Sand Control with Ceramic Screens in Unconsolidated Reservoirs demonstrated in the mature Gaiselberg Oilfield

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Abstract

The Oil Production in the operation Centre ZIstersdorf of the Rohöl-Aufsuchungs AG (RAG) looks back to a long history and to a great variety of different types of completions. After the first oil bearing well RAG-002 in 1937 the development of the RAG field started, followed by more explorations successes in the Gaiselberg oil field 1938 onwards.

Primarily the production comes from the sandstones reservoirs of the Sarmat, the deeper horizons show usually a good compaction paired with a reasonable permeability. The lower layers, however, are more and more unconsolidated. For the prevention of sand production and to protect the completion equipment metal screens in combination with gravel packs had been installed.

Gravel Packs, however, generate an additional pressure drop, which can lead in some cases to a production loss of up to 50% from the very beginning. In addition they are prone to abrasion and come with high completion costs.

With the completion of the new developed sand control screen based on ceramic materials, the next step to sand control in unconsolidated reservoir succeeded after the successful protection of well jewellery in wells after massive hydraulic frac operations [1, 2, 3].

In this article the construction, deployment in the well Ga-016 below a sucker rod pump as well as the analysis of the production performance is discussed. It will be demonstrated that with this application a fundamental step in sand control in unconsolidated reservoirs has been achieved.

Introduction

Experience shows that erosion is a severe operational issue in the oil and gas production of the exploration and production industry, and many operators suffer from sand production. Maersk Oil for example described erosion issues in the long horizontal wells of their Valdemar field as well as in their gas wells in the Tyra field. At Valdemar, proppant backflow during clean-up operations after massive frac treatments had to be faced as well as during bean-up. In addition to the resulting erosion of tubulars and sliding sleeves, the operator also faced economic losses during the long clean-up periods at the end of the stimulation phase (rig standing idle during clean-up period), but also due the presence of sand in the facilities (filling-up separators) and flow restrictions in pipelines. There is another economic incentive that is to phase out using resin coated sand from the fracturing operation due to its classification as a "red" chemical.

In the Tyra field, the production of gas wells turned unmanageable due to sand production and had to be shut in permanently so that the reserves had to be de-booked.

In both cases, conventional sand control methods could not be applied due to the insufficient erosion resistance of the supporting metal screens. Therefore, it was looked into alternative materials showing higher hardness and consequently better erosion resistance. With their unique properties advanced ceramics were qualified, and a new sand screen design was developed which offers impressive advantages.

In three wells of the Valdemar field, ceramic screens were applied to protect the sliding sleeves while placing them opposite of the perforations, and a dedicated testing program including production logging and well flow testing was performed in one of them which allowed evaluation of the performance of the ceramic screened sleeves [1–3]

In all cases the ceramic sand screens performed according to expectations and showed the high potential of the new sand control technology.

Ceramic Sand Screen Design – General Principles

The design of the ceramic sand screen consists of three construction elements: a stack of ceramic rings, two coupling elements and a fixing device to mount the assembly to a tubular support.

For the ceramic rings, sintered silicon carbide (SSiC) was chosen as material. SSiC boasts a unique combination of properties, including excellent abrasion and corrosion resistance, low density, heat stability (up to 1800 °C), high hardness and high stiffness. For more details see [1]. Table 1 compares relevant material data of silicon carbide, silicon nitride, steel and hard metal.

The SSiC ring geometry (ID, OD, and gap width/shape) can be freely chosen and adapted to nearly any prevailing wellbore geometry or well conditions. Preferably, the rings are spherically dished on the bottom face of the rings providing keystone gaps that are narrower on the outside surface of the ring. This design allows high laminar flow rates and prevents plugging of the gap by fines since any particle passing through the gap at the outer diameter will continue to flow through rather than lodging within the gap. The upper face of the rings shows a number of equally spread bumps that are used to adjust the gap width of the ceramic stack. The gap width can be chosen according to the frac sand or any other grain size

Table 1 **Comparison of typical material properties**

Material Properties	Stainless Steel	Hard Metal	Silicon Nitride	Silicon Carbide
Knoop Hardness, HK 0.1 GPa	<0.5 (Rc 30–40)	16	14.5	21–25
Compressive Strenght, MPa	2200	5000	>2500	2200–2500
Thermal Conductivity, W/(mK)	35–45	95	25–40	75–125
Density, g/m³	7.8	14.9	3.2	3.1–3.2
Flexural Strenght (4 Point Bending), MPa	N/A	1550	700–800	400–650
Young's Modulus, GPa	200	520–620	310	410
Fracture Toughness K_{Ic}, MPa $m^{0.5}$	N/A	10–20	6	4–6

