DuneFront
Simulate - Evaluate - Optimize

Managing Sand Production in Unconsolidated Reservoirs

Philip Wassouf

Managing Director, DuneFront

philip@dunefront.com | www.dunefront.com

Poll Question

Are you a Young Professional (aged 35 or younger)?

Poll Question

Is this the first live webinar you have attended?

Poll Question

How often to you attend webinars?

Today's Speaker

Philip Wassouf
Founder/Managing Director, DuneFront

Philip Wassouf is the founder and Managing Director of DuneFront, an independent oilfield engineering consultancy providing a full range of sand control software, consulting and training services. Prior to founding DuneFront, he worked for Schlumberger in a number of positions, including field engineering roles in both completions and pumping services, before taking on the role of Product Champion at its sand control headquarters in Houston. There, he worked on a variety of new technology projects, including downhole tools, screens and software. As such, he was heavily involved in supporting worldwide sand control operations while also training both young and experienced engineers. He now works internationally on the design and evaluation of sand control completions for a variety of clients and has also authored a number of technical papers, presentations and patents relating to completions and sand control. He is a member of SPE and received a Master's Degree in Mechanical Engineering (MEng) from Imperial College London.

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Overview

- Introduction
- Effects of Sand Production
- Formation Sand Characteristics
- Causes of Sand Production
- Predicting and Monitoring Sand Production
- Sand Control Techniques
- Summary

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Introduction

- In highly unconsolidated formations, production of formation fluids is usually associated with production of formation sand
- Sand production often leads to reduced productivity and/or excessive maintenance to surface and downhole equipment
- The goal of sand control is to stop sand production while maintaining or maximizing production
- Sand production is a worldwide problem

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Effects of Sand Production

Sand Accumulation in Separator
(Courtesy Oilfield Wiki)

Pipe Failure Due to Sand Erosion
(Courtesy Oilfield Wiki)

- Sand accumulation at surface
  - High production velocities can carry sand to surface
  - Reduce capacity of separators
  - Frequent workovers
- Sand accumulation in wellbore
  - Low production velocities can settle sand in the wellbore
  - Impairs production
  - Limits wellbore access
- Equipment erosion
  - Surface and downhole equipment
  - Could lead to catastrophic failure

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Effects of Sand Production

Drainage Pipe Collapse Under Stress
(Courtesy Maverick Inspection Ltd)

- Formation collapse
  - Reduced permeability due to rearrangement of particles
  - Increased stress on casing which may result in eventual failure
- Sand disposal
  - Sand is considered hazardous waste (environmental concerns)
  - Proper cleaning and disposal can be expensive
- Sand production has a negative impact on hydrocarbon production and should be controlled as much as possible

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Poll Question

Which of the following effects of sand production is most likely to be a problem in a well with low production rates?

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Formation Sand Characteristics

- Sand is generally defined as:
  - Granular material with particle sizes of 0.0625 - 2 mm in diameter
  - Consisting mostly of silicon dioxide (SiO_2), although other minerals are present
- Strength of sandstone is developed over time by compaction, cementation and dissolution of sand grains at contact points
  - Cementation by minerals is the most important means of natural consolidation (most commonly quartz, calcite and dolomite)
  - Sand trapped in environments with insufficient cementing material or adverse conditions remains unconsolidated or weakly consolidated
- Unconsolidated or weakly consolidated sands usually have high porosity and permeability, but require sand control

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Formation Sand Characteristics

Quicksand

Partially Consolidated

- Quicksand (or unconsolidated)
  - Completely unconsolidated sands with no cementing agent, held together by small cohesive forces and compaction
  - Difficult to drill and take cores
  - Continuous sand production immediately with fluid production
- Partially Consolidated
  - Some cementing agents present but only weakly consolidated
  - Cores can be taken but crumble easily
  - Large variations in sand production

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Formation Sand Characteristics

Friable

Consolidated Rock

- Friable (or semi-competent)
  - Well cemented and can be easily cored
  - Little or no sand production initially but increases as conditions change over life of well (pore pressure, production rate, water production, etc.)
  - Uncertainty on whether sand control is required
- Consolidated Rock
  - Very well cemented and generally does not require sand control

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Poll Question

Which of the following formation types is most likely to have immediate and continuous sand production?

