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# Effect of Wire Design (Profile) on Sand Retention Parameters of Wire-Wrapped Screens for Conventional Production: Prepack Sand Retention Testing Results

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**Abstract:** There are many technologies to implement sand control in sand-prone wells, drilled in either weakly or nonconsolidated sandstones. Technologies that are used to prevent sanding can be divided into the following groups: screens (wire-wrapped screens, slotted liners, premium screens, and mesh screens), gravel packs, chemical consolidation, and technological ways (oriented perforation and bottomhole pressure limitation) of sanding prevention. Each particular technology in these groups has their own design and construction features. Today, slotted liners are the most well-studied technology in terms of design, however, this type of sand control screen is not always accessible, and some companies tend towards using wire-wrapped screens over slotted liners. This paper aims to study the design criteria of wire-wrapped screens and provides new data regarding the way in which wire design affects the sanding process. Wires with triangular (wedge), trapezoidal, and drop-shaped profiles were tested using prepack sand retention test methodology to measure the possible impact of wire profile on sand retention capabilities and other parameters of the sand control screen. It was concluded that a trapezoidal profile of wire has shown the best result both in terms of sand production (small amount of suspended particles in the effluent) and in particle size distribution in the effluent, that is, they are the smallest compared to other wire profiles. As for retained permeability, in the current series of experiments, high sand retention did not affect retained permeability, although it can be speculated that this is mostly due to the relatively high particle size distribution of the reservoir.

**Keywords:** sand production; sanding; sand control; wire-wrapped screens; prepack sand retention test



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## 1. Introduction

Sand control technologies are widely used to prevent sand production. Thus, reducing costs and time loss due to well workovers in many areas worldwide. The application of sand control technologies is dictated by the necessity to protect both subsurface and surface equipment from erosion provided by sand grains. A hypothetical "perfect" screen would completely eliminate sand influx into the well (or reduce it to a negligible scale) and allow free passage to the fluid. In reality, screens are designed with the intent to let some sand grains pass through screen slots in order to prevent plugging of the slots, which will result in an overall decrease in production rates. Screens also cause flow redistributions (and velocity increase [1]) due to possible impairment of the slots [2], which results in fluid moving toward the slot opening in the near-screen area. This leads to additional pressure drop in the "bottomhole zone–wellbore" system.

In general, the performance assessment of any screen must be evaluated by the following parameters:

1. Open to flow area (OFA);
2. Sand production decrease due to screen implementation;
3. Retained permeability of the screen (or "bottomhole zone–screen" system);
4. Particle size distribution of the filtered particles.

There are also criteria to follow in terms of the mechanical integrity of the screen [3]:

1. Screen installation (torque and other strains);
2. Screen operation (resistance to erosion and corrosion).

Some authors also note that a screen should provide stability of the bottomhole formation zone [4] and this is essentially achieved by retaining sand grains with a size >50 microns, which hold most of the overburden loadout [5].

Fattahpour [6] argues that instead of using OFA as a parameter in screen performance assessment, aperture size should be used due to the possible misinterpretation of OFA. The screen can have a very high opening, but a limited number of slots (or slots per column (SPC)), and it will have the same OFA as a screen with narrow openings and a large amount of these openings. However, the difference in the amount of sand that each of these screens can "produce" is obvious.

Some researchers argue that an effective screen should not produce more than 0.12 lbs/ft$^2$ (580 grams/m$^2$) [2]; or 0.15 lbs/ft$^2$ (732 grams/m$^2$) [7] of sand. However, this raises a concern. Are these thresholds about equipment protection (by restricting solids production we eliminate erosion) or about preventing sand plugs from forming? Equipment used by different companies is different (in terms of resistivity to corrosion or overall strength) and that also depends on the manufacturer's capabilities and other features of surface and subsurface equipment [8,9]. As for sand plugs forming, this process depends on the rate of liquid production. Thus, extremely productive wells can also have high solids production. However, this is rarely a problem due to the high velocity of fluids in the production string, which prevents sand plugs from forming.

One of the parameters of the screen that affects 3/4 of the listed parameters is slot (wire) geometry. Bennion [10] provided an exquisite explanation of the slot geometry effect for slotted liners (SL), however, there is no study regarding the effect of wire profile for wire-wrapped screens (WWS).

In addition to the properties of the sand control technology implemented, the process of sanding is basically affected by the following properties and parameters of the fluid and reservoir:

1. Fluid viscosity—the higher the viscosity, the higher is the amount of produced sand [11,12];
2. Gas content [5,6,13–15];
3. Particle size distribution of the reservoir and shape parameters of particles [16,17];
4. Clay content [4,18];
5. Stress distribution in the bottomhole formation zone [19–21];
6. Pore pressure [22,23];
7. Bottomhole pressure, production rate, and velocity of fluids in the reservoir [1,5,24–26];
8. Flow regime [13,21,27];
9. Reservoir depletion [15,28,29];
10. Ramp-up rate [15,16,30];
11. Water cut [31,32];
12. Properties of the reservoir—the amount of reservoir cement, rock strength, etc. [33–36].

Essentially, there are two most widely used and adopted screens, namely wire-wrapped screens and slotted liners. Both have their pros and cons, whilst slotted liners tend to have a higher strength, low cost, and ease of production [37–39]. Wire-wrapped screens have a higher OFA (which means they are less prone to plugging and create less pressure drop) [6,35,40] and provide more options in terms of applicability.

On the other hand, OFA is a criterion that does not properly describe sand control screens in terms of overall efficiency due to the nature of OFA itself. It combines both sand control (through screen aperture size) and flow efficiency (through slots per column or opening width) parameters, which act against one another in most cases. In general, higher OFA means higher sand production [12,41], but lower additional pressure drop due to flow convergence [5,25] and lower plugging tendency [4,35].

Slotted liners are widely used in SAGD-wells in Canada, where flowrates in the producer ("bottom well") are not that high. Thus, a high open to flow area does not necessarily means that this will affect amount of produced sand. Reservoirs comprised from weakly consolidated sandstones, tend to have very high permeabilities [42–44]. Thus, wells can have flowrates as high as 500 tons/day (approx. 3500 bbl/day). In this case, OFA is a crucial parameter, the importance of which cannot be underestimated. The only thing that is left to change in terms of sand retention is the geometry of the screen itself.

Mahmoudi [3] has shown that under the effect of high flowrates, perforation tunnels in a base pipe deform from a round to an oval shape in corrosive-active environments. Thus, the base pipe can be considered a weak component. This is mostly the case for slotted liners since the screen itself is a base pipe with openings of a particular form. Furthermore, erosion can also cause a change in metal profile creating spots of increased aperture size, that allow high sand production.

