УДК 622.276

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IMPROVING OIL EXTRACTION EFFICIENCY IN WELLS COMPLICATED BY MECHANICAL IMPURITIES USING SIMULTANEOUS-SEPARATE EXPLOITATION TECHNOLOGY

Mechanical impurities pose significant challenges in oil extraction, particularly in multilayer reservoirs with horizontal wells. These impurities, including dispersed rock particles, corrosion products, asphaltene-resin-paraffin deposits (ARPD), and mineral salts, lead to equipment failures, reduced flow rates by 20-50%, and increased repair costs up to 30-40% of operational expenses. In early-stage development (fund realization <2%), with impurity concentrations up to 1000 mg/L, traditional methods are inefficient due to near-wellbore zone (NWZ) destruction under depression. This study investigates simultaneous-separate exploitation (SSE) technology integrated with combined impurity control methods to enhance extraction efficiency in such complicated wells [1, 2]. Mechanical impurities originate from four main sources: the reservoir (rock destruction products and proppant from hydraulic fracturing), process fluids (poorly filtered killing fluids, flushing liquids, and reagents), equipment (corrosion products and metal salts), and debris (from drilling, repairs, and perforations, including cement crusts, rubber fragments, and mud). Even short stops (15-20 minutes) cause sedimentation, jamming plungers in rod pumps or clogging impellers in electric submersible pumps (ESPs), inducing vibrations and failures. High-impurity bursts (>500 mg/L) reduce equipment lifespan by 1.5-2 times [3, 4].

To mitigate these issues, wear-resistant ESPs are employed, with modifications for impurity tolerance: standard up to 100 mg/L, wear-resistant up to 500 mg/L, and corrosion-wear-resistant up to 1000 mg/L. Key enhancements include niresist impellers and guide vanes, rubber bearings replacing textolite, steel heat-treated bushings, and additional radial supports to prevent shaft bending. Dual-support stages improve axial bearing reliability and shaft isolation from abrasion, increasing stiffness and service life, though at higher cost and complexity. These designs optimize depression, reduce colmatation, and boost extraction by 15-25% [5, 6]. Wellbore filters are widely used for protection, varying in length and type: mesh, wire-wrapped, slotted, and gravel-pack. Mesh filters, with multilayer grids, handle fine particles (<50 μm) but have high hydraulic resistance and low maintainability. Wire-wrapped filters, using profiled wire on a frame, offer larger filtration areas and better anti-clogging due to trapezoidal profiles, proving more durable. Slotted filters maintain fixed gaps (trapezoidal for reduced colmatation) but have low porosity, addressed by support structures. Gravel-pack filters, with quartz sand around a base filter, provide high capacity, low resistance, and NWZ reinforcement but are costly and non-retrievable, requiring precise impurity analysis [7].

Filter tails complete wells, cemented in the reservoir roof or as casing extensions, with slots (0.75-3 mm) forming natural sand filters behind them. Perforated casings with additional filters enhance drainage but risk colmatation from imperfect openings.

Advanced methods include NWZ consolidation via oil coking, injecting hot air (260-450°C) to oxidize hydrocarbons, forming binding coke from asphaltenes. Suitable for high-viscosity oils in shallow reservoirs, it is limited by cost and complexity. Resin-coated proppant (RCP) in mini-hydraulic fracturing (up to 5 tons) consolidates sandy zones, curing at >69 atm or 90°C, with activators for low-temperature wells. It reduces sand production but requires careful selection to avoid proppant flowback.

Chemical consolidation uses silicon-organic compounds, synthetic resins, or urethane prepolymers to form permeable screens. Urethane achieves 6 MPa strength with <20% permeability loss, creating "sand-polymer" systems in weakly cemented collectors. Tamponade compositions like "Geoterm-01" resin form permeable stones but may increase hydrodynamic resistance.

Desanders, such as gravitational modular filters (FMG-01), separate sand via centrifugal forces in a housing, directing clean fluid to ESP intake while accumulating solids in NK tubes. Inertial desanders (USPSH.01-73) change flow direction, separating gas and large particles via spirals, suitable for multi-well pads. Modular sludge traps integrate with ESPs, centrifuging impurities into accumulators and dispersing gas bubbles.

Coiled tubing enables operations without killing, maintaining hermetic wellheads up to 70 MPa, reducing NWZ contamination and enabling sand plug cleanouts. Advantages include no repression, faster trips, and ecological compliance.

Short-term operation (STO) cycles pumping (5-10 min) and accumulation (30-60 min) using overproductive ESPs with frequency converters. In accumulation, the well acts as a separator, reducing water cut and impurities via lower depression.

Optimal depression maintenance prevents NWZ destruction, cone formation, and hydrate buildup, determined by techno-economic calculations. Periodic bottomhole flushing circulates fluid to remove settled impurities, using direct, reverse, or combined methods with specialized nozzles.

SSE integrates these methods for multilayer reservoirs with horizontal wells (89% of the fund), heterogeneous collectors (porosity 17.2-32.9%, permeability 0.12-2475.6 mD), and low water cut (7.1%). Modeling shows debit increases of 20-30%, mean time between failures 1.5-2 times, applicable to 26 operating wells.

Results demonstrate novelty in adapting SSE with combined approaches (dual-support ESPs, USPSH desanders, urethane prepolymers) for horizontals, optimizing processes and minimizing loads. Practical implementation improves efficiency, reduces repairs, and supports sustainable development in complicated reservoirs.

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