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Causes of Sand Production

- Sand production occurs when stresses on the formation exceed formation strength and result in rock failure
  - Can be due to tectonic action, overburden pressures, pore pressures, stress changes from drilling as well as drag forces of producing fluids
- Sand production can occur at any time over the life of a well
  - Highly unconsolidated formations may produce sand from the outset
  - More competent formations may produce sand later in their life
- Sand production is a dynamic problem
  - May occur at any depth
  - It is rate sensitive
  - Can often be initiated or increased by the onset of water production
  - Can be impacted by a variety of other factors

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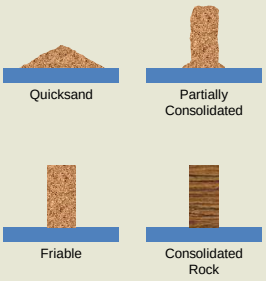
Causes of Sand Production



- Degree of consolidation
  - Measured as unconfined compressive strength (UCS)
  - More consolidated formations are less likely to produce sand
  - Younger formations tend to be less consolidated
- Production rate and drawdown
  - High production rates can create significant frictional drag forces
  - High drawdowns can create significant stress on the formation
  - Changes in conditions create instability

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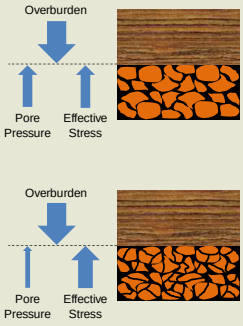
Causes of Sand Production



- Depletion
  - Overburden supported by reservoir rock and pore pressure
  - Stress on reservoir rock increases with depletion, causing failure
- Viscosity of reservoir fluids
  - Higher viscosity fluids apply greater frictional drag forces
- Water Production
  - Sand production can often be initiated or increased by the onset of water production

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Poll Question

When does sand production occur?

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Poll Question

What is the impact of depletion on sand production?

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Predicting Sand Production

- Understanding the reservoir is key to predicting whether a well will produce sand
- A number of analytical techniques/guidelines, are available to determine the need for sand control:
  - Previous experience in producing area
  - Logging (Sonic, Porosity, etc)
  - Core-based Tests (UCS, Brinnel, etc)
  - Numerical simulators
  - Drill Stem Tests (DSTs)
- No technique is universally acceptable so regional guidelines or rules of thumb are generally followed

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Predicting Sand Production – UCS Test

- UCS is a measure of a material's resistance to deformation in one direction (uniaxial) without lateral restraint.
  - The harder the material, the greater the force required to deform it
  - UCS can be linked with consolidation and porosity in rock samples

Description	UCS (psi)	Porosity
Zero strength dry sand	0	< 35%
Very weak damp sand	< 200	< 30%
Weakly cemented	< 500	< 25%
Weak more cemented	< 1000	< 22%
Gray area	< 4,000	< 20%
Consolidated rock	> 5,000	< 18%

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Monitoring Sand Production

- Monitoring of sand production is important for continuously assessing need for sand control and effectiveness of existing completion
- A number of methods can be used to detect and/or quantify produced sand, usually on surface:
  - Wellhead Shakeout / Grind out Test
  - Volumetric sand traps
  - Erosion Probes / Safety Plugs
  - Fluid Sampling
  - Acoustic Transducers
  - Erosion Monitoring
- Downhole detection to determine the location and extent of sand production is desirable but still in the early stages.

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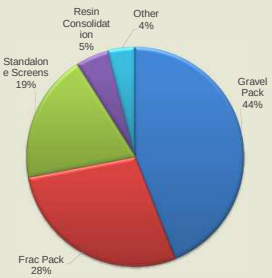
Sand Control Techniques



- Reactive
  - Surface Sand Handling
  - Rate control
- Chemical
  - Resin Consolidation
- Mechanical
  - Slotted Liners
  - Standalone Screens
  - Pre-Packed Screens
  - Gravel Packs
  - High Rate Water Packs
  - Frac Packs

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Poll Question

Which of the following are the most robust and commonly used sand control techniques?

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Reactive Techniques

Surface Sand Handling

- Allow sand to be produced and handle/dispose at surface
- Surface handling equipment is required
- Downhole equipment/tubulars still susceptible to erosion and failure
- Wellbore access can be impacted by accumulation of sand
- Generally not feasible as a long term solution

Rate Control

- Restrict production rate to minimize drag forces and likelihood of sand production
- Cheap and easy option but results in lost production
- Rate will need to be continuously reduced which is usually not viable economically
- Generally not feasible as a long term solution

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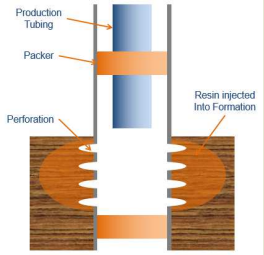
Resin Consolidation