Bennion [10] has shown that the geometry of the slotted liner slots affects the efficiency of the slotted liner in terms of sand control (solids production) and pressure drop. Rolled/seamed top slots (Figure 1) tend to have the lowest additional pressure drop and the lowest sand production. The mechanism of that is not actually explained, although the author argues that plugging happens on top of the slot, rather than in the slot itself in most cases.


**Figure 1.** Slotted liner slot configuration [by authors].

Different slot configurations and patterns were studied by Xie [37]. It is noted that for strength-related reasons (withstanding strain deformations and torque) OFA of slotted liners is designed to be much lower than it should be for effective production [45]. Although calculations for OFA should be different for different types of slots, for straight slots it does not matter which diameter you choose, however, for keystone or rolled/seamed slots, it is better to use the outer diameter.

There is a great difference in the basis of slotted liners and wire-wrapped screens. While a slotted liner must withstand all the stresses and loads and still maintain high enough production capabilities, this role in WWS is played by the base pipe, thus, creating a lot of space for wire designing. For example, wires can be made out of stainless steel or any other alloy that can ensure long-term operation under corrosive-active conditions [39]. This also helps to prevent plugging either by corrosion byproducts or by fine particles, that attach to these byproducts [46,47].

The main concern in the field of slot geometry for slotted liners is whether the enlargement of the opening towards the inner part of the screen results in a better performance in terms of sand retaining and the plugging tendency of the slot [48]. This paper is aimed at studying the same effect, but for wire-wrapped screens (Figure 2).

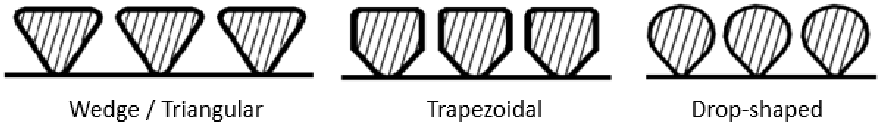


**Figure 2.** Different wire profiles [by authors].

## 2. Materials and Methods

Conventional production does not require accounting for such difficulties in sand control testing as high temperatures, thermal expansion, and some other quirks of SAGD production that are widely studied by different authors [49].

Laboratory testing for this publication was made in the form of a Prepack sand retention test (Prepack SRT). It features conditions when a large portion of the bottomhole formation zone collapses into the wellbore, which is highly likely due to stress distributions and the impossibility of the formation to withstand stresses exerted by reservoir drawdown in weakly consolidated or nonconsolidated reservoirs [50].

A series of tests were run to measure the efficiency of different wire profiles for implementing them in wire-wrapped screens. It is important to note that there is not a single work examining this effect. Images of different wire-wrapped screens with different wire profiles can be seen in Figure 3.


**Figure 3.** Wire-wrapped screens with different wire profiles [by authors] (wires are welded to elements of longitudinal supporting ribs).

These are screens with an aperture size of 150 microns. The same screens, though with an aperture of 200 microns, were also tested.

The methodology of sand preparation, experiment procedure, and other features of Prepack SRT have been covered in many papers. The authors have used a methodology that was previously implemented [42,50]. It is important to note that in this series of tests, sand, which was extracted from the bottomhole formation zone, was used to prepare the core rock models. Core rock models were also saturated with reservoir water before an experiment. The particle size distribution (PSD) of the reservoir rock can be seen in Figure 4.

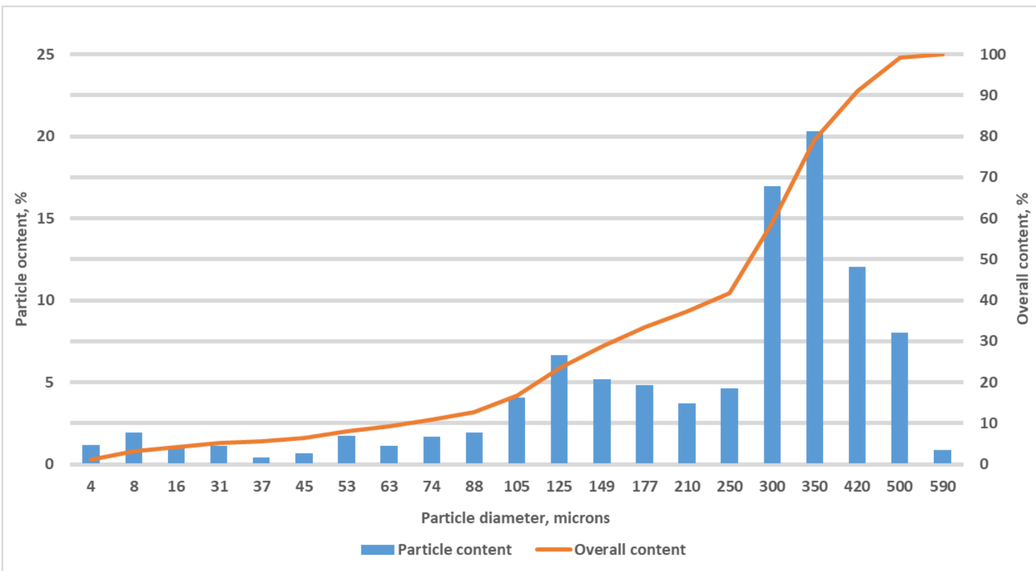


**Figure 4.** Formation particle size distribution.

Note that reservoir PSD is governed by sand particles with high particle diameters. Applying the criterion proposed by Fermaniuk, Coberly, Suman, Markestad, and Gillespie for wire-wrapped screens gives a summary of screen aperture sizes for particular PSD mentioned in this paper (Table 1):

**Table 1.** WWS aperture sizes by different authors.

| Author | Criterion | Screen Aperture Size, Microns |
|---|---|---|
| Fermaniuk | 2·D30 < aperture < 3.5·D50 | 300 < aperture < 900 |
| Coberly | 2·D10 | 140 |
| Suman | D10 | 70 |
| Markestad | D10 < aperture < 2·D10 | 70 < aperture < 140 |
| Gillespie | Aperture < 2·D50 | Aperture < 500 |

Screen aperture sizes of 150 and 200 microns follow Coberly's and Gillespie's criteria.

Researchers note that recalculation of overburden pressure (rock pressure) from the reservoir to laboratory conditions is a challenge that should be carefully examined. Anderson [51] was applying the same rock pressure as in the reservoir. In this series, the authors decided to apply rock pressure that will make it possible for the reservoir rock models to have the same permeability as in reservoir conditions. Thus, during preliminary tests, rock pressure in the coreholder was set to 450 psi (3 MPa approx.), which is approximately 3.5 times smaller than the actual overburden (rock) pressure acting in the reservoir.

