and recognised network of expertise in the subsurface area. It sees itself as a platform for initiating and supporting new (also publicly funded) joint research projects. The focus is currently on issues arising from the future utilisation of pore storage facilities and caverns. The presentation will provide an overview of the current activities of the Energy Storage Working Group and the contribution of the DGMK's interdisciplinary network to the successful transformation of underground storage facilities.

Key words: hydrogen, transformation, network, interdisciplinary, joint research

1. Introduction to DGMK

DGMK is a scientific society, an association that aims to bring industry and research together. Key areas of the energy sector are covered by this network, i.e. from subsurface topics to liquid fuels, lubricants, petrochemicals and carbon management DGMK is a cross-sector association focussed on research and technical exchange. This exchange comprises internal committee work and working groups as well as at public conferences. The organisation also initiates and coordinates research projects on industry-related topics with an annual volume of around € 2.5 million, roughly 1/3 of which is financed by varying industry consortia and 2/3 from public funds.

Members include industry, science, authorities and associations, bringing together more than 180 organizations and a good 1,200 personal members, many of whom in an active role within DGMK. Underground storage has been an active research area for more than a decade, including studies on methane storage, influence of carbon dioxide on subsurface equipment and reservoir parameters and, of course, in the recent years, focused on hydrogen storage.

2. Overview recent projects

DGMK has a history of research projects concerning subsurfaces storage. More than a decade ago, it was debated to add a percentage of bio-methane to natural gas, as well as a low amount of hydrogen. Hence, in 2013, two studies were launched to assess the influence of bio-methane and hydrogen on underground gas storage [1] and the impact of hydrogen in the equipment [2]. While the presence of bio-methane was considered as unproblematic, a yet-to-be quantified risk of considerable technical and economic consequences was stated associated with storing a mixture of hydrogen and natural gas.

Almost in parallel, another study [3], addressed potential issues with an increased carbon dioxide content associated with an increased biogas content was published. This study concluded, that also under this aspect, no serious risk had to be expected when adding bio-methane to the natural gas transport infrastructure. All these studies between 2013 and 2015 have been based on literature.

DGMK as a partner in public projects: In the publicly funded project SUBI (Safety of underground storage facilities under cyclic loading: functionality and integrity of storage facilities and boreholes) [4], running from 2017 – 2020, carried out by a large research consortium, DGMK was involved as a project partner. It was studied, to which extent an increased frequency and amplitude in storage operation, as to be expected in comparison with Methan storage cycles, would have an impact on the integrity of underground gas storage facilities. It was found, that generally both pore and cavern storage systems can be qualified and upgraded for higher-frequency operation. Also boundary conditions were defined and verification concepts were outlined.

During this project, several ideas for further studies have been developed, especially since the focus had so far been on geomechanical properties and rock mechanical conditions and associated modelling. Well integrity, the impact of hydrogen on cements, equipment and steel were then targeted in several DGMK projects, while DGMK also partnered in the SUBI-follow-up project SAMUH2 [5], which is dedicated to the development of strategies for retrofitting existing storage facilities and the design of modern storage facilities on the basis of systematic investigations as well as a holistic view of the entire life cycle of the UGS.

In DGMK 858 Completion Integrity [6], a reliable test procedure was developed for the large number of different cements and steels already in use, allowing conclusions about the compatibility and safety of completion systems. Exemplary material combinations were tested leading to general statements on the mechanisms involved in sealing a hydrogen well and therewith defining decisive parameters thereafter.

In particular, laboratory tests on cement gas permeability were conducted, the phase behaviour was analysed or more specifically interfacial tension and contact angle were investigated and simulations of hydrogen permeability were carried out.

