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The history of UGS Strachocina investment as an example of success achieved by cooperation between a western company and Polish oil and gas companies

Historia inwestycji PMG Strachocina jako przykład sukcesu współpracy firmy zachodniej z polskimi przedsiębiorstwami z sektora ropy naftowej i gazu ziemnego

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ABSTRACT: In 2006 Oil and Gas Institute, Underground Gas Storage Department was given the task of designing the UGS Strachocina working volume, production and injection rates enlargement. Gas storage Strachocina is located in the south eastern part of Poland, near Sanok. The UGS Department ran some analysis before that date, which gave us the answer that the old vertical well technology would not be enough to achieve investment success. We knew that we needed to use horizontal well technology in which we had no experience at all. At that time there were only a few horizontal wells drilled in Poland. We decided to start cooperation with the company Baker Hughes, and asked them to help us to design the drilling technology and well completions. We knew that we needed to drill 8 horizontal wells in difficult reservoir conditions. Based on Baker Hughes' recommendations, the EXALO Polish drilling company's experience and the Institute's knowledge of storage reservoir geology, the trajectories of 8 new wells were designed. Working with Baker Hughes, we designed the well completion based on expandable filters, the second time this type of completion technology had been used in the world at that time. During drilling, we were prepared for drilling fluid losses because of the extensive Strachocina reservoir's natural fracture system. The investment was in doubt during the drilling of the first two horizontal wells because of huge drilling fluid losses and the inability of drilling the horizontal section length as designed. We lost 4000 cubic metres of drilling fluid in a one single well. During the drilling of the 2nd well, we asked Baker Hughes to help us to improve the drilling technology. Our partners from Baker Hughes prepared the solution in 3 weeks, and so we were able to use this new technology on the 3rd well drilled. It turned out that we could drill a longer horizontal section with less drilling fluid loss. The paper will show the idea of the project, the team building process, the project problems solved by the team, decisions made during the UGS Strachocina investment and the results. It will show how combining "western" technology and experience with "eastern" knowledge created a success story for all partners.

Key words: UGS Strachocina, horizontal well, natural gas, gas storage, UGS expansion.

STRESZCZENIE: W 2006 roku Instytutowi Nafty i Gazu, Zakładowi Podziemnego Magazynowania Gazu, powierzono zadanie zaprojektowania rozbudowy PMG Strachocina poprzez powiększenie pojemności czynnej i zwiększenie mocy zatłaczania oraz odbioru gazu. Magazyn gazu Strachocina zlokalizowany jest w południowo-wschodniej Polsce, niedaleko Sanoka. Zakład Podziemnego Magazynowania Gazu przeprowadził analizę eksploatacji PMG Strachocina do roku 2006. Wykonana analiza dała odpowiedź, że stara technologia odwiertów pionowych nie wystarczy do osiągnięcia sukcesu inwestycyjnego, polegającego na rozbudowie magazynu Strachocina. Zakład PMG wiedział, że musi skorzystać z technologii odwiertów poziomych, w której nie posiadał żadnego doświadczenia. W tym czasie wykonano w Polsce tylko kilka odwiertów poziomych. Postanowiliśmy nawiązać współpracę z firmą Baker Hughes i poprosiliśmy ją o pomoc w zaprojektowaniu technologii wiercenia i wykonania odwiertów. Zespół Zakładu PMG obliczył, że musi zostać odwierconych 8 otworów horyzontalnych, w trudnych warunkach geologicznych. Na podstawie zaleceń Baker Hughes, doświadczeń polskiej firmy wiertniczej Exalo oraz wiedzy Instytutu z zakresu geologii PMG Strachocina zaprojektowano trajektorię 8 nowych odwiertów. Współpracując z Baker Hughes, wspólnie zaprojektowaliśmy udostępnienie horyzontów magazynowych z wykorzystaniem technologii filtrów poszerzalnych. W tamtym czasie technologia ta została zastosowana na świecie po raz drugi. Podczas wiercenia byliśmy przygotowani na ucieczki płynów wiertniczych ze względu na rozległy system naturalnych spękań występujących w horyzontach magazynu Strachocina. Osiągnięcie parametrów inwestycyjnych było zagrożone podczas wiercenia dwóch pierwszych odwiertów poziomych ze względu na duże straty płuczki wiertniczej oraz niemożność odwiercenia projektowanej długości odcinka poziomego. W jednym odwiercie straciliśmy 4000 metrów sześciennych płuczki wiertniczej. Podczas wiercenia drugiego odwiertu

