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Drilling Evaluation Completion Production Intervention

Modeling and Testing of Sand Jet Perforation as a Safer Alternative to Conventional Tubing-conveyed or E-line Explosives Techniques (IPS-12-19)

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Sand Jet Perforator System

- Introduction
- Product Development
- Prototype Perforator
- Laboratory Testing
- Advantages
- Applications
- Conclusion
- Questions

Introduction to Sand Jet Perforators (SJPs)

- **SJPs are down hole tools that utilize**:
  - High pressure abrasive laden fluids
  - Perforate casing, cement, and extend cavity into reservoir
- **SJPs are safer**
  - Tubing conveyed perforating
  - E-line perforating
- **SJPs run on jointed tubing or coiled tubing**
  - Depth
  - Temperature
- **SJPs can be customized for specific phasing**
  - Jet nozzle quantity
  - Orifice diameter

Product Development

Sand Jet Perforator CFD Erosion Modeling

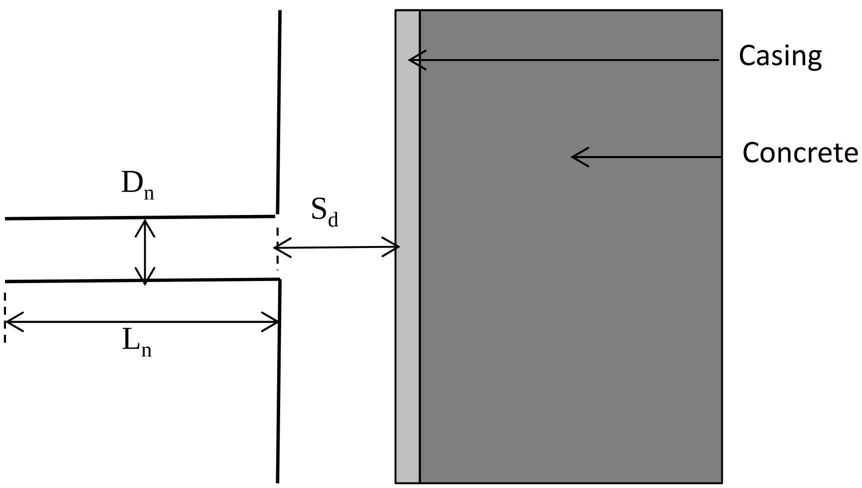
- **CFD fluid simulation**
  - Sand particle motion analysis
  - Erosion modeling with dynamic mesh
- **Erosion is dependent on**
  - Fluid conditions
  - Sand particle, casing & cement properties
- **No structural analysis is required**

Product Development

CFD Erosion Modeling Configuration

Geometry

Nozzle Diameter (D_n)	0.125in & 0.188 in.
Nozzle length (L_n)	1.25in
Standoff distance from nozzle exist to casing (S_d)	0.08-0.35in
Casing OD/ID	4.5/3.5in



Schematic of the SJP model

Flow Conditions

Flow Rate	26 - 43gpm
Perforation pressure	2500psi
Reference conditions	75degF & 14.5psi