In this study, reservoir fluids were simulated with suitable fluids. Oil was modeled by mixing polymethylsiloxane oils with viscosities of 5 and 50 mPa·s to reach a viscosity of 9 mPa·s, which corresponds to oil viscosity in reservoir conditions. Reservoir water was prepared using distilled water and corresponding salts to match the content of different salts in reservoir conditions.

In current field conditions, lots of wells operate with water cuts equal to 70% or higher. Thus, models of oil and reservoir water were injected into the model at a ratio of 30% "oil" and 70% "water".

A schematic representation of the installation, that was used to conduct experiments, is shown in Figure 5.

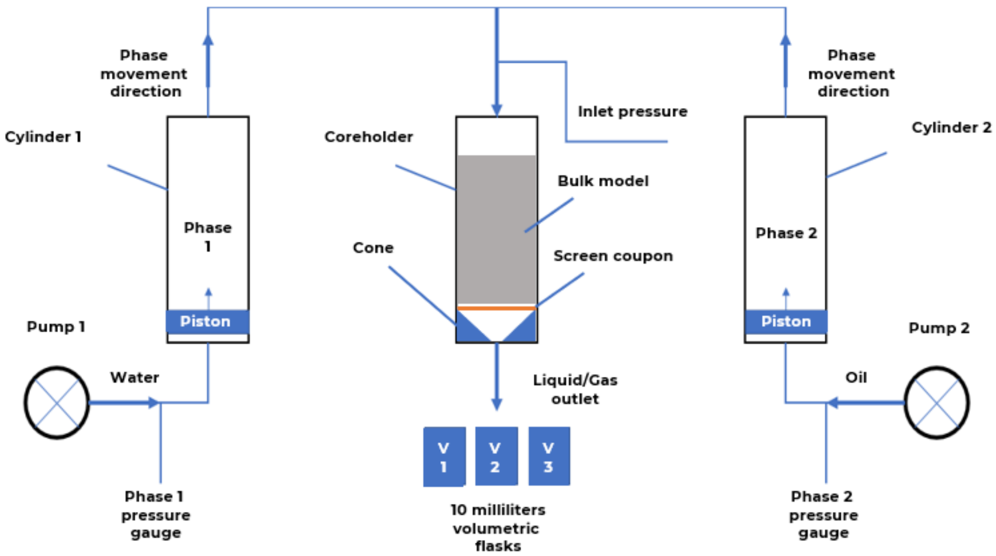


**Figure 5.** Scheme of the installation for Prepack SRT implementation [by authors].

Associated gas content is relatively small with values from 10–15 cubic meters per ton of oil. Thus, it was decided to not account for it and use only 2 pumps (for "oil" and for "water"). The installation used in these experiments allows the use of core rock models, which were saturated before an experiment. However, the size (volume) of the core rock model is relatively small compared to models of the reservoir in the linear or radial sand control evaluation test, however, the small scale allows for the perfect simulation of reservoir properties on a constant basis.

## 3. Results

During the experiments, three key parameters of the sand retention media were measured: suspended particles content (SPC); particle size distribution (PSD) of the particles, that passed through the screen; and retained permeability of the screen.

Results of the data analysis regarding SPC and PSD of particles in the effluent can be seen in Figures 6 and 7.

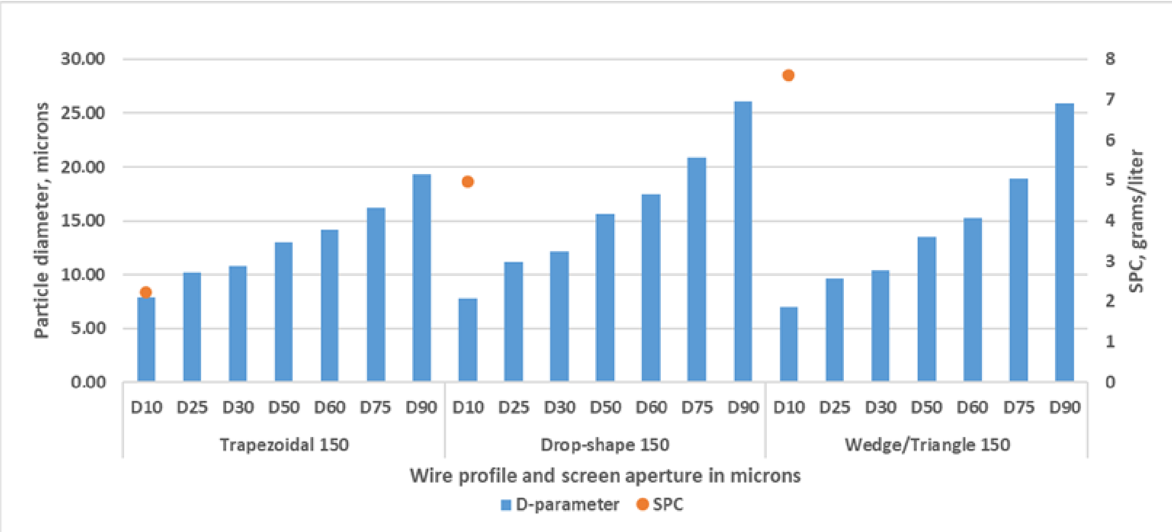


**Figure 6.** Experimental results for screens with an aperture size of 150 microns.

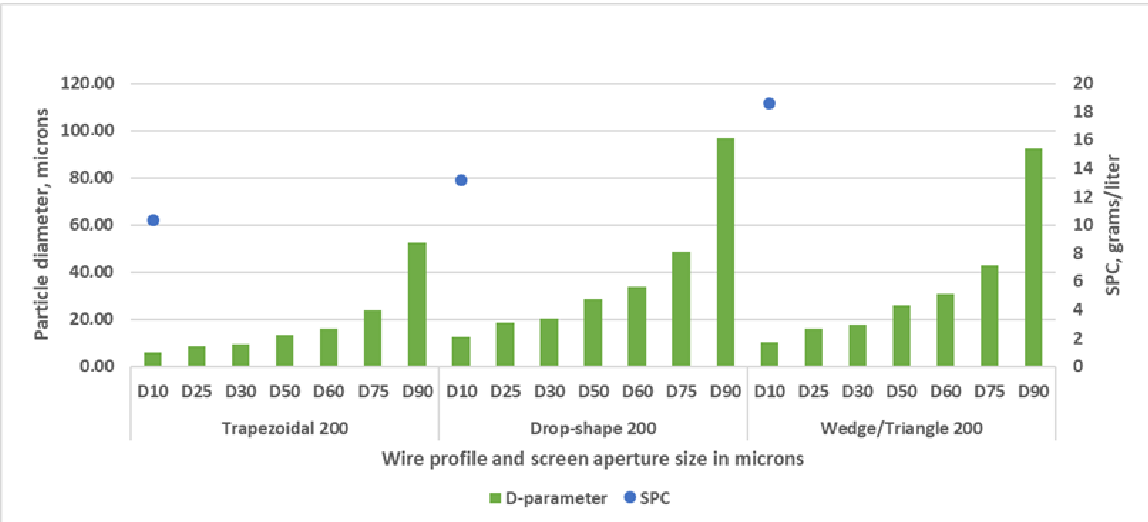


**Figure 7.** Experimental results for screens with an aperture size of 200 microns.

It is worth noting that even though the screen's aperture increased by 50 microns (which is 1/3 of the original 150 microns screen value), the resulting diameter of washed out particles increased by 2–3 times for drop-shape and wedge/triangle wire profiles. This is mostly the case for a larger part of the D-parameter (D75–D90) of particles, though.

