



Well Stimulation

Improvement with Fluid Pulse Technology

Wavefront's fluid pulse technology adds a new dimension to horizontal well stimulation. Wavefront provides a wide range of coil tubing conveyed tools.

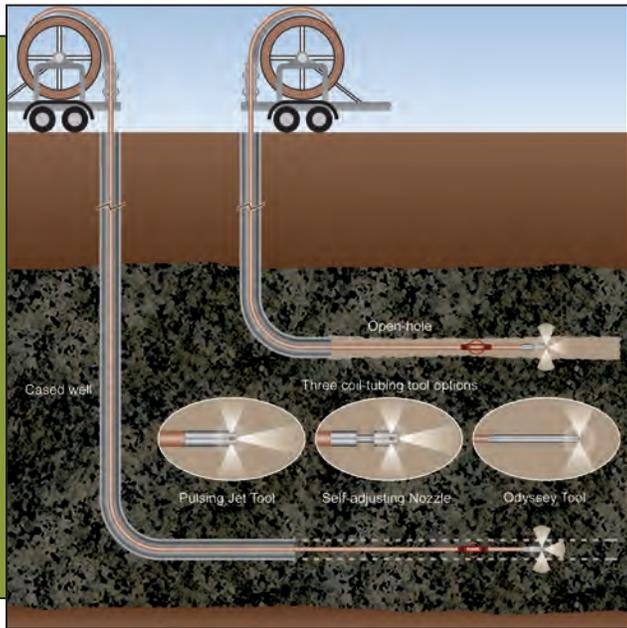
Fluid pulse technology creates high inertial fluid momentum which improves the flow efficiency of the wellbore, the near wellbore region and the reservoir. The nature of fluid displacement energy ensures that any pulsed fluid will penetrate the matrix proximal to where the tool is placed.

Fluid pulse technology is ideal to improve the placement of chemical treatments, production solvents, water, gas and combinations thereof.

If you can intervene in a wellbore, you can utilize fluid pulse technology.

WAVEFRONT
FROM BIT TO LAST DROP™

Technology Overview



Fluid Pulse Benefits

- High amplitude displacement waves effectively distribute treatment fluid into the reservoir evenly along the completed interval
- The creation of new fluid pathways to improve contact with the reservoir
- Promotion of radial flow distribution negating the effects of fluid channelling through higher permeability areas or thief zones
- Increased fluid penetration compared to bullheading, chemical squeezes and multi-zone stimulation methods

Deeper Fluid Penetration

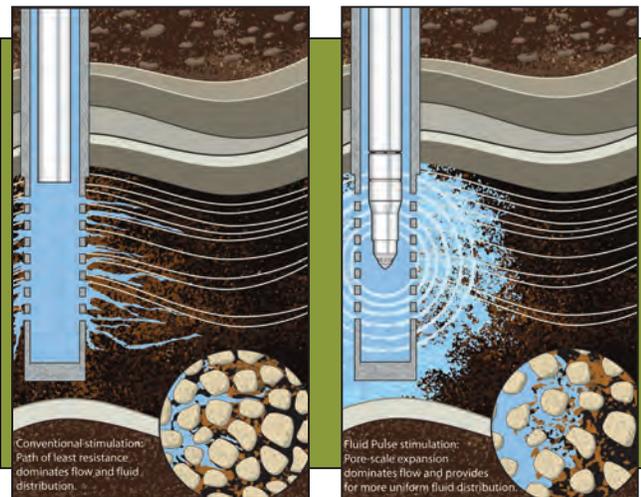
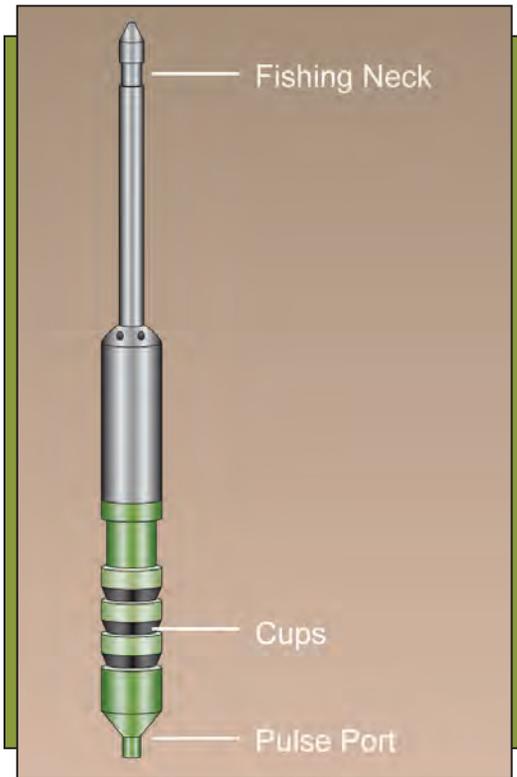


