GKD
WORLD WIDE WEAVE

KPZ mesh in oil and gas exploration: higher flow rates and longer life cycles

Groundbreaking results from an experimental study and CFD simulations on sand control screen erosion

A major oil and gas exploration and production company has investigated the erosion behaviour of conventional filter media used in well pipes in the framework of a comprehensive study of sand control screen erosion. The results show that the plain or twilled weave filter meshes conventionally deployed in the well are not capable of handling the local pore velocities in the well. So far, the risk of premature production breakdowns could only be countered by reducing flow rates. In supplementary CFD modelling of flow paths and the distribution of pore velocities, GKD – GEBR. KUFFERATH AG was able to prove that – in contrast to previous assumptions – the flow-dependent multiplier term is higher not by a factor of 2 or 3 but, even at just medium flow rates, by a factor of 63. The only filter media capable of standing up to such pore velocities in the long run are KPZ meshes, which, thanks to the higher volume porosity of their construction, reduce flow velocity by around 30 percent. Also featuring high mechanical robustness, this type of woven wire mesh is therefore capable of facilitating sustainably higher daily production rates than any other mesh type that could be deployed in this sector.

Profitability of the production of oil and natural gas is dependent on the ratio between downtimes and production rates. One significant threat to efficiency is the erosion of the filter media used, which causes serious production failures and damage to downstream equipment. The main reason for this erosion is the local development of high pore velocities in the filter media, and this represents an incalculable breakdown risk. In order to maintain high production rates, the existing feed pressure has to be increased, with the result that pore velocities and abrasion through the sand particles contained in the fluid also increase. Mesh weaves that are not designed for such conditions tend to succumb to erosion in a very short time. So far, the only preventive option that seemed to be available to well operators was to throttle back the flow rates according to empirical guidelines based on average flow velocities. With the objective of transforming this blanket reaction into a specific well strategy, various defective pipes were pulled out of a field in the Gulf of Mexico and the exact locations of erosion damage were examined. Parallel to this, an experimental erosion study was started in order to identify the flow parameters that were leading to the destruction of the filter mesh. The objective here was to model the interrelationship between life cycle of pipes and flow rates more precisely than ever before and to derive a formula that could be used as a basis for the development of more realistic flow guidelines. To achieve this, the study combined empirical data and experimental work with CFD simulations in order to supplement the knowledge gained from field and lab studies through findings regarding a flow-optimised design of filter mesh.

Plain dutch weave, twilled dutch weave and KPZ mesh in comparison

For the experimental tests, the erosion behaviour of filter screens was measured on a laboratory scale in terms of various production variables like inlet face velocity, sand concentration and particle size. The screen configuration for the test corresponded to a design used in numerous subsea gas wells and in the pipes retrieved. On the basis of an empirically derived erosion model, the high-speed results from the laboratory test were translated into field erosion predictions and further developed into new flow guidelines for wells. The supplementary CFD simulation was of crucial importance in this process, as it allowed the flow streams through the pores of the filter mesh to be visualised. It was on the basis of these calculations that it became possible for the first time to determine local inlet face and pore velocities and the resulting patterns of erosion.

For the laboratory test, 55 millimetre test coupons were used which corresponded in their diameter and stacked structure to the real pipes from the Gulf of Mexico. The top layer was a perforated plate with four holes, each five millimetres in size, then came a drainage layer of square weave mesh followed by the screen media itself and finally another square weave mesh drainage layer. The four layers were not sintered together, but instead simply sealed along their edges. Plain dutch weave (PDW), twilled dutch weave (TDW) and reverse twilled dutch weave (RTDW), which GKD manufactures under the name KPZ mesh, were used as filter media and their respective erosion behaviour compared. The test was performed by placing the screen coupons for a period of 48 hours in a watery silicon carbide suspension and exposing them to three different inlet face velocities: 0.18 m/s, 0.73 m/s and 0.98 m/s. This test duration equates to a service life of about five years in an oil field. The grain density of the test slurry was 800 mg/l with an average particle size of approx 0.03 millimetres and a hardness of 30 GPa on the Vickers scale. Because the filter mesh is the part of the screen pack with the smallest apertures, pore velocities are highest there – and, as a result, abrasion always begins on the filter mesh. With increasing inlet face velocity, the force of the mechanical assault on the mesh surface also increases, and so does the erosion. The test allowed the mass-based screen erosion to be calculated, i.e. specific erosion as the delta from final weight to initial weight in grams divided by the original weight in grams. For the filter medium layer of the test coupon – with its maximum penetrating particle (MPP) of 155 µm, a 150 µm pore size sample of each of the three mesh types was selected. At regular intervals during the course of the test, the changes occurring in the mesh sample in terms of pressure drop, material loss and pore size were measured. In the case of the PDW mesh, the MPP rose to 216 µm (after only one hour) and to 268 µm (after 2.5 hours). The TDW mesh sample's performance was somewhat better, but still not satisfactory. Only the single-layer KPZ mesh (RTDW) showed no signs of changes in its pore size and only marginal, negligible specific erosion. The filtration functionality of the KPZ mesh was still entirely there, even after completion of the 48-hour test.