Concrete Property

Compressive strength	7500psi

Sand Properties

Concentration	1ppg
Size	20/40 Ottwa

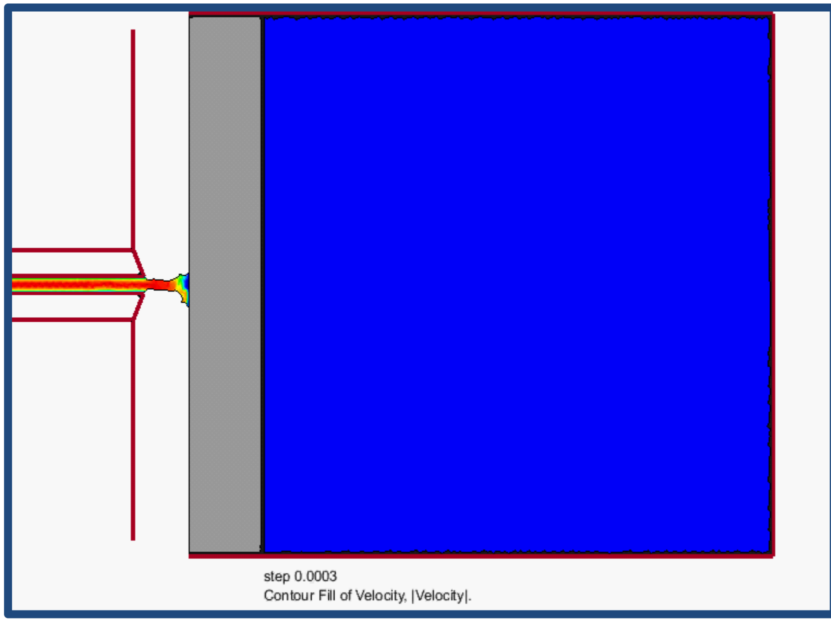
Casing Material Properties

Weight	2.87lbm/in^3
Young's modulus	30M psi
Poisson's ratio	0.3
Yield stress	110ksi

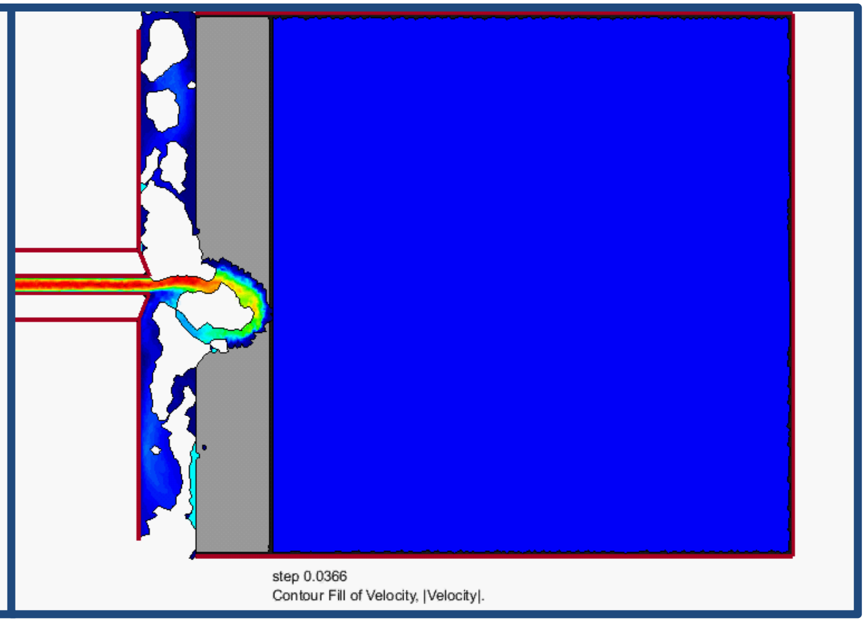
Product Development

CFD Erosion Modeling

1st Cut Through Casing



2nd Cut Through Cement



Prototype Perforator

- **Contains a flow actuated valve**
  - Allows function of hydraulic tools below when open
  - Allows high pressure abrasive perforating when closed
  - Switch flow is adjustable from 40–185gpm (1–4.5 bpm)

- **Enables multiple operations during a single trip**
  - Operates a motor for milling operations then perforates
  - Reactivates motor for well cleanout
  - Sets a plug then perforates

Laboratory Testing

- **Cutting fluid of density 9 lbs./gal**
  - Gel, water and 20/40 sand at 1ppg concentration
- **Minimum cutting pressure (2500 psi)**
- **Cutting time ranges from 15 to 30 min**
- **Two and Four nozzle patterns per respective orifice diameter**
  - 0.125” (3.175 mm)
  - 0.188” (4.763 mm)
- **Jet stand-off 3 times orifice diameter**
- **4.5 in. OD casing of P110 material (0.50” thickness)**