A trapezoidal wire profile has shown outstanding performance both in terms of suspended particle content (SPC) and in terms of the washed-out particles' diameter. This might be crucial for wells that work in a periodic regime (for example, 1 h of work and 1 h of accumulation) since such a regime does not provide a sand screen with suitable conditions to form stable sand arches (or bridges), which reduce sand production naturally. For wells that work in a stable regime, sand production stabilizes over time with a certain suspended particle content [2,32,52].

Note that an increase in screen aperture to 50 microns resulted in an almost five times increase in SPC for the trapezoidal screen, almost three times for the drop-shape screen, and in 2.5 times for the screen with a wedge-shaped profile (which is a "conventional" wire-wrapped screen).

This had to affect retained permeability, since larger particles must have formed a bridge on the surface of the screen, thus, decreasing its permeability. The retained permeability of the screens is shown in Figures 8 and 9.

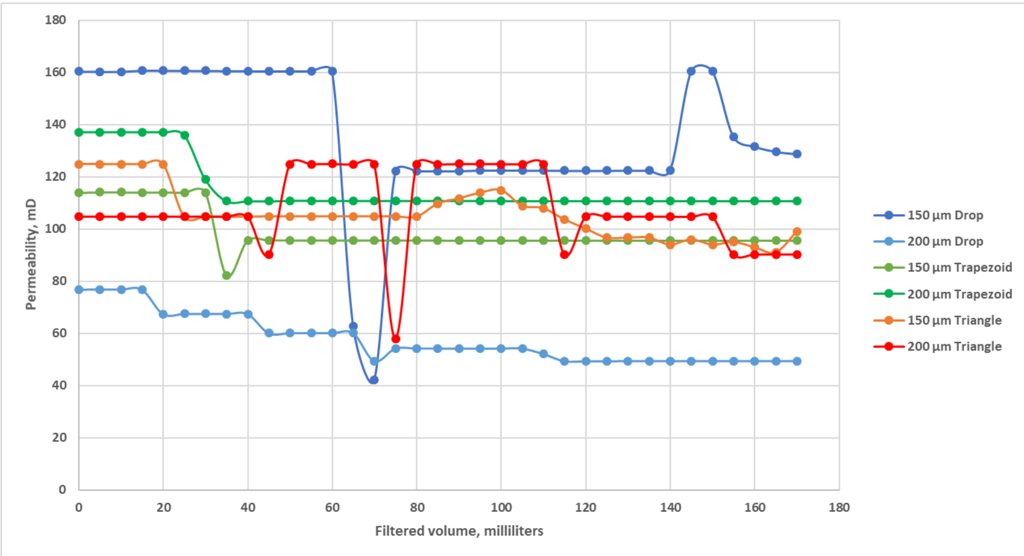


**Figure 8.** Retained permeability of screens in millidarcies.

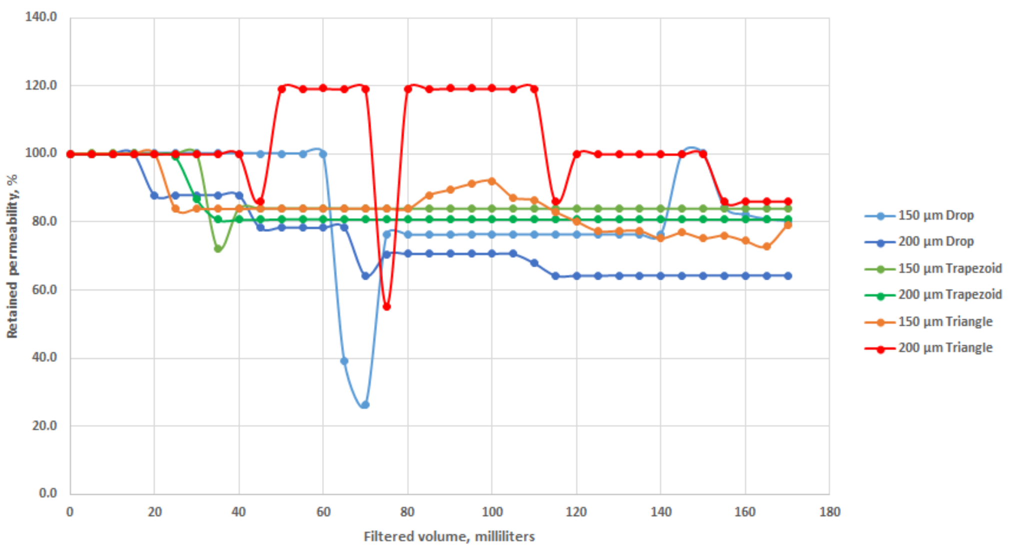


**Figure 9.** Retained permeability of screens in percent.

Figure 8 represents the pressure difference during the tests for each screen. Since core rock models have varying permeability, it is better to compare screens with different wire profiles in relative changes in permeability, as it is presented in Figure 9. The first point on the graph (for zero filtered volume) represents a situation where pressure reached the required value (for each core model it was different, ranging from ~345,000 pascals (50 psi) to ~518,000 pascals (75 psi)). Thus, zero filtered volume is not actually zero.

Although large fluctuations in permeability can be described via the working principle of the pressure transducer (due to a mixture of water and oil, the transducer sensor might translate the wrong data), in general, screens with a lower aperture size (150 microns (µm)) show the lowest retained permeability. In the 150 µm group, the trapezoidal screen shows the highest permeability. In the 200 µm group, it shows the worst permeability. The drawdown pressure (and permeability, as follows) can be also explained via fines migration. A large portion of particles have a high diameter, thus, pore channels also have a relatively large diameter, which allows particles of a smaller size to completely block them, which would explain the decrease in permeability.