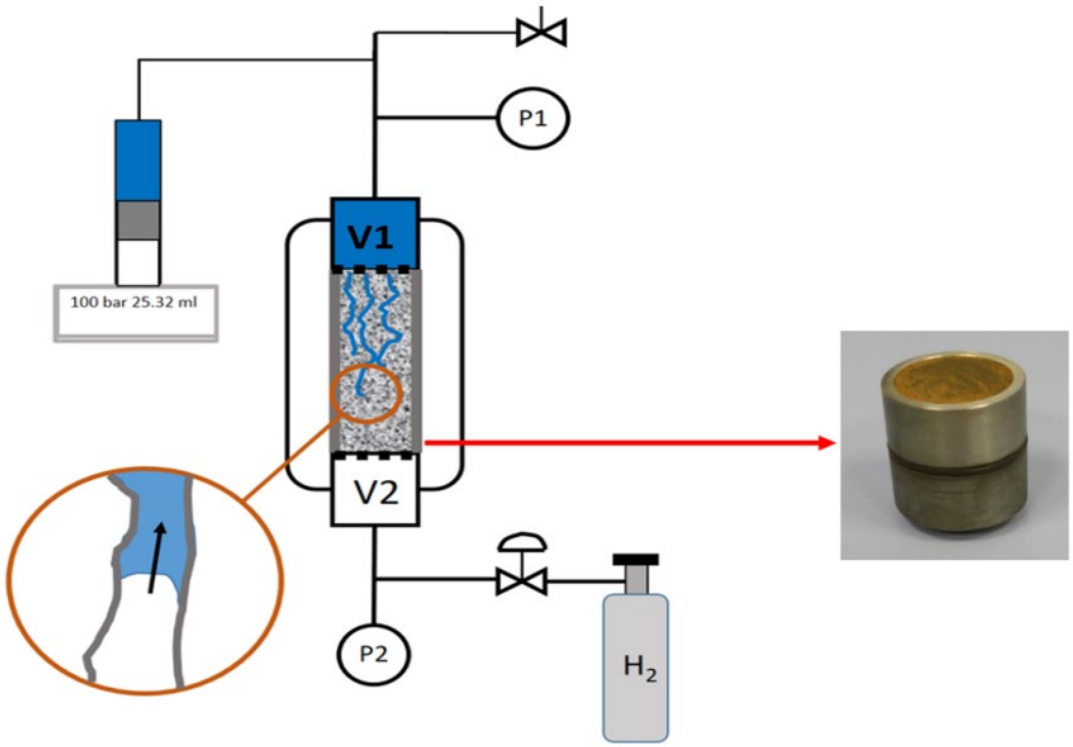

Figure 1, Schematic Dispay of the test procedure for cement incl. a photo of a cast-in cement sample [6].

2022 a new project was launched to investigate under which conditions different steels used in deep drilling (as classified by API) are suitable for hydrogen [7]. In the 1st phase of the project, the integrity assessment method was developed. In the 2nd phase the comprehensive investigation program based on the findings of the 1st phase are carried out.
A similar study DGMK 884 [8], is addressing the suitability of special components regarding exposure to hydrogen. The necessary conversion measures of existing underground gas storage facilities for the storage of hydrogen in accordance with DVGW G260 5th gas family or for the storage of natural gas-hydrogen mixtures of the 2nd gas family are placing special demands on the technical equipment. Based in an extensive literature study a comprehensive test methodology is currently being developed.

The most recent study, DGMK 894 [9], was initiated early this year with a focus on accompanying substances in hydrogen gas, in order to show which components may be relevant and in what concentration as well as a comparison of possible treatment steps with regard to current hydrogen quality standards.

3. Working group AK Energiespeicher

While many underground storage operators, and the associated service companies and research institutions have been members of DGMK for a long time and topics related to underground storage of natural gas and possibly other gases have been covered during the annual DGMK Frühjahrstagung for more than 20 years, a dedicated working group to foster technical exchange and the development of research ideas has formed only in 2023.

The group consists of representatives from operators, service industry and academia and meets roughly twice per year to discuss, e.g. legal aspects of transforming natural gas storage locations to hydrogen storage, of applicability of knowledge gained from city gas storage. In the past two years, also a one-day-event to present and discuss projects around the storage of hydrogen in Germany and beyond has been organised.

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