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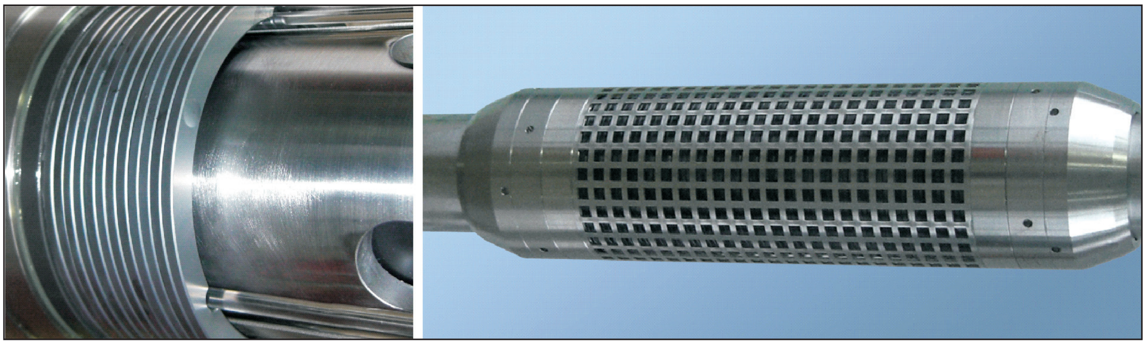

Fig. 1 **Ceramic screen mounted on 3.5″ sliding sleeve, a) during assembly and b) prototype covered by protective shroud**

distribution resulting from sand production. Ideally, the ceramic rings are manufactured with three bumps shaped as spherical segments ensuring only point contacts between the stacked rings. In combination with the spherically dished ring shape, this design is well suited to ceramics, giving flexibility to the stack of ceramic rings and stability against torsion as well as flexure.

The stack of ceramic rings is placed between the upper and lower coupling elements and mounted on the tubular support (e. g. a sliding sleeve or a perforated base pipe). Clamping features on both sides of the stack mechanically constrain the ceramic rings. The load is transferred to the stack of rings via a number of spring elements and the coupling elements. The flexibility of the spring elements enables the dissipation of any mechanical stress that could be either imposed by torsion, bending, shock or temperature induced thermal stresses between metal and ceramics. This type of clamping mechanism prevents any accidental damage of the basic sleeve and provides excellent damage-tolerance to the ceramic assembly. In addition, the outer part of the assembly can be surrounded by a metallic shroud to protect the ceramic screens from being damaged during installation.

The ceramic screen can be mounted on any type of tube or tubular flow-through device with flexible lengths (Fig. 1).

Field Application at Rohöl-Aufsuchungs AG (RAG)

Sand control has always been a major problem in RAG's oil production in Zistersdorf. The "Gaiselberg" and the "RAG" fields were discovered in 1937 about 50 km northeast of Vienna with an acreage of only 5 km². The production peaked in 1943 with 320,000 t/a; the current production is ~20,000 t/a from 30 production wells. Almost 150 wells were drilled until 2011 into the oil bearing reservoirs of the Badenien and Samartien layers, the main boundary is the so called "Steinberg Bruch".

More than 600 reservoir compartments and the unconsolidated shallow reservoirs (average depth about 900 m TVD), which are the growing part of the production in the development and capacity enhancement of the fields represent the biggest remaining potential of producible reserves. Almost 20 producing wells are equipped with a sand screen/gravel pack assembly.

A great number of sand control methods have been tested and applied over decades in the fields of Zistersdorf and up to now the gravel pack was considered the best technical and economical solution. It turned out during planning of the gravel pack completion that the distinction between vertical and deviated production intervals is essential. For vertical wells the use of water-packs including a pre-pack is recommended. To prevent the movement of pre-packed gravel pack with respect to the deviated well during completion operation, no pre-pack should be placed. The best solution for optimum gravel placement was the slurry pack.