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poprosiliśmy firmę Baker Hughes o pomoc w udoskonaleniu technologii wiercenia. Nasi partnerzy z Baker Hughes przygotowali rozwiązanie w 3 tygodnie. W związku z tym udoskonalona technologia została zastosowana podczas wiercenia trzeciego odwiertu. Okazało się, że możemy wywiercić dłuższy odcinek poziomy z mniejszymi stratami płynu wiertniczego. W artykule przedstawiona została idea projektu, proces budowania zespołu, problemy projektowe rozwiązane przez zespół, decyzje podjęte w trakcie realizacji rozbudowy PMG Strachocina oraz ich rezultaty. Głównym celem publikacji jest pokazanie, jak połączenie „zachodniej" technologii i doświadczenia ze „wschodnią" wiedzą tworzy historię sukcesu wszystkich partnerów.

Słowa kluczowe: PMG Strachocina, odwiert horyzontalny, gaz ziemny, magazynowanie gazu, rozbudowa PMG.

Introduction

The Strachocina Underground Gas Storage facility (UGS facility) is located in the south eastern part of Poland, near Sanok (Miziołek and Zamojcin, 2012). The storage was built in a depleted natural gas field. The Strachocina gas reservoir is situated in Istebna sandstone, within an anticlinal structure with two clearly distinguished production horizons (Fig. 1). The average effective thickness of the upper layer (hor I) is 45 m and the average thickness of the lower layer (hor II) is 63 m. The porosity values for hor I and hor II are respectively 11.9% and 10.1%. The permeability values for hor I and hor II are respectively 13.7 mD and 24.8 mD.

The history of the Strachocina gas field's production started in 1928. The original Strachocina gas in place was 4200 million m^3. The initial reservoir pressure was 10 MPa. The reservoir pressure before gas storage operations, which started in 1982, was 1 MPa. UGS operations, injection and withdrawal were conducted without a compression station until June 2011. The gas was injected into the storage directly from the pipeline with gas at high pressure (Hermanowice–Pogórska Wola). During the withdrawal season gas was delivered to a pipeline with low gas pressure. The non-compression system had both advantages and disadvantages. However, it significantly limited the use of the maximum capabilities of UGS Strachocina because the amount of gas that could be produced and injected was heavily dependent on gas pipeline pressures. Before investment, the working gas volume of the UGS was 100 million m^3 and the cushion volume was 725.5 million m^3 because of low working pressure operation, which ranged between 3.7 and 2.6 MPa. The storage had 34 vertical wells used during injection and production seasons. The largest amount of gas delivered to the market was 147 million m^3 in winter 2005/06. However, the time needed to do this was 152 days.