## 4. Discussion

There is no referent article to study the effect of the profile of wire in a wire-wrapped screen and how it can possibly affect the results of a sand retention test. It is possible to find an explanation for the phenomenon in other topics. Fattahpour [38] argues that the difference in results between linear and radial sand control evaluation (LSCE/RSCE) tests may be due to the fact that bridging (or the forming of sand arches) occurs more easily on curved surfaces than on the flat surface. Trapezoidal and triangular wires have the same form at the entrance point—they are both flat. This means the prolongation of the wires is what makes the difference in the tests.

The prolongation of the wires allows the particle to have more chances to be "stuck" in the screen media if a particle of sand goes through the bridge (or there is no bridge formed yet on a particular point on the screen's surface). Figures 10–12 represent different scenarios for the wire-wrapped screen operation. The contact line (screen with particles) is the smallest for the wedge/triangular screen; it is essentially a point. Once a particle passes through that point, it can no longer be captured by the screen.

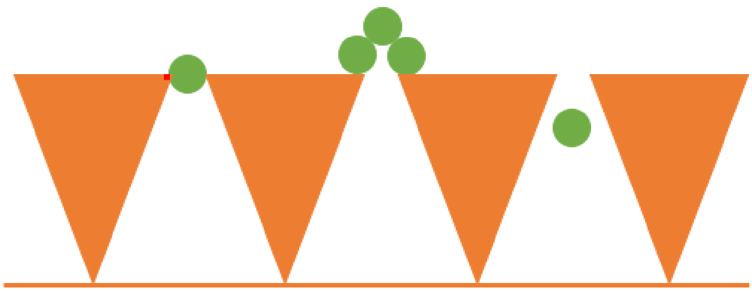

**Figure 10.** Wedge/Triangular wire profile and its interaction with particles.

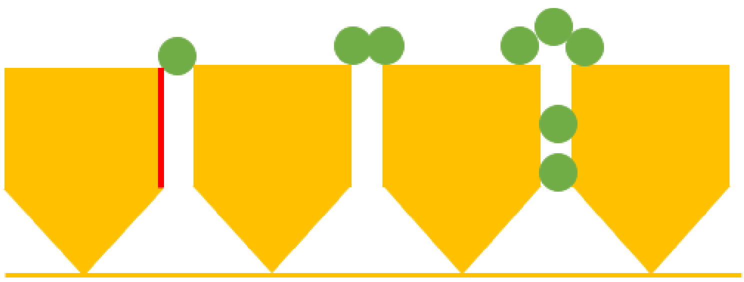

**Figure 11.** Trapezoidal wire profile and its interaction with particles.

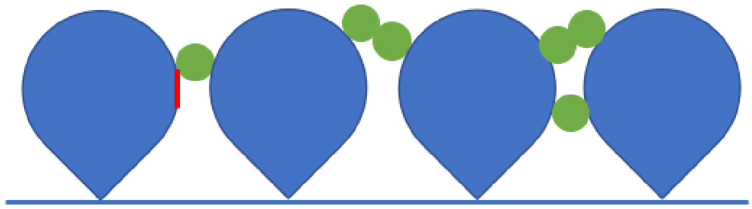

**Figure 12.** Drop-shaped wire profile and its interaction with particles.

The contact line of the trapezoidal profile is the largest. Thus, particles can be stuck easily two or more times during their path through the screen. The drop-shaped profile has a mediocre size of the contact line. Thus, it should be positioned between the previous two wire profiles in terms of produced sand and retained permeability [53].

The difference for produced sand can be observed in Figures 6 and 7, and one can say that it is fair, however, the retained permeability is not that simple due to the complex nature of the sanding process and the inability of scientists to duplicate the results on a constant basis due to sand mixture during core rock model preparations.

Another item of concern is a particle's "roundness", which can be measured via the aspect ratio and sphericity ratio of the particle [17]. Roundness should have a higher effect on screens with higher outer diameters of the screen opening, compared to inner diameters. This mostly applies to a drop-shaped profile of the wire. This is mostly due to the high open to flow area of the drop-shaped screen on the outer area. Thus, if it will be properly blocked by a particle of an irregular shape, it will have higher permeability compared to other wire profiles (and screens made of them) in general.

The height of the opening also increases the overall strength of the wire-wrapped screen (due to the higher content of metal, compared to other screens), which makes it more reliable in terms of installation failures and helps to ensure the screen's efficiency, saving even in emergency situations.

In this study, core rock models were made of the same rock. Thus, it was impossible to study the effect of particle shape parameters on the screen efficiency of different wire profiles. Due to the differences in inner and outer diameters of the wire-wrapped screens of all profiles, the results would differ between them. From a logical point of view, a drop-shaped wire profile of wire-wrapped screens would be the best choice for particles of irregular shape since it has the same actual screen aperture (in the "middle-part"), though it has a higher OFA due to increase in aperture towards the outer part of the screen.

A large topic of discussion is the erosion of wire-wrapped screens. Since erosion depends on many variables, such as the velocity of the fluid [54–56], fines content [57], and degree of plugging (through localized velocity increase) [58]. Among them stands the impact angle. According to [59], impact angle is defined as the angle between the targeted surface and the direction of particle impact velocity. In a study reported by [60], it was shown that the maximum erosion rate is reached when the impact angle is close to the surface normal (i.e., 90°). There are also publications [55] that suggest that the highest erosion rate is reached when the impact angle is close to 45°. The difference can be explained by different methodologies in the experiments since an angle of 90° is reported for liquid flow, while the 45° angle was achieved via sand–air mixture blasting. Zhang [61] widely discussed the effect of turbulence on the erosion of different sand control screens. The authors concluded that turbulent flow attributes to the constant change in impact angle without any connection to the angle between the perforation tunnel or pore-space exit opposite to the screen surface. They also noted that different impact angle causes different types of wear (erosion). The low impact angle causes microcuttings of the screen surface, whereas high angles and speeds cause the particle to apply cracks or extrusive lips on the screen surface. Given that the drop-shaped wire profile has a curved surface, it should be less prone to erosion from liquid flows and more prone to erosion from gas-induced erosion (high speeds and turbulent flows). A trapezoidal wire profile is still prone to liquid-flow induced erosion, just as the triangular (basic) wire-wrapped screen is. Extra plugging caused by the drop-shaped wire-wrapped screen (hence the high probability of localized erosion) can be balanced out with the screen curvature.

Another thing of concern is the form (or shape) of the PSD curve. In this study, the PSD curve was steadily growing (in the overall content of particles) towards the higher size of particles. However, there are also PSD curves that have a bell-shaped profile or even a reverse bell shape, which would also affect the results of the screen tests.