- Pump commercially available liquid resins into formation:
  - Epoxies,
  - Furans (including furan/phenolic blends)
  - Pure phenolic
- Consolidates individual sand grains and increases unconfined compressive strength (UCS)
- Increase in UCS must be sufficient to withstand drag forces at desired production rates

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Resin Consolidation

Pros

- Good technique for marginal wells with relatively low flow rates
- Comparatively inexpensive and easy to install
- No hardware deployment required
- Leaves wellbore open for large completion

Cons

- Difficult to get good zonal coverage (limited to perforated intervals of 20-30 ft)
- Limited to formations with temperature < 250 ^{o}F
- Generally leads to impairment of permeability
- Careful treatment planning required as many stages involved

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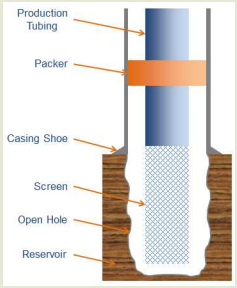
Standalone Screens



- Screens (no gravel pack) installed across producing interval:
  - Slotted Liner
  - Wire-Wrap
  - Premium
- Screens allow hydrocarbons to pass but not formation sand
- Generally sized for d10 of the formation particle size distribution
  - 10% of sand particles would be larger than the d10 particle size
  - Designed to retain larger particles but allow fines to be produced

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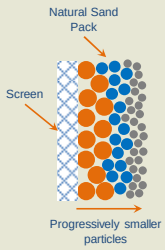
Standalone Screens



- Sand control mechanism relies on formation of a natural sand pack
- Larger grains form stable arches (or bridges) against the filter with progressively smaller grains being held behind them
- Generally used in formations with well-sorted, clean sands and relatively large grain sizes
- The industry as a whole is trying to extend the application envelope of these types of completions

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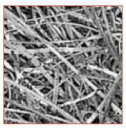
Types of Screens

Wire Wrap (courtesy Absolute)

Woven Wire Mesh (courtesy Absolute)



Steel Wool (courtesy Absolute)

- Slotted Liners
- Wire-Wrap Screens
- Premium Mesh Screens
- Pre-Packed Screens
- Expandable Screens

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Standalone Screens

Pros

- Cheaper than gravel packing
- Operationally simple
- Reliable in relatively clean sands
- Several types of screens available for selection
- Can be used for long or horizontal intervals

Cons

- Only provides one level of filtration
- Requires formation of natural sand pack
- More expensive/difficult in very fine sands
- Screen plugging could be an issue in poorly sorted sands or due to poor completion practices
- Generally not suitable for cased hole applications

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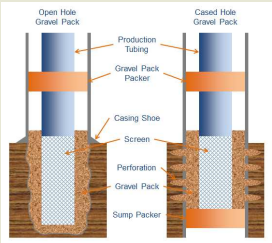
Gravel Pack



- Screen placed in the wellbore and the surrounding annulus packed with high permeability gravel
- Gravel is sized to retain the formation sand and the screen is sized to retain the gravel
- Gravel pack stabilizes formation with minimal impairment to well productivity
- Complete packing of wellbore annulus is critical for preventing movement of formation sand

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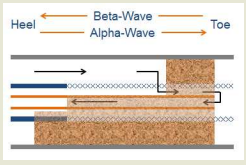
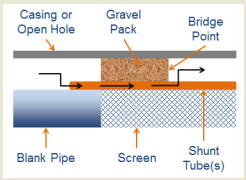
Gravel Pack





- Alpha/Beta and Alpha/Alpha
  - Brine carrier fluid with low gravel concentration
  - Primarily used in horizontal open hole completions
- Slurry Pack
  - Viscous carrier fluid with higher gravel concentration
  - Can avoid fracturing by allowing placement at lower pump rates
- Shunt Tubes
  - Slurry pack with the use of shunt tube technology to overcome bridging

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Gravel Pack

Pros

- Generally accepted as the most successful and widely applicable sand control technique
- Proven effective in controlling sand production in poorly sorted and fine sands
- Provides an additional filtration layer via the gravel to contain formation sand
- Stabilizes the open hole

Cons

- Expensive in comparison to standalone screens and resin consolidation
- Successful design and execution may present challenges depending on reservoir/wellbore conditions
- Requires pumping equipment which brings additional cost and logistical considerations

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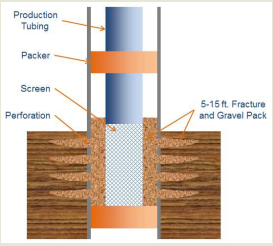
High Rate Water Pack