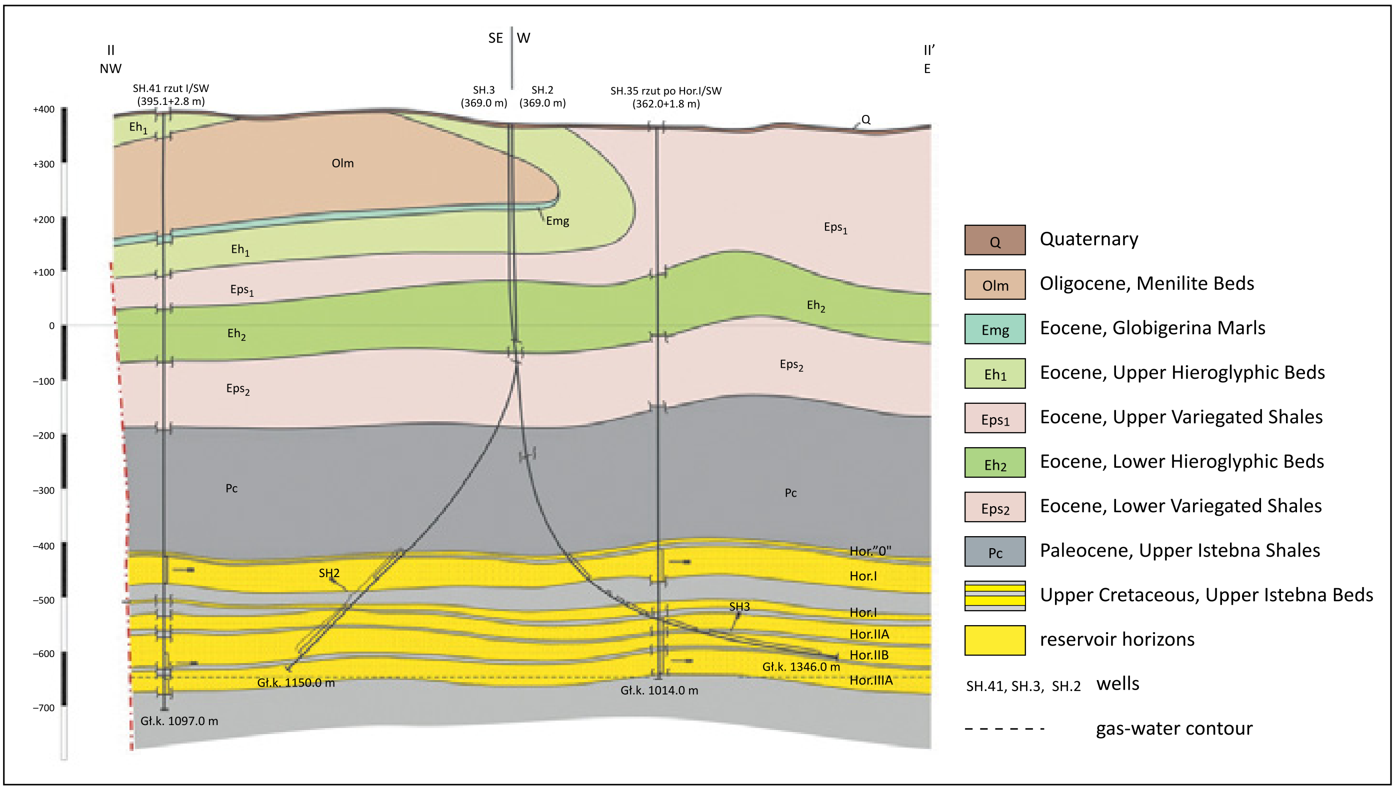

Fig. 1. The geological cross-section of the Strachocina gas field

Rys. 1. Przekrój geologiczny przez złoże gazu ziemnego Strachocina

The investment idea

In 2006 market demand from one side and the flow capacity of the pipeline system from the other side stated that the working gas volume of the UGS should be increased to the value of Va = 330 million m^3. The working gas volume expansion required a change in the operating pressure range by increasing its top working pressure. On the other hand, the increase of the storage facility working pressure required the installation of a gas compressing unit. It is worth mentioning that the gas compressing unit was planned to be used not only during gas injection but also during the gas withdrawal phase.