As far as wire production is concerned, it is a rather flexible process in which the shape of the wire can be changed depending on the results of laboratory experiments and any other necessary conditions. The wire is produced by cold rolling, and the only component of the process that needs to be changed is the shape of the die. The economics of wire production depends on the supplier's price for the cold rolling of a wire.

## 5. Conclusions

The development of sand control screens has led to a new field of research in their design and geometry. The main aspect of these screens is slot geometry (opening profile). Slotted liners are well studied in that matter, however, they are not always applicable. This paper studies the effect of wire profiles on sand control capabilities and other parameters of sand screens during prepack sand retention testing. A trapezoidal profile shows outperforming results compared to other screens in both screen groups. Compared to other screens, it has the lowest amount of suspended particles in the effluent, and these particles are the smallest in size.

A screen with a trapezoidal wire profile with an aperture size of 150 microns had 2.5 times less suspended particles content (SPC) than a screen with a drop-shape wire profile and almost four times less SPC than a "conventional" wedge-shaped wire wrapped screen. In comparing the results of screens with different wire profiles with 200 microns aperture sizes, the trapezoidal wire profile also showed the best results, even though in this group, the difference in results was not that notable—1.4 times less than the drop-shaped screen and 1.8 times less than a "conventional" wedge-shaped wire wrapped screen.

Retained permeability of the "core rock model–screen" system for a screen with a trapezoidal wire profile (for both apertures) was approximately 80% of the initial, and it is just a bit smaller than the best results shown by the "conventional" wire wrapped screen with a triangular (wedge) wire profile, which was approximately 85%.

**Author Contributions:** Conceptualization, E.S. and D.T.; methodology, M.G. and M.K.; validation, I.S. and L.F.; investigation, M.G.; resources, D.T. and E.S.; data curation, M.G.; writing—original draft preparation, M.G.; writing—review and editing, D.T., E.S., M.K., I.S. and L.F.; visualization, M.G.; supervision, D.T.; project administration, E.S. and M.G.; All authors have read and agreed to the published version of the manuscript.

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## References

1. Cameron, J.; Zaki, K.; Jones, C.; Lazo, A. Enhanced Flux Management for Sand Control Completions. In Proceedings of the SPE Annual Technical Conference and Exhibition, Dallas, TX, USA, 24 September 2018; p. 16.
2. Chanpura, R.A.; Hodge, R.M.; Andrews, J.S.; Toffanin, E.P.; Moen, T.; Parlar, M. A Review of Screen Selection for Standalone Applications and a New Methodology. *SPE Drill. Complet.* **2011**, *26*, 84–95. [CrossRef]
3. Mahmoudi, M.; Roostaei, M.; Fattahpour, V.; Sutton, C.; Fermaniuk, B.; Zhu, D.; Jung, H.; Li, J.; Sun, C.; Gong, L.; et al. SPE-191553-MS Standalone Sand Control Failure: Review of Slotted Liner, Wire Wrap Screen, and Premium Mesh Screen Failure Mechanism. In Proceedings of the SPE Annual Technical Conference and Exhibition, SPE Annual Technical Conference and Exhibition, Dallas, TX, USA, 24 September 2018; pp. 1–26.