In the past, wire-wrapped sand screens made of stainless steel were used with a gravel pack (usually mesh 20/40) in order to avoid any sand production. The system proved to be reliable, but the performance of some gravel packs was crucial. In addition, some screens collapsed due to the combination of acid stimulations and/or erosion.

The recently completed ceramic sand screen does not require any gravel packing and shows a very low pressure loss during production, that results in reduced workover costs and a higher gross production rate.

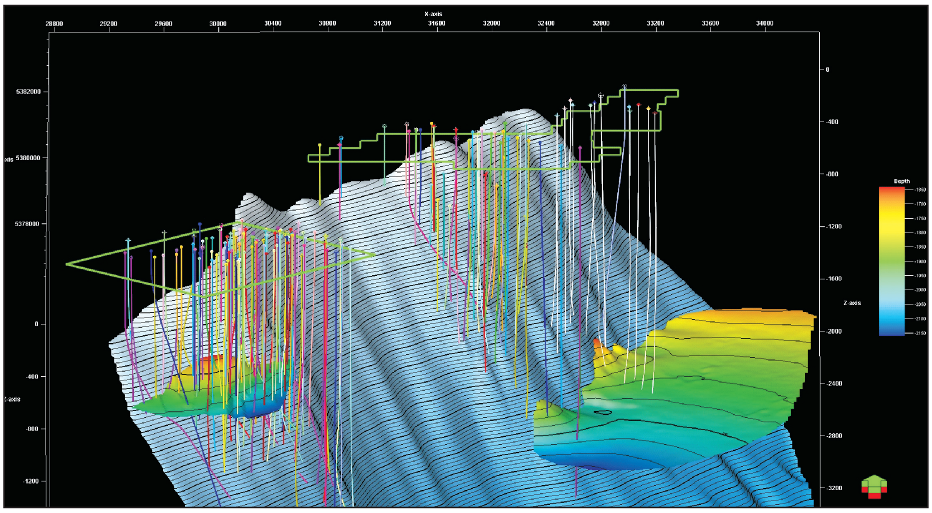

Fig. 2 **Seismic section of the Gaiselberg and RAG fields**

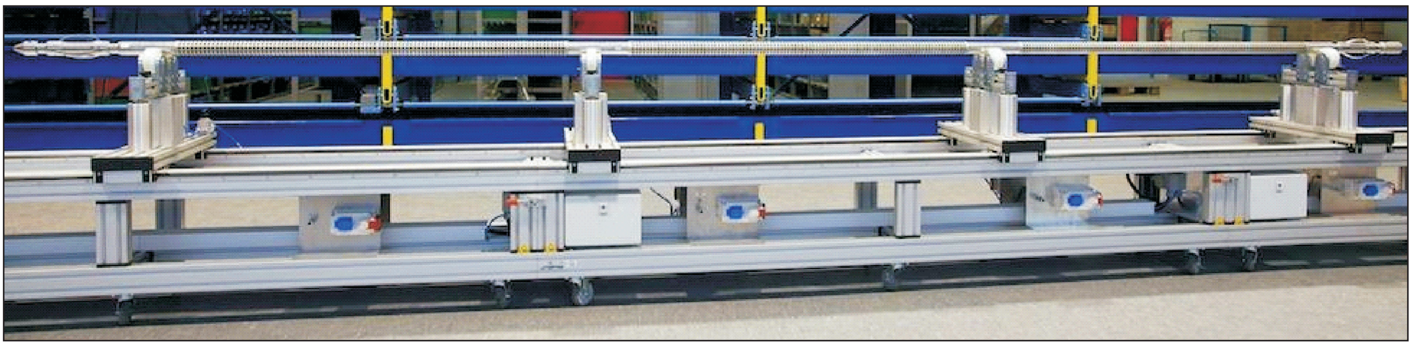

Fig. 3 **Ceramic screen assembly: three screen modules (each 5 ft long) with interconnectors, bull nose, centralizers and cross over**

