The Application of Sonic Waves for Enhanced Oil & Gas

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Application of US waves

- Nautics
- US Welding
- Density measurement
- Surface treatment (space industry)
- Material Sciences (non destructive material testing)
- Medicine (pregnancy, dental calculus removal, abscesses, optical spectrometers …)
- Flow meter (pipes, facilities)
- Fumigation
- …..

? Petroleum Engineering – Oil & Gas Production, Geothermal Heat Recovery
Definition and Basics on US waves

• Above 16,000 Hertz - the human ear's audibility limit.
• Gaseous environment acts as a dampener for US waves.
• Liquid environment allows for good US transfer (limited dampening effect).
• At a certain point cavitation occurs (bubbles implode) -> extraordinary high pressure and temperature generated (used for cleaning effect).
Cavitation is the formation and then immediate implosion of cavities in a liquid – i.e. small liquid-free zones ("bubbles") – that are the consequence of forces acting upon the liquid.

It usually occurs when a liquid is subjected to rapid changes of pressure that cause the formation of cavities where the pressure is relatively low.

When the cavitation pimples implode, forces, which can be 1000 times higher than the primary forces from US-field, are discharged.

Cavitation can be generated by the US – waves maelstrom.
Piezoelectric Effect

• The piezoelectric effect is a **reversible process** in materials where applied mechanical pressure generates an electrical charge.

• The reverse piezoelectric effect is defined as the internal generation of a mechanical strain resulting from an applied electrical field.
Generation of US waves

• To dissipate electro mechanic oscillation a force is required which originates from the reverse piezoelectric effect.

• The word *piezoelectricity* means electricity resulting from pressure.

• US waves are produced by electro mechanic transformers.
Degassing by US waves

Oilfield Application:

• Oil / Gas separation
• Water / Gas separation
• Mud degassing
Paraffin removal by US waves

- Paraffins and asphaltenes are different in chemical structure.

- Paraffins are alkanes of relative high molecular weight (C18 to C70) and can be straight-chained or branched (CnH2n+2).

- They cannot be attacked by basis or acids.

- The solubility of paraffin depends on temperature and their molecule size.

- Paraffins are soluble in most liquid petroleum fractions.
Asphaltene removal by US waves

- Asphaltenes are black colored, polycyclic, aromatic, complex components.

- They are colloidal and surrounded by neutral resins of lower molecular weight and aromatic hydrocarbons.

- In crude oil asphaltenes occur as dispersed solid particles, but they can also be found in condensates of gases.

- Due to the presence of oxygen, sulfur, nitrogen and various metals in the asphaltenes structure, they show polar characteristics.

- In aromatic solvents like benzene, toluene and xylene their solubilities are quite good, as well as in carbon tetrachloride and carbon disulfide.

- But in distillates such as kerosene and diesel oil, and other low molecular weight hydrocarbons the solubility of asphaltenes is not given.
Removal process

Paraffin, Asphaltene, Scale and other damages plugging pore spaces

Ultrasound irradiate the formation, cavitation and resonance begin

Poral space and permeability restored
Problems with wax precipitation

• Reduced inside diameter – more pressure losses
• Lower production rate
• Higher friction – more energy consumption
• Plugging of surface facilities
• Plugging of pipelines
• ....
Reasons for scale precipitation

- Change of temperature
- Evaporation (concentration increases)
- Change of pressure on solution
- Supersaturating
- Mixing various waters with incompatible components
- Changes of pH-value
- Contact time
- Agitations
Problems with scaling

- Plugging of near wellbore zone
- Plugging of perforations (production, injection)
- Deposition on artificial lift components
- Natural radioactivity

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Deliquification of gas wells
Deliquification of gas wells

• US waves solid particles get reduced to smaller pieces.

• The same effect applies to liquid droplets.

• The efficiency factor gets higher, when the frequency decreases.

• Atomizing of liquids the medial size of the droplets decreases, when higher frequencies are used.
Water Treatment for Re-Injection

Problem:

- Plugging perforations and near wellbore zone by injecting poor water quality.
- Regular acid stimulation (cost, corrosion).
- Reduced injectivity -> Higher energy consumption.
- Bacteria injection -> sour gas production (corrosion, product quality).
- Plugging of sand filters

Solution:

- Ultrasonic / UV light treatment
Formation impairment

[Diagram showing particulates, inorganic precipitates, hydrocarbon residue, and bacteria]
Hydrates

- Gas hydrates are clathrate hydrates: Water ice with gas molecules trapped within.

- Nonpolar molecules such as methane can form hydrates with water, especially under high pressure.

- Hydrates in oil and gas production may plug tubings, chokes, safety installations, surface facilities etc.
Test Apparatus & Sonotrodes

Progress Ultrasonics AG
Environmentally Friendly Oil Well Stimulation
Application ranges and effects

Application range up to 7'000 m (21'000 feet)

Effective range 1-100m

Sandstone / Limestone
Production increase: +30% up to 350%
System overview

- **Electric Power Generator**
  - 3x 400VAC (50/60 Hz)
  - >18 kVA
  - Diesel Engine
  - 1500 RPM

- **Ultrasonic Generator**
  - PG20150 5kW
  - PG20250 10kW

- **Logging Cable**
  - 200 - 7000m on the spooler unit / bobbin

- **Resonator**
  - TIT 44: d=44mm (1 3/4"")
  - TIT 76: d=76mm (3"")
During stimulation of the well we got instant increase in oil production. Starting as low as 49 b/d ending up 24h later at an daily average of 235 b/d.

Increase more than 100% (before: 899 b/d after stabilized on 1869 b/d.)
Photo Log Mexico offshore

The tool ready to go downhole
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THANK YOU!

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