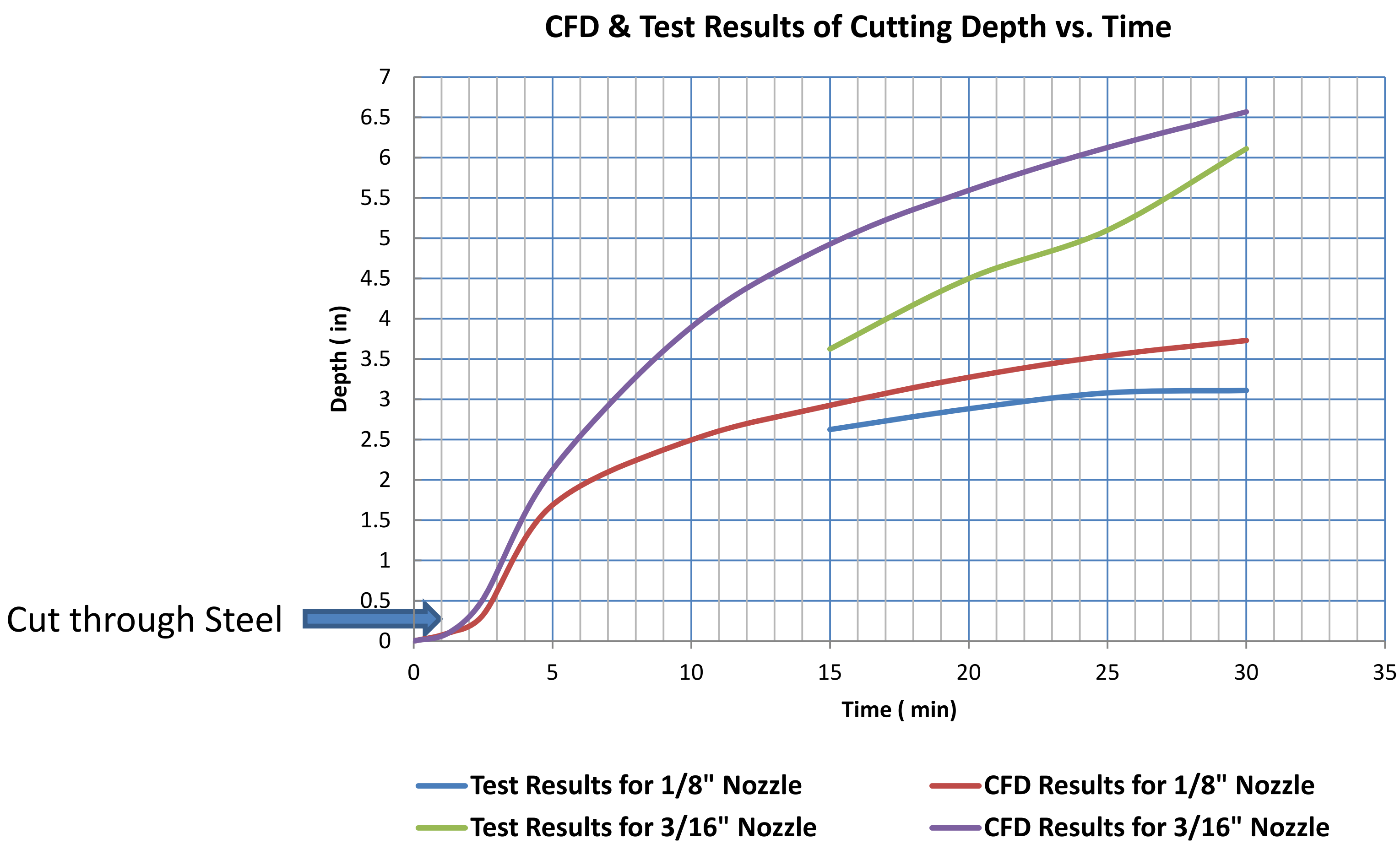
Laboratory Testing Results

OUTPUT DATA 4-1/2” OD WITH 1/8” NOZZLES	CUT # 1	CUT # 2	CUT # 3	CUT # 4
Cutting Time (min)	15	20	25	30
Avg. Flow Rate (gpm)	84	84	84	84
Avg. Perf. Pressure (psi)	2500	2500	2500	2500
Avg. Perf. depth (inches)	2.63	2.90	3.23	3.5