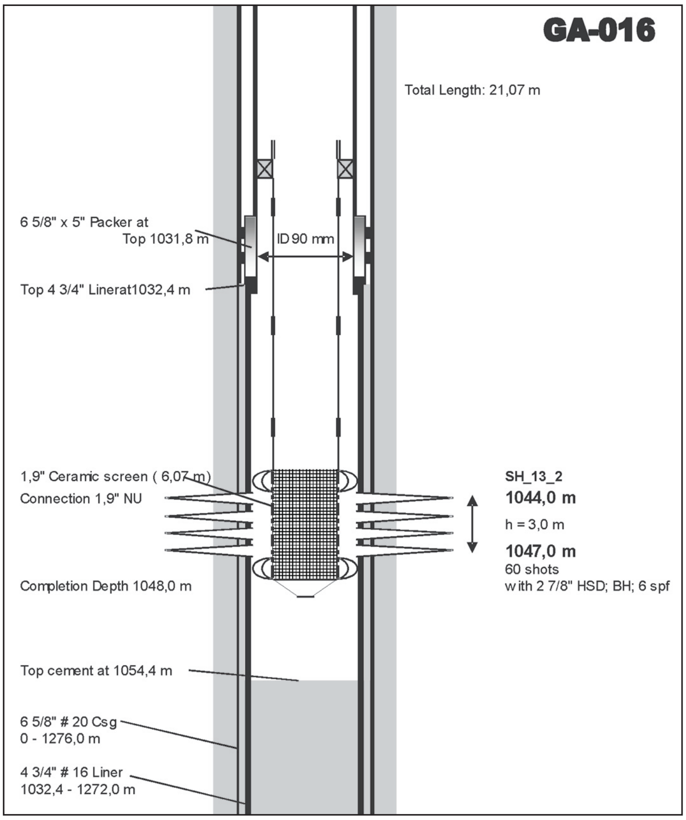

Fig. 4 Completion drawing of GA-016

Fig. 5 Unpacking the sand screen

The Ceramic Screen for GA-016

For longer ceramic sand screens, a modular setup is preferred where metal intersections align the individual ceramic screen section. This set-up was chosen for the screen used in Gaiselberg GA-016. The existing completion, in which the filter had to be introduced, allowed a maximum screen OD of 2.2″. The screen was designed accordingly, with a max OD of 2.12″. In order to cover the perforation zone (stretching over 3 m), three screen modules (each with 5 ft length) were interconnected with metal joints which are protected by a polymeric tube. The slot width of the ceramic ring stack with 200 µm was adapted to the particle size distribution of the formation sand of the zone in production. The stack was mounted on a slotted liner with an ID of 0.95″. On the tip, a stainless steel bull nose was attached. To connect the screen with the tubing, a 1.9″ non-upset crossover was chosen. In the upper and lower sections centralizers were used to enable an easier deployment and a correct setting of the screen in the perforation zone. In Figure 3, the assembled screen is shown in the workshop.

The sand screen has been installed in December 2011 after the reservoir has been perforated in the Sarmatian 13 formation which is known to consist of unconsolidated sand. In Figure 4 the completion of the well is shown.

The well was completed with a conventional workover rig operational in the Zistersdorf production department. Some pictures of the completion of the well show the simplicity of the workover and the key features of the sand screen.

On Dec. 15, 2011 the well was set on production with a rate of some 50 m³/d, fluid level and the percentage of fines in the production stream were monitored regularly. Within two weeks the percentage of fines dropped to zero, which allowed the rate to be increased to 90 m³/d. This was reflected instantaneously in a drop of the fluid level. The rate increase did not lead to any new produc-

Fig. 6 Before deployment, left the bull nose with centralizer

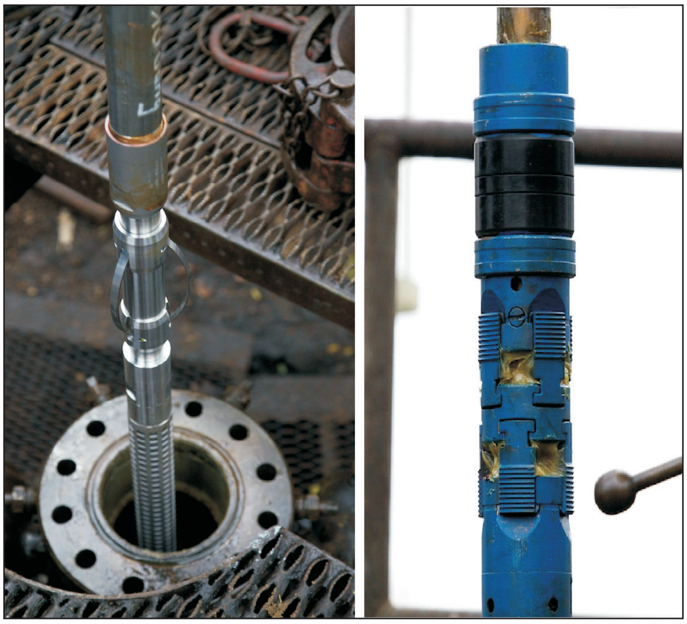

Fig. 7 a) Top of sand screen with centralizer, b) Packer

tion of fines. After six weeks of constant, fines-free flow there was evidence that a secondary gravel pack was formed outside the screen.