New base parameters for erosion predictions in flow guidelines

The test impressively demonstrated that plain weave mesh is simply not up to the challenges of deployment in oil fields. After just 2.5 hours of exposure to the slurry flow, it had to be replaced in the test. It emerged that, from a specific erosion of 0.53 percent onwards, the mesh was already so badly damaged that sand began to penetrate the screen, i.e. sand control was lost. In the case of the twilled weave mesh, this effect occurred at a specific erosion level of 0.63 percent. At the same time, the test also showed clearly that mass loss only occurs topically – only where the holes in the perforated shroud layer are located. Consequently, for specific erosion – taking the correlation of increases in pore size and mass loss into consideration – a value calculated by GKD to derive a new base parameter for their formula for erosion prediction was used. The F scalar the erosion model is based on is a corrective value that takes factors into account like angle of impact, screen porosity, fluid viscosity and fluid density. The hardness term HRa – i.e. the hardness ratio between the surface of the metal mesh and the sand – was defined as an average exponent of 0.59. Previous measurement methods had not allowed closer specification of the angle of impact or the dynamic change in particle composition.

Well-specific predictions through CFD simulation

This is where the CFD simulations performed by the mesh experts at GKD brought clarity into the picture. Using this procedure, GKD can, from now on, reliably predict the angle at which particles will hit the wires of the filter medium for any given inlet face velocity. This, in turn, makes it possible, for example, to harden the stainless steel surface of the mesh wires to meet the specific requirements of individual wells. Using CFD simulations, GKD could also prove that the flow velocity multiplier ζ – which is used to infer pore velocity from the inlet face velocity – is in fact a great deal higher than the previously assumed factor of two to three. GKD verified that the maximum pore speed at an average flow rate can be determined from the inlet face velocity using a factor of 63. GKD's computer-assisted flow simulation also allows such inferences to be drawn for multi-layer constructions. Furthermore, it is also possible using this method to infer changes in the effective porosity of deployed filter media that can be specifically expected in the field. As an example, GKD modelled this for a plain weave mesh with three different inlet face velocities (0.18 m/s = slow; 0.73 m/s = medium; 0.97 m/s = fast). After one hour of slow flow, the mesh showed no weight loss. At medium flow over the same period of time, there was already a weight loss of 0.06 grams, and at the highest flow speed, the loss was already 0.14 grams after just one hour.

Clear recommendation for the use of KPZ mesh

The new findings make it immediately possible to achieve significantly more efficient well pipe construction. In order to determine a well-specific optimised mesh design using CFD simulation, all GKD needs are details of the specific composition of fluids or gases, and distribution, composition and hardness of the particles. On the basis of these data, the mesh experts can select – from three standard work materials – the one best suited to this particular scenario. Starting with the desired pore aperture and solidity requirements, the mesh is selected from a wide range of variants. Using simulations, GKD then configures the mesh precisely to the specific field operating conditions and the desired production rates. Because this calculation is done computationally rather than empirically, Sand Control Screens from GKD offer the certainty of high flow rates and long life cycles for pipes equipped with them. This precision from planning through to production on high-tech looms with comprehensive quality control is also a reason for the superiority of woven metal meshes over gravel packs as filter media. In the study the cleaned, annealed and 100% camera-inspected KPZ meshes proved to be particularly efficient. The extremely stable, single-layer KPZ meshes excel through their high porosity and their correspondingly low pore velocity. Not only do they surpass the mechanical capabilities of all other filter media alternatives on the market, they also enable well operators to achieve highly efficient production on the basis of filter media that have been optimally configured to their particular field. Available in a wide range of variants – there are four different mesh types to choose from in the 150 µm range alone – KPZ meshes from GKD also offer enormous flexibility in terms of their configuration. They can be optimised exactly to meet the wishes of operators in terms of erosion performance, price or even robustness. This opens up completely new perspectives for economically sustainable exploration and production of oil and natural gas.

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GKD – GEBR. KUFFERATH AG

The owner-run technical weaver GKD – GEBR. KUFFERATH AG is the global market leader for metal and plastic woven solutions as well as transparent media facades. Under the umbrella of GKD – WORLD WIDE WEAVE the company combines three independent business units: SOLID

WEAVE (industrial meshes), WEAVE IN MOTION (process belt meshes) and CREATIVE WEAVE (architectural meshes). With its six plants – including the headquarters in Germany and other facilities in the US, South Africa, China, India and Chile – as well as its branches in France, Great Britain, Spain, Dubai, Qatar and worldwide representatives, GKD is never far from its customers.