4. Guo, Y.; Nouri, A.; Nejadi, S. Effect of Slot Width and Density on Slotted Liner Performance in SAGD Operations. *Energies* **2020**, *13*, 268. [CrossRef]
5. Romanova, U.G.; Gillespie, G.; Sladic, J.; Weatherford, T.M.; Solvoll, T.A.; Andrews, J.S. A Comparative Study of Wire Wrapped Screens vs. Slotted Liners for Steam Assisted Gravity Drainage Operations. In Proceedings of the World Heavy Oil Congress, New Orleans, LA, USA, 5 March 2014; p. 24.
6. Fattahpour, V.; Mahmoudi, M.; Wang, C.; Kotb, O.; Roostaei, M.; Nouri, A.; Fermaniuk, B.; Sauve, A.; Sutton, C. Comparative Study on the Performance of Different Stand-Alone Sand Control Screens in Thermal Wells. In Proceedings of the SPE International Conference and Exhibition on Formation Damage Control, Lafayette, LA, USA, 7–9 February 2018; Volume 2.
7. Adams, P.R.; Davis, E.R.; Hodge, R.M.; Burton, R.C.; Ledlow, L.; Procyk, A.D.; Crissman, S.C. Current State of the Premium Screen Industry: Buyer Beware, Methodical Testing and Qualification Shows You Don't Always Get What You Paid For. *SPE Drill. Complet.* **2009**, *24*, 362–372. [CrossRef]
8. Dvoynikov, M.; Sidorov, D.; Kambulov, E.; Rose, F.; Ahiyarov, R. Salt Deposits and Brine Blowout: Development of a Cross-Linking Composition for Blocking Formations and Methodology for Its Testing. *Energies* **2022**, *15*, 7415. [CrossRef]
9. Rogachev, M.; Aleksandrov, A. Justification of a Comprehensive Technology for Preventing the Formation of Asphalt-Resin-Paraffin Deposits during the Production of Highlyparaffinic Oil by Electric Submersible Pumps from Multiformation Deposits. *J. Min. Inst.* **2021**, *250*, 596–605. [CrossRef]
10. Bennion, D.B. Protocols for Slotted Liner Design for Optimum SAGD Operation. *J. Can. Pet.* **2009**, *48*, 21–46. [CrossRef]
11. Dong, C.; Zhang, Q.; Gao, K.; Yang, K.; Feng, X.; Zhou, C. Screen Sand Retaining Precision Optimization Experiment and a New Empirical Design Model. *Pet. Explor. Dev.* **2016**, *43*, 1082–1088. [CrossRef]
12. Devere-Bennett, N. Using Prepack Sand-Retention Tests (SRT's) to Narrow Down Liner/Screen Sizing in SAGD Wells. In Proceedings of the Thermal Well Integrity and Design Symposium, SPE-178443-MS, Baniff, AB, Canada, 24 November 2015.
13. Ahad, N.A.; Jami, M.; Tyson, S. A Review of Experimental Studies on Sand Screen Selection for Unconsolidated Sandstone Reservoirs. *J. Pet. Explor. Prod. Technol.* **2020**, *10*, 1675–1688. [CrossRef]
14. Andrews, J.S.; Jøranson, H.; Raaen, A.M. OTC 19130 Oriented Perforating as a Sand Prevention Measure-Case Studies from a Decade of Field Experience Validating the Method Offshore Norway. In Proceedings of the Offshore Technology Conference, Houston, TX, USA, 5 May 2008; p. 12.
15. Isehunwa, S.; Farotade, A. Sand Failure Mechanism and Sanding Parameters in Niger Delta Oil Reservoirs. *J. Eng. Sci. Technol.* **2010**, *2*, 777–782.
16. Eshiet, K.I.-I.I.; Sheng, Y. Investigating Sand Production Phenomena: An Appraisal of Past and Emerging Laboratory Experiments and Analytical Models. *Geotechnics* **2021**, *1*, 492–533. [CrossRef]
17. Cespedes, A.E.M.; Roostaei, M.; Uzcátegui, A.A.; Gomez, D.M.; Mora, E.; Alpire, J.; Torres, J.; Fattahpour, V. SPE-199062-MS Sand Control Optimization for Rubiales Field: Trade-Off Between Sand, Flow Performance and Mechanical Integrity. In Proceedings of the SPE Latin American and Caribbean Petroleum Engineering Conference, Virtual, 27 July 2020; p. 31.
18. Gillespie, G.; Deem, K.; Malbrel, C. SPE 64398 Screen Selection for Sand Control Based on Laboratory Tests. In Proceedings of the SPE Asia Pacific Oil and Gas Conference and Exhibition, Brisbane, Australia, 16–18 October 2000.
19. Salahi, A.; Dehghan, A.N.; Sheikhzakariaee, S.J.; Davarpanah, A. Sand Production Control Mechanisms during Oil Well Production and Construction. *Pet. Res.* **2021**, *6*, 361–367. [CrossRef]
20. Salehi, M.B.; Moghadam, A.M.; Marandi, S.Z. Polyacrylamide Hydrogel Application in Sand Control with Compressive Strength Testing. *Pet. Sci.* **2019**, *16*, 94–104. [CrossRef]
21. Ikporo, B.; Sylvester, O. Effect of Sand Invasion on Oil Well Production: A Case Study of Garon Field in the Niger Delta. *Int. J. Eng. Sci.* **2015**, *4*, 64–72.
22. Kuncoro, B.; Ulumuddin, B.; Palar, S. *Sand Control for Unconsolidated Reservoirs*; IATMI: Jakarta, Indonesia, 3 October 2001; p. 7.
23. Bouteca, M.J.; Sarda, J.-P.; Vincke, O. Constitutive Law for Permeability Evolution of Sandstones During Depletion. In Proceedings of theSPE International Symposium on Formation Damage Control, Lafayette, LA, USA, 23 February 2000; p. 8.
24. Al-Awad, M.N.J.; El-Sayed, A.-A.H.; El-Din, S.; Desouky, M.; Soliman, M.A.; Ibrahim, A.A. Factors Affecting Sand Production from Unconsolidated Sandstone Saudi Oil and Gas Reservoir. *J. King Saud Univ.* **1998**, *11*, 163–181. [CrossRef]
25. Montero, J.D.; Chissonde, S.; Kotb, O.; Wang, C.; Roostaei, M.; Nouri, A. SPE-189773-MS A Critical Review of Sand Control Evaluation Testing for SAGD Applications. In Proceedings of the SPE Canada Heavy Oil Technical Conference, Calgary, AB, Canada, 13 March 2018; p. 21.
26. Nouri, A.; Belhaj, H.; Rafiqul Islam, M. Comprehensive Transient Modeling of Sand Production in Horizontal Wellbores. *SPE J.* **2007**, *12*, 468–474. [CrossRef]
27. Sultanbekov, R.; Islamov, S.; Mardashov, D.; Beloglazov, I.; Hemmingsen, T. Research of the Influence of Marine Residual Fuel Composition on Sedimentation Due to Incompatibility. *J. Mar. Sci. Eng.* **2021**, *9*, 1067. [CrossRef]
28. Garolera, D.; Carol, I.; Papanastasiou, P. Micromechanical Analysis of Sand Production. *Int. J. Numer. Methods Eng.* **2018**, *43*, 1207–1229. [CrossRef]
29. McPhee, C.; Farrow, C.; McCurdy, P. Challenging Convention in Sand Control: Southern North Sea Examples. *SPE Prod. Oper.* **2007**, *22*, 223–230. [CrossRef]
30. Mardashov, D. Development of Blocking Compositions with a Bridging Agent for Oil Well Killing in Conditions of Abnormally Low Formation Pressure and Carbonate Reservoir Rocks. *J. Min. Inst.* **2021**, *251*, 617–626. [CrossRef]