The Oil and Gas Institute's UGS Department carried out various analyses of the possibilities of expanding the Strachocina storage. The analyses showed that the main problem of the storage was low production and injection rates of vertical wells (Filar et al., 2000). Preparing for the investment, the Institute, UGS Department did a lot of work and analysis. The main goal of the work was to find an optimal method for increasing well productivity. After analysis of the Strachocina storage reservoir and petrografical conditions, it turned out that storage horizons are naturally fractured (Miziołek, 2002). In the final conclusion of the preparation work, it was decided to design the entire investment project based on horizontal well technology (Filar, 2005). It turned out that to meet peak deliverability rates we needed to drill 8 horizontal wells. Wells were designed to open separately in the upper layer (4 wells) and lower layers (4 wells). The main idea was that the wells should be drilled to the bottom of each layer and open the entire thickness of the target layer. The reason for opening the entire thickness of the storage layers is that each layer is composed of sandstone interbedded with some shale laminations which were reducing the vertical flow of natural gas (Miziołek et al., 2010). The trajectory of each well was designed for 300 m to open the reservoir section. Consequently, the designed gas storage expansion investment assumed the following tasks:

- increase of the working gas volume up to Va = 330 million m^3;
- leave the volume of the cushion gas unchanged;
- build new surface infrastructure with a gas compressing unit;
- drilling 8 new production/injection horizontal wells, drilled from 2 well pads.

Team building process

Before starting the feasibility study, which was granted to the Institute's UGS Department, it was clear that our Institute team had no experience, especially in horizontal well drilling and completion technology (Filar and Miziołek, 2006). We decided from the beginning that we would build a team comprised of companies to design new wells and to drill them, and also to design surface equipment and to run the gas storage after completion of the investment. So the team was comprised of persons from the following companies:

- INiG – PIB (Oil and Gas Institute National Research Institute), UGS Department, general designer of the UGS Strachocina investment, the leader of the team;
- PGNiG SA (Polish Oil and Gas Company) Sanok Branch, the investor and operator of the UGS;
- Exalo Drilling SA, drilling company;
- Nafta-Gaz Jasło, oil and gas surface infrastructure designing company;
- Baker Hughes, a company which had experience in the drilling and completion of horizontal wells.

The cooperating members of that team began at the beginning of the feasibility study in June 2006 and continued until the end of the investment in 2011. It should be emphasized that at each stage of the investment the specialists from the team jointly consulted on their ideas, designed storage parameters, solved problems and made the decisions that were the basis for future success.

The problems and how the team solved them

The first problem occurred during the design of well completion. After discussion, the team agreed to use Baker Hughes' expandable sand screens because of sanding problems observed in some wells. It was the second time this type of technology had been used in the world (after UGS in Austria). The really big problems started during the drilling of the second well because of drilling fluid losses. We expected some fluid losses because of low reservoir pressure (around 3.2 MPa) and the naturally fractured reservoir. But we were surprised by the scale of the losses. The biggest fluid loss on a single well was almost 4000 m^3, with the highest loss rate between 50–100 m^3/hour. So, during the drilling of the 2nd well we asked Baker Hughes to help us to improve drilling technology. Our partners from Baker Hughes prepared the solution in 3 weeks, so we were able to use new technology on the 3rd well drilled. It turned out that we could drill longer horizontal sections with less drilling fluid loss. The large drilling fluid losses created problems with reaching the designed length of the well's horizontal section. Simply, the horizontal sections in almost all wells were shorter than planned (300 m). The shorter opening reduced expected production rates, so we decided to open both the upper and the lower layers in each well drilled to the lower layer (hor II). After drilling 8 wells, it turned out that the total opening length in the upper layer was 1185 m (designed 1200 m) but only 814 m in the lower storage layer (designed 1200 m). In that situation we decided, together with the investor, to drill one more horizontal well. The well was drilled to open both horizons I and II.

The investment results

The operation of the expanded UGS Strachocina began with the injection of gas in 2011. Gas injection in the 2011 season can be divided into two periods. The first injection phase, which lasted from April 1 to July 6, consisted in injecting gas without the use of a compression station. The second injection period, which began on 7 July and lasted until 30 September, was conducted using a gas compression station. After the injection period, UGS Strachocina achieved a designed working capacity of 333.9 million cubic metres. At the end of the injection, the gas pressure in the storage measured at the wellhead reached 4.14 MPa, while the design value was 4.1 MPa.

Figure 2 presents the storage injection gas rates designed in 2006 and the real one achieved during the gas injection period in 2011. As we can see, the real injection rates confirm the designed rates, starting from a working volume of 170 million m^3. The real storage rates at the beginning were lower than the designed rates because UGS had to run all the technical tests.

The gas production season, after reaching the designed working volume, started on 16th November 2011 and finished on 15th April 2012. During winter 2011/2012, the storage delivered to the gas market 328.73 million m^3 of natural gas. Figure 3 shows that from the inventory level of about 170 million cubic metres, the storage production rates reached in winter 2011/2012 confirmed the designed rates. During the beginning of the withdrawal season, the storage produced gas without using the compression station, so the rates were lower than designed. The projected maximum gas withdrawal rates were reached in winter 2012/2013.

The data obtained during both the gas injection and withdrawal seasons of UGS Strachocina's operation, after investment, confirmed the achievement of a designed working volume of 330 m^3, designed injection and production storage gas rates, and the designed range of working pressure (Filar et al., 2011).

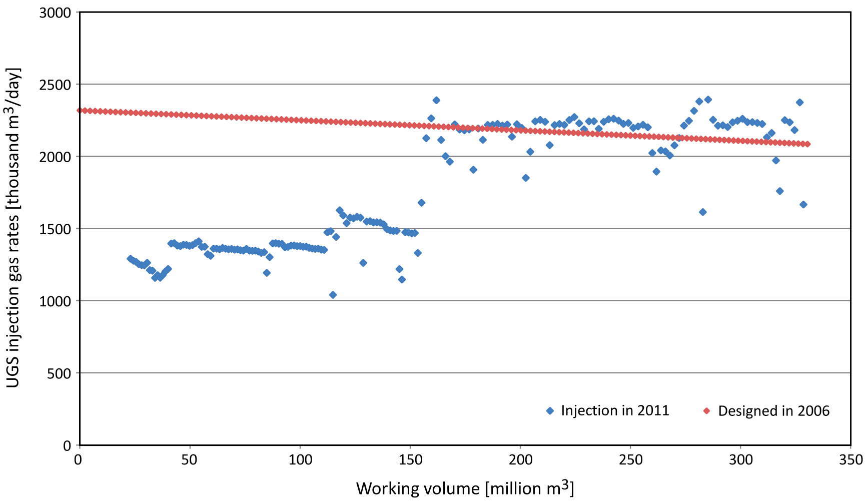

Fig. 2. The storage injection gas rates designed in 2006 and real rates in 2011

Rys. 2. Wydajność zatłaczania gazu projektowana w 2006 r. oraz rzeczywista wydajność zatłaczania gazu osiągnięta w roku 2011

Fig. 3. The storage production gas rates designed in 2006 and real rates achieved in winter 2011/2012

Rys. 3. Wydajność odbioru gazu projektowana w 2006 r. oraz rzeczywista wydajność odbioru gazu osiągnięta w zimie 2011/2012

Conclusions

The expansion of UGS Strachocina was a success because the designed parameters were achieved. It is worth noting that the success was achieved in difficult geological conditions and with the use of innovative technical solutions. Investment success was possible because:

- at the beginning of the investment a team was built comprised of companies needed to design new wells, drill them, and also to design surface equipment and to run gas storage after investment completion;
- there was close cooperation of all companies involved in the investment until the end of the investment;

- emerging problems during the investment were solved without delay;
- all decisions were made to reach the designed UGS Strachocina parameters.

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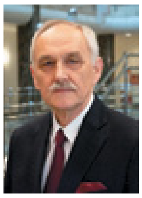

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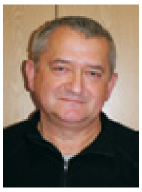

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