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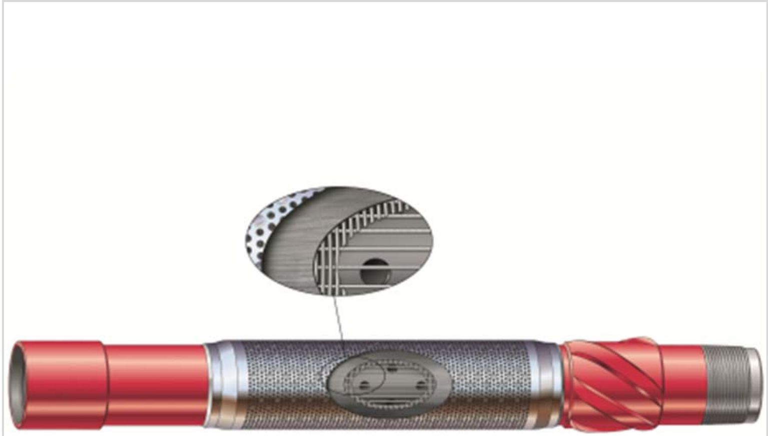
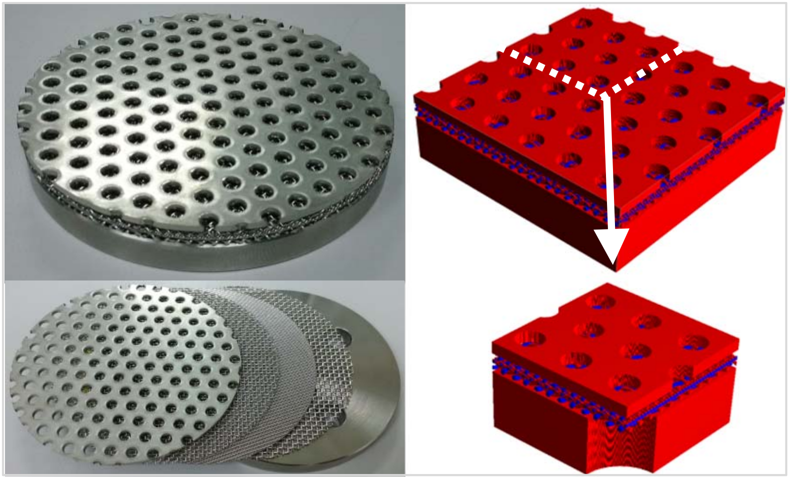
Picture 1: The efficiency of oil platforms results from the ratio of life cycles of the pipelines and flow rates.



Picture 2: Stacked structure of the investigated pipes.

Picture 3: For the laboratory test, test coupons were used which corresponded in their diameter and structure to the real pipes from the Gulf of Mexico.



Picture 4: Real and virtual structure of the filter configuration.

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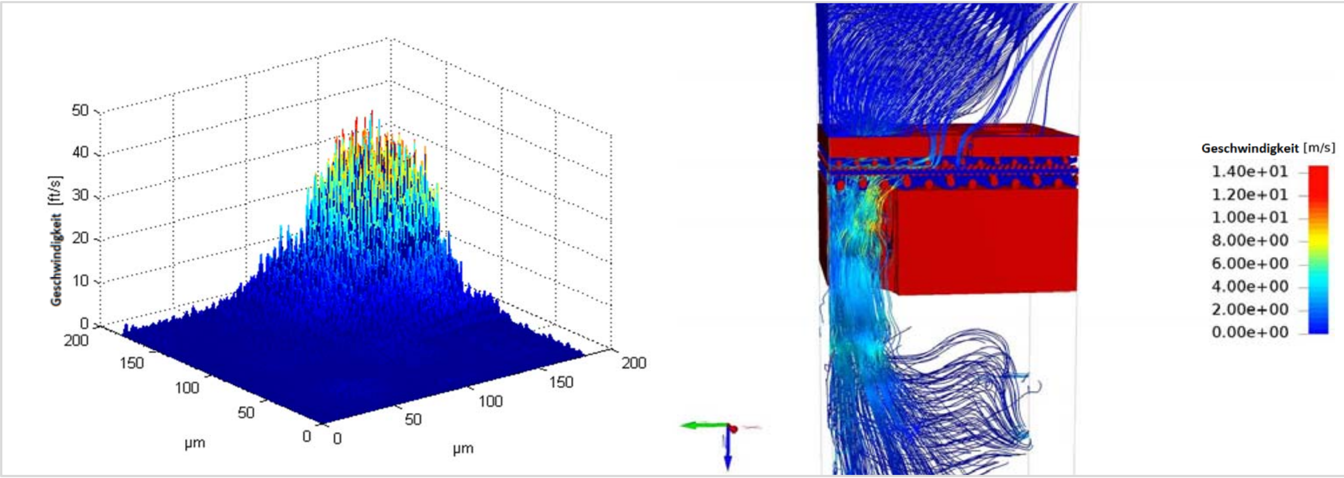

Picture 5: Estimation of the pore velocities based on CFD simulations from GKD inside the woven filter media.

We will be happy to send you the desired images in printable resolution by e-mail.

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