E.S.P.*—ANOTHER APPROACH TO INCREASED PRODUCTION

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INTRODUCTION

The formation of scale and various other deposits in producing and injection wells has been a recognized problem for many years. The research departments of every oil company and major university in the Nation have long been, and are still, researching casual conditions, preventive measures, and methods of removal of these deposits.

This writing does not presume to enlarge upon the hundreds of excellent references available on these subjects, but a generalized recap of conditions and practical applications is indicated to establish continuity.

Moving fluids carry with them, or gather enroute, various minerals and chemical elements indigenous to their originating, or surrounding environment. These elements may remain in solution and/or suspension as long as the physical conditions (temperature, pressure, saturation level, rate of flow, etc.) remain reasonably constant. See Fig. 1.

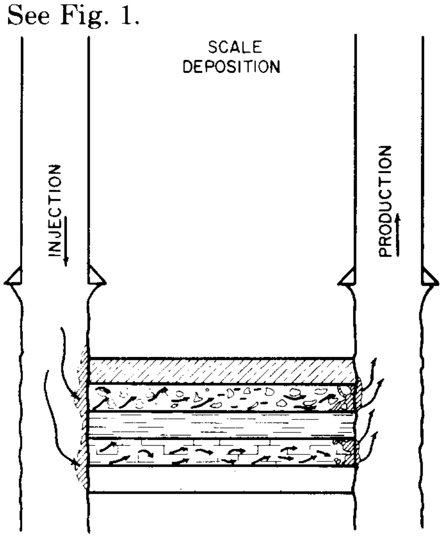

FIG. 1—SCALE DEPOSITION

*Environmental Scale Pulverizing

Changes in one or more of these conditions can allow the elements to precipitate or unite with other chemical forms, causing a deposition of scale at the point of change.

The buildup, or scale, generally forms in the wellbore, at the face of the formation, and for some limited radius from the wellbore into the formation, thus plugging or sealing off the wellbore from the producing formation. Removal and/or penetration of these barriers is necessary to re-establish fluid flow and restore efficient production or injection rates.

The accumulations may be composed of one or a combination of several materials and range from those materials completely soluble in fresh water to those insoluble in acid. Silts and unconsolidated fines are often bonded in the scale matrix or compacted behind liners or in the formation just outside the perimeter of the wellbore. Some of the more frequently encountered deposits are paraffin, salt, iron oxide, iron sulphide, calcium carbonate, calcium sulphate and barium sulphate.

REMOVAL OF DEPOSITS

The more soluble of these materials can usually be removed from the wellbore by solvents, sometimes without interrupting production; but when insoluble scales or massive accumulations form, other methods of removal are indicated.

Converters (Fig. 2A)

Some relatively insoluble scales lend themselves to chemical conversion, rendering them soluble in acid solutions. This method of application requires large volumes of chemically treated fluids and constant agitation or circulation of these fluids if efficient removal is to be accomplished. Only the scale inside the wellbore is removed by this method since the fluids are not forced into the formation.

Hydraulic Fracturing (Fig. 2A)

Pumping fluids into the well at high volumes and pressures to rupture or fracture the impermeable scales does penetrate the block, but due to the nature of the fracturing process, only a small percentage of the perimeter of the wellbore is opened to flow and can rescale in a relatively short time. Difficulty in containing the treatment may cause fracturing into a new, unwanted zone.

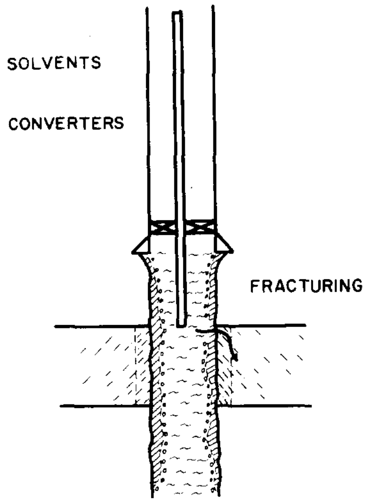

FIG. 2A—REMOVAL BY FLUIDS

Mechanical Methods (Fig. 2B)

Scrapers, reamers and/or drillout can remove scale from the wellbore effectively, but these often involve considerable expense. Since they affect the wellbore only, these methods should be used in conjunction with other methods for complete penetration of the scale sheath.

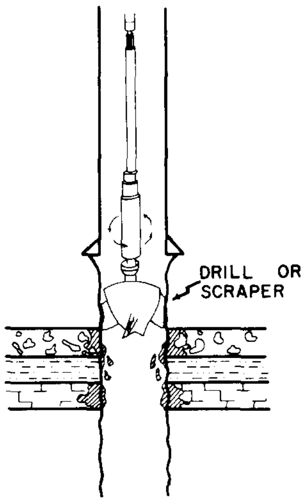

FIG. 2B—MECHANICAL REMOVAL

Explosive Devices (Fig. 2C)

Several applications of explosive devices may be used to rupture the scales. Removal of scale is fairly good; but compaction at the formation face may cause permeability damage and there is some danger of rupturing the casing over perforated intervals. Perforating in conjunction can achieve penetration of compacted or scale-intruded formation but, as with hydraulic fracturing, only a small portion of the wellbore is opened.

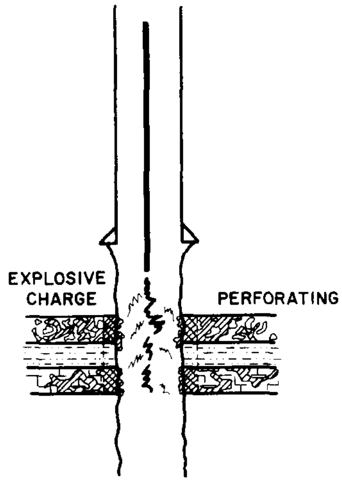

FIG. 2C—