31. Luo, W.; Xu, S.; Torabi, F. Laboratory Study of Sand Production in Unconsolidated Reservoir. In Proceedings of the SPE Annual Technical Conference and Exhibition, San-Antonio, TX, USA, 8 October 2012; p. 14.
32. Bianco, L.C.B.; Halleck, P.M. Mechanisms of Arch Instability and Sand Production in Two-Phase Saturated Poorly Sandstones. In Proceedings of the SPE European Formation Damage Conference, SPE 68932, The Hague, The Netherlands, 21 May 2001; p. 10.
33. Fattahpour, V.; Moosavi, M.; Mehranpour, M. An Experimental Investigation on the Effect of Grain Size on Oil-Well Sand Production. *Pet. Sci.* **2012**, *9*, 343–353. [CrossRef]
34. Hisham, B.M.; Leong, V.H.; Lestariono, Y. Sand Production: A Smart Control Framework for Risk Mitigation. *Petroleum* **2020**, *6*, 1–13.
35. Khamehchi, E.; Ameri, O.; Alizadeh, A. Choosing an Optimum Sand Control Method. *Egypt. J. Pet.* **2015**, *24*, 193–202. [CrossRef]
36. Dvoynikov, M.; Buslaev, G.; Kunshin, A.; Sidorov, D.; Kraslawski, A.; Budovskaya, M. New Concepts of Hydrogen Production and Storage in Arctic Region. *Resources* **2021**, *10*, 3. [CrossRef]
37. Xie, J. Slotted Liner Design Optimization for Sand Control in SAGD Wells. In Proceedings of the SPE Thermal Well Integrity and Design Symposium, Banff, AB, Canada, 23–25 November 2015; pp. 23–25. [CrossRef]
38. Fattahpour, V.; Roostaei, M.; Hosseini, S.A.; Soroush, M.; Berner, K.; Mahmoudi, M.; Al-Hadhrami, A.; Ghalambor, A. Experiments with Stand-Alone Sand-Screen Specimens for Thermal Projects. *SPE Drill. Complet.* **2021**, *36*, 188–207. [CrossRef]
39. Van Vliet, J.; Hughes, M.J.; Limited, V.C. Comparison of Direct-Wrap and Slip-On Wire Wrap Screens for Thermal Introduction to Wire Wrap Screen. In Proceedings of the SPE Thermal Well Integrity and Design Symposium, Banff, AB, Canada, 23–25 November 2015; pp. 1–14. [CrossRef]
40. Matanovic, D.; Cikes, M.; Moslavac, B. *Sand Control in Well Construction and Operation*; Springer Environmental Science and Engineering; Springer: Berlin/Heidelberg, Germany, 2012.
41. Mahmoudi, M.; Roostaei, M. SPE-179036-MS Sand Screen Design and Optimization for Horizontal Wells Using Reservoir Grain Size Distribution Mapping. In Proceedings of the SPE International Conference and Exhibition on Formation Damage Control, Lafayette, LA, USA, 24–26 February 2016.
42. Tananykhin, D.; Grigorev, M.; Korolev, M.; Solovyev, T.; Mikhailov, N.; Nesterov, M. Experimental Evaluation of the Multiphase Flow Effect on Sand Production Process: Prepack Sand Retention Testing Results. *Energies* **2022**, *15*, 4657. [CrossRef]
43. Palyanitsina, A.; Safiullina, E.; Byazrov, R.; Podoprigora, D.; Alekseenko, A. Environmentally Safe Technology to Increase Efficiency of High-Viscosity Oil Production for the Objects with Advanced Water Cut. *Energies* **2022**, *15*, 753. [CrossRef]
44. Petrakov, D.G.; Penkov, G.M.; Zolotukhin, A.B. Experimental Study on the Effect of Rock Pressure on Sandstone Permeability. *J. Min. Inst.* **2022**, *254*, 244–251. [CrossRef]
45. Xie, J.; Fan, C.; Wagg, B.; Zahacy, T.A.; Matthews, C.M.; Fang, Y. Wire Wrapped Screens in SAGD Wells. *World Oil* **2008**, *229*, 115–120.
46. Romanova, U.; Ma, T. SPE 165111 An Investigation of the Plugging Mechanisms in a Slotted Liner from the Steam Assisted Gravity Operations. In Proceedings of the SPE European Formation Damage Conference & Exhibition, Noordwijk, The Netherlands, 5 June 2013; p. 8.
47. David, J.; Pallares, M.; Wang, C.; Haftani, M.; Pang, Y. SPE-193375-MS Experimental Assessment of Wire-Wrapped Screens Performance in SAGD Production Wells. In Proceedings of the SPE Thermal Well Integrity and Design Symposium, Banff, AB, Canada, 27–29 November 2018. [CrossRef]
48. Korotenko, V.A.; Grachev, S.I.; Kushakova, N.P.; Mulyavin, S.F. Assessment of the Influence of Water Saturation and Capillary Pressure Gradients on Size Formation of Two-Phase Filtration Zone in Compressed Low-Permeable Reservoir. *J. Min. Inst.* **2020**, *245*, 569–581. [CrossRef]
49. Fattahpour, V.; Azadbakht, S.; Mahmoudi, M.; Guo, Y.; Nouri, A.; Leitch, M. Effect of near Wellbore Effective Stress on the Performance of Slotted Liner Completions in SAGD Operations. In Proceedings of the SPE Thermal Well Integrity and Design Symposium, Banff, AB, Canada, 28 November–1 December 2016; pp. 142–153. [CrossRef]
50. Tananykhin, D.; Korolev, M.; Stecyuk, I.; Grigorev, M. An Investigation into Current Sand Control Methodologies Taking into Account Geomechanical, Field and Laboratory Data Analysis. *Resources* **2021**, *10*, 125. [CrossRef]
51. Anderson, M. SPE-185967-MS SAGD Sand Control: Large Scale Testing Results. In Proceedings of the SPE Canada Heavy Oil Technical Conference, Calgary, AB, Canada, 15 February 2017; pp. 15–16.
52. Chernykh, V.I.; Martyushev, D.A.; Ponomareva, I.N. Study of the Formation of a Well Borehole Zone When Opening Carbonate Reservoirs Taking Into Account Their Mineral Composition. *Bull. Tomsk Polytech. Univ. Geo Assets Eng.* **2022**, *333*, 129–139. [CrossRef]
53. Galkin, V.I.; Martyushev, D.A.; Ponomareva, I.N.; Chernykh, I.A. Developing Features of the Near-Bottomhole Zones in Productive Formations at Fields with High Gas Saturation of Formation Oil. *J. Min. Inst.* **2021**, *249*, 386–392. [CrossRef]
54. Greene, R.; Moen, T. The Impact of Annular Flows on High Rate Completions. In Proceedings of the SPE International Symposium and Exhibition on Formation Damage Control, Lafayette, LA, USA, 15–17 February 2012; Volume 2, pp. 886–897. [CrossRef]
55. Kanesan, D.; Mohyaldinn, M.E.; Ismail, N.I.; Chandran, D.; Liang, C.J. An Experimental Study on the Erosion of Stainless Steel Wire Mesh Sand Screen Using Sand Blasting Technique. *J. Nat. Gas Sci. Eng.* **2019**, *65*, 267–274. [CrossRef]
56. Cameron, J.; Jones, C. Development, Verification and Application of a Screen Erosion Model. In Proceedings of the European Formation Damage Conference, Scheveningen, The Netherlands, 30 May–1 June 2007. [CrossRef]

57. Abduljabbar, A.; Mohyaldinn, M.; Younis, O.; Alghurabi, A. A Numerical CFD Investigation of Sand Screen Erosion in Gas Wells: Effect of Fine Content and Particle Size Distribution. *J. Nat. Gas Sci. Eng.* **2021**, *95*, 104228. [CrossRef]
58. Hamid, S.; Ali, S.A. Causes of Sand Control Screen Failures and Their Remedies. In Proceedings of the SPE European Formation Damage Conference, The Hague, Netherlands, 2–3 June 1997; pp. 445–458. [CrossRef]
59. Abduljabbar, A.; Mohyaldinn, M.E.; Younis, O.; Alghurabi, A.; Alakbari, F.S. Erosion of Sand Screens by Solid Particles: A Review of Experimental Investigations. *J. Pet. Explor. Prod. Technol.* **2022**, *12*, 2329–2345. [CrossRef]
60. Liu, Y.; Zhang, J.; Ma, J.; Li, X. Erosion Wear Behavior of Slotted Screen Liner for Sand Control. *Tribology* **2009**, *29*, 283–287.
61. Zhang, R.; Hao, S.; Zhang, C.; Meng, W.; Zhang, G.; Liu, Z.; Gao, D.; Tang, Y. Analysis and Simulation of Erosion of Sand Control Screens in Deep Water Gas Well and Its Practical Application. *J. Pet. Sci. Eng.* **2020**, *189*, 106997. [CrossRef]