Figure shows the benefits of fluid pulsing stimulation over conventional treatments

Well Applications

- Wellbore and near wellbore scale, solids, sand and cement removal
- Wellbore (post drilling) completion cleanouts
- Stimulation treatments using any fluid; gas, solvents, acids, surfactants, or combinations
- Open and cased hole implementation
- Coil tubing, wireline or jointed pipe conveyed
- Conventional oil, heavy oil (cold and thermal production) and gas wells



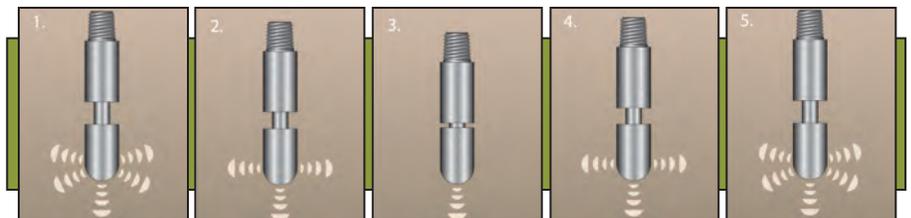
Retrieval Wireline Conveyed Tool

Near Wellbore Tools

The Pulsating Jet Tool (PJT) can accommodate any fluid, gas or mixture. A vortex is formed inside the tool, which produces oscillating pulse energy. This energy produces sonic stress waves that have a far greater effectiveness than common jet nozzles. The pulsating jet tool is very effective in cleaning the wellbore and can provide a shallow stimulation treatment into the near reservoir region.

In coil tubing applications the pulsating jet tool assists the extended reach capabilities of coil tubing by enhancing the "worming effect" needed to creep the coil horizontally. The tool can be manufactured in a number of port orientations to direct flow in both forward and reverse orientations to ensure removed debris does not pile up and "stick" the coil tubing.

The Self Adjusting Nozzle Tool (SAN) is able to direct its jet stream energy from multiple ports to a single port and back to multiple ports as determined by what is encountered down hole. If the nozzle tags (say hard scale or a scale plug/bridge) the tool will shut off its back and side ports to direct greater energy towards the tag. As the nozzle washes through the tag the nozzle reverts back to its multiple port configuration. The nozzle is extremely efficient in horizontal wells because the back facing ports are able to wash fill as the work string (coiled tubing or tubing) is retracted. The PJT and SAN tools are available in any size.



Wavefront's Self Adjusting Nozzle Positions



Wavefront Coil Tubing Tools with Nozzles Assembled

Deep Penetration Tools

One of the greatest challenges in stimulation is placing the remedial fluid where it is needed most. Improved fluid placement with Wavefront's Odyssey line of tools is achieved by creating energy-packed fluid pulses that propel liquid deep into the reservoir. The pulses allow injected fluids to be diverted away from established flow paths—typically not obtainable with other stimulation approaches.

The Odyssey tools can be deployed on jointed pipe or coil tubing and once placed at the desired depth; they only require a constant stream of treatment fluid to be effective. No diversion methods need to be employed, as the tool will pulse the treatment fluid adjacent to where it is placed, thereby improving zonal coverage.

Injection Comparison

Powerwave Odyssey Tool

- **Significant control over fluid distribution**
- Designed specifically for fluid injection
- **Deep penetration of injected fluids (≥ 24 inches)**
- High amplitudes
- Low frequency; asymmetric wave form
- Will overcome large permeability contrasts

Fluidic Oscillators and Acoustic Tools

- **Marginal, if any control over fluid distribution**
- Designed for filter cake, scale, and paraffin removal of liners and screens
- **Penetration of injected fluids (≤ 2 inches)**
- Low amplitudes
- High frequency; sinusoidal wave form
- Will not overcome large permeability contrasts

Bull Heading of Fluids

- **No control over fluid distribution**
- Pumping rate and pressure designed to overwhelm the reservoir
- **Penetration of injected fluids highly variable, and poorest where most needed**
- No amplitude, constant rate and pressure
- Will not overcome large permeability contrasts



Odyssey Radial Valve Tool



Odyssey Rotary Tool