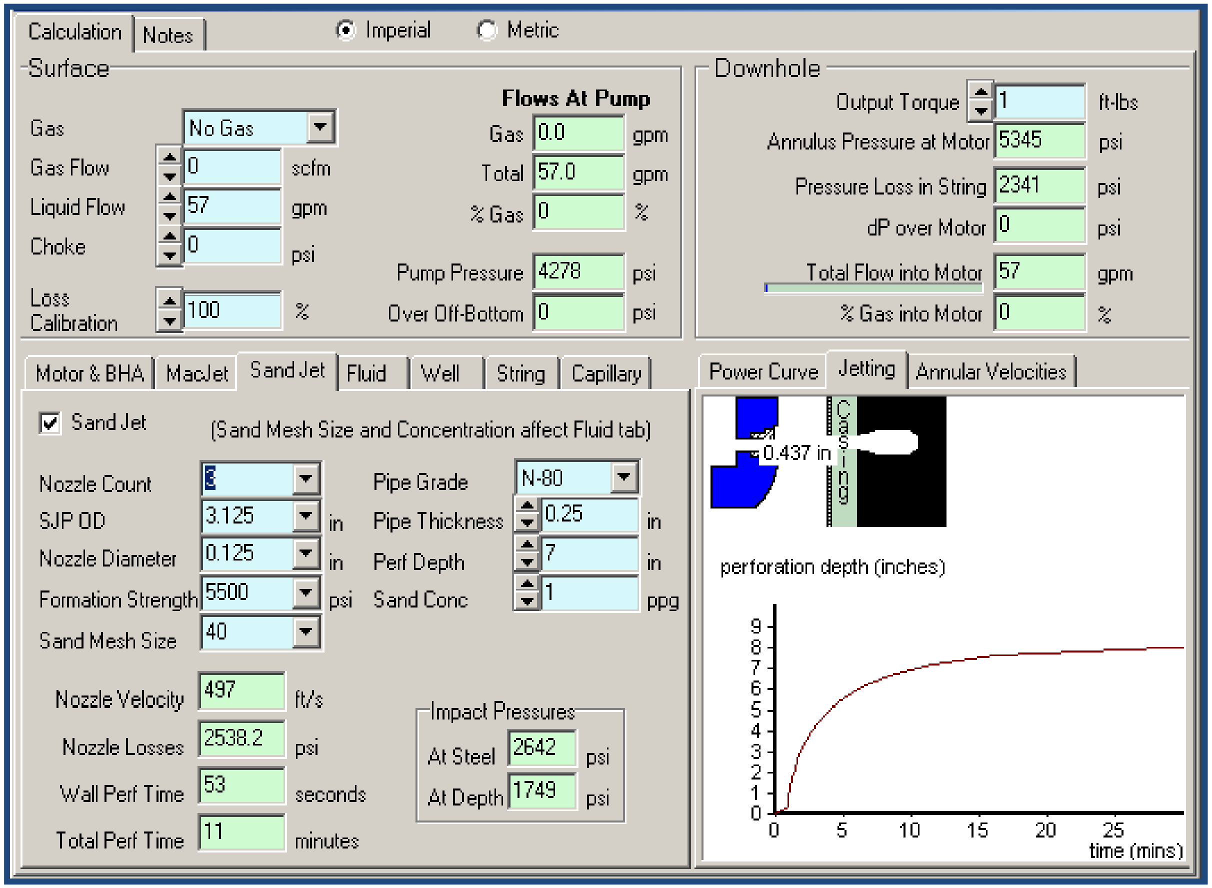
Laboratory Testing Results

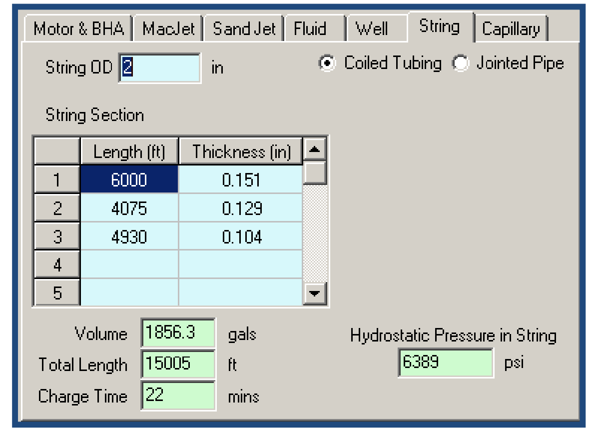
OUTPUT DATA 4-1/2" OD WITH 3/16" NOZZLES	CUT # 1	CUT # 2	CUT # 3	CUT # 4
Cutting Time (min)	15	20	25	30
Avg. Flow Rate (gpm)	84	84	84	84
Avg. Perf. Pressure (psi)	2500	2500	2500	2500
Avg. Perf. depth (inches)	3.5	3.75	4.25	6.25