- Gravel packs pumped above fracture pressure to initiate small fractures in the formation
- Aim to place very short (5-15 ft) and relatively thin fractures
- Generally use brine carrier fluids at low gravel concentration
- Important to pack both perforations and wellbore annulus with gravel to ensure success
- Can be a cheaper alternative to frac-packs in low cost wells

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High Rate Water Pack

Pros

- Provides some of the benefits of fracturing (e.g. bypass near wellbore damage)
- Saves cost of fracturing fluids and breakers
- Minimizes risk of fracturing into proximate water or gas zones
- Preferred over frac-packs in wells requiring low cost completion

Cons

- Can be more expensive, complex and risky than a gravel pack
- Requires the same equipment as a frac-pack, which brings additional cost and logistical considerations
- Short, thin fracs do not provide the high conductivity and low skin associated with frac-packs

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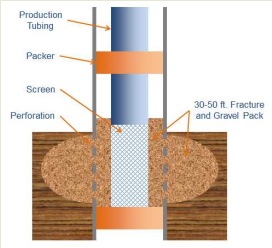
Frac-Pack



- Simultaneous hydraulic fracturing of the formation and placement of a gravel pack
- Used primarily in cased hole wells with moderate to high permeability that are prone to sand production
- Performed above fracturing pressure using viscous fluid with high gravel concentration
- Typically designed for relatively short fractures (around 30-50 ft) with large width (>1")

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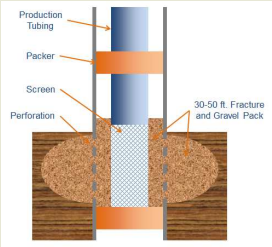
Frac-Pack



- Bypasses near wellbore damage and creates a highly conductive path for fluid to flow
- Lowers sand production by reducing flow velocity and drawdown
- Potential to obtain negative skins and increase productivity
- Can be more expensive, complex and risky than other sand control techniques

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Frac-Pack

Pros

- Bypasses near wellbore damage
- Increases effective wellbore radius (can result in negative skin)
- Reduces sand production by lowering flow velocity and pressure drop
- Gravel pack prevents formation sand being produced

Cons

- Increased cost, complexity and risk in comparison to other techniques
- Not feasible in reservoirs without containment or those with proximate water/gas zones
- Productivity limitations in wells with very high transmissibility (kh/μ) due to flow through perforations

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Poll Question

Which of the following requires the formation of a natural sand pack?

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Poll Question

Which of the following might be used in a low cost well requiring stimulation?

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Technique Selection

- Technique selection depends on a number of factors
- Different considerations involved in technique selection include:
  - Sand failure characteristics
  - Particle size distribution
  - Well condition
  - Reservoir characteristics
  - Production performance
  - Reservoir management
  - Reliability, cost and risk
- There are no hard and fast rules and technique selection is often based on personal or company experience and comfort

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Modeling – Design and Evaluation

- Modeling is critical during all stages of well development, from technique selection to execution and post-job evaluation
- Feasibility of some techniques can only be assessed with proper modeling to fully account for all variables and scenarios
  - Important to ensure they can be successfully executed under the given reservoir and wellbore conditions
  - There are many design parameters which must be optimized
- A combination of experience and appropriate engineering tools is key to maximizing the likelihood of success
  - Investigate the impact of design changes to identify the best solution
  - Plan the treatment in advance to minimize risk and NPT
  - Evaluate post-job data to confirm success and investigate failure

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Summary

- Sand production is a global problem that can be detrimental for a range of reasons, usually resulting in lost production
- It is typically linked with quicksand and partially consolidated formations but not usually observed in friable or consolidated rock formations
- It is a complex and dynamic phenomenon driven by a number of factors that may change over the life of the well
- It is difficult to accurately predict the need for sand control, especially in virgin reservoirs with no prior data/experience
- A variety of surface monitoring methods can help detect and manage sand production but downhole monitoring is still in the early stages

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Summary

- A number of techniques are used in the industry to control sand production
  - Reactive techniques are usually not economically viable, so proactive techniques are required for longer term solutions
  - Chemical techniques are cheap and relatively easy to install but have limited applications (usually in marginal wells with low flow rates)
  - Mechanical techniques are the most commonly used with each having its own advantages and challenges
- Technique selection depends on a number of factors which need to be fully assessed before making a decision
- Modeling is critical during all stages of well development, from technique selection to execution and post-job evaluation

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Thank you!

Questions

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