In order to investigate the performance of the well in more detail a MURAG 20 system (Fully Automated Fluid Level Measurement Tool) was installed on Feb. 9, 2012. A dedicated test programme was designed to test the full functionality of the sand screen. In a first step the production rate was decreased to 60 m³/d. An immediate reaction of the fluid level was monitored. After a couple of days the production rate was increased again to 90 m³/d and as expected an immediate reaction of the fluid level together with a short peak of fines was observed, the level stabilised after a short period of time. The final proof of stable borehole conditions was achieved when the well was completely shut in for two days, again an immediate increase of the fluid level was observed, which showed that the slots of the screen were free, and even more after re-starting the production about 1% fines were produced for half a day and disappeared. Production rate and fluid level are stable since then. Unfortunately the chosen reservoir for this test produces with a water cut of 99%, so that the economical success is only marginal. A graphical overview of the production performance is given in Figure 8

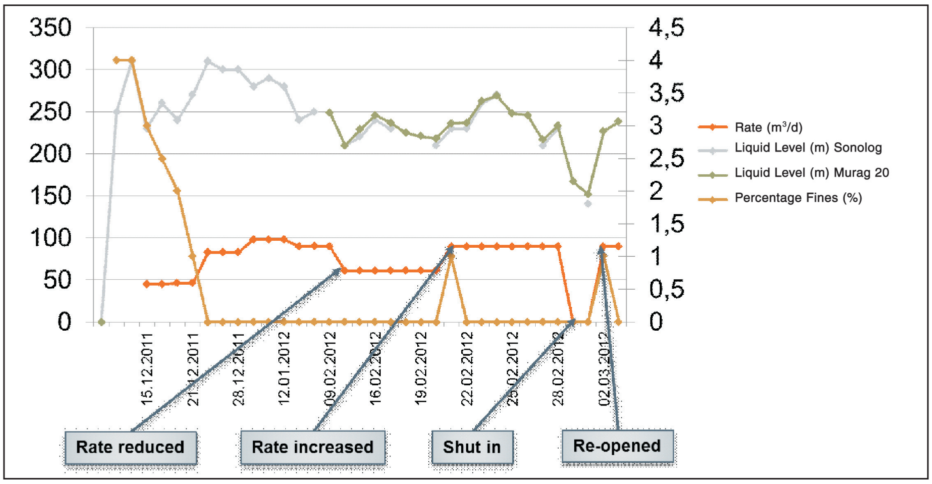

Fig. 8 Production Performance GA-016

On the side line a comparison was made between Sonolog and MURAG fluid level detection, the measured values are always comparable as expected. The Sonolog, however, measures only in tubing length steps (some 10m), whereas the Murag system delivers values between the couplings. The evaluation of the production performance of well GA 16 shows the successful application of an innovative sand control concept, which has the potential of replacing costly and difficult gravel pack operations.

Conclusion and Way Forward

The new development of an advanced sand control device based on ceramic material was successfully deployed as full functional sand screen in well GA-016. The screen demonstrated excellent performance in terms of production stability at expected level and the amount of fines produced during bean-up operations. It could be shown, that the borehole situation around the screen is stable despite the unconsolidated reservoir. No clogging and no erosion occurred as expected. The installation proved to be simple and cost-efficient. With the deployment of the ceramic sand screen in GA-016 a significant improvement in production performance and longevity of production equipment has been achieved.

Four candidate wells producing from unconsolidated reservoirs have been identified that are completed with gravel packs with sub-optimal production performance. After completion of this investigation two of the four candidate wells will be completed with ceramic sand screens, so that a direct comparison with gravel packed wells is possible. At the time of writing this article, it was decided to pull the screen in the GA-016 well as the investigated zone in this well showed an uneconomically high watercut and re-use the screen in another well.

Literature

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