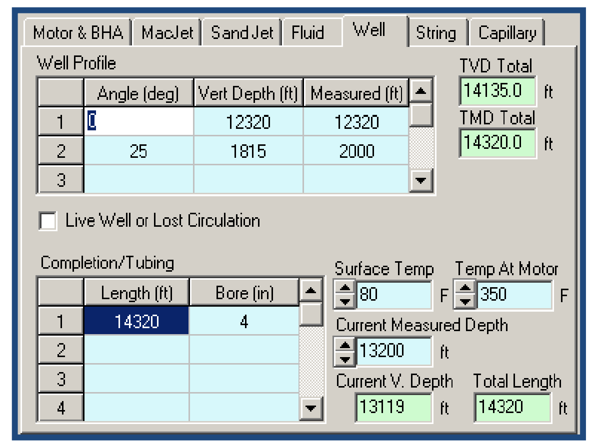
Comparison of CFD & Test Results



Job Modeling Capabilities

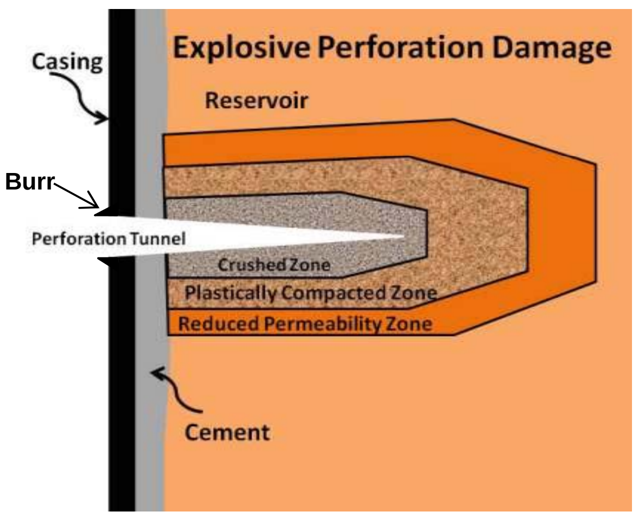


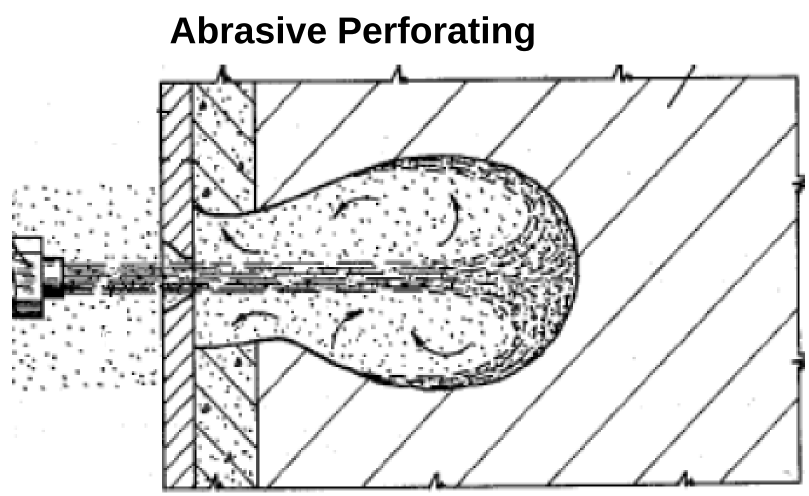




Abrasive Perforating Advantages

- Reduces near wellbore friction effects → Better Frac
- Does not require explosives → Safer operations
- Does not induce formation damage → Lower breakdown pressures & increased permeability





Applications

- **Perforating new vertical and horizontal completions**
- **Re-perforating trouble zones**
  - Substantial formation damage
  - Production reduced due to the sediment build-up
- **Perforation and treatment of coal bed methane wells**
- **Integrated one-trip applications that utilize**
  - Bridge plugs for zonal isolation
  - Motors for well cleanout prior to perforating
- **Cut tubing or slotting**

Conclusions

- **CFD Erosion Modeling**
  - Pure CFD erosion modeling
  - P110 material and 7500 psi C.S.
- **Laboratory Testing**
  - CFD results correlates well with test results
  - Perforation depth of up to 6.25”
  - ½” thick P110 material and 7,500 psi C S. Concrete
- **Perforator Versatility**
  - Bridge plugs for zonal isolation
  - Motors for well cleanout prior to perforating
- **Safer because no explosives is required**
  - Eliminate concerns of misfiring or unexploded ordnance returning to surface
  - Reduce transportation cost
  - Eliminate military escort for international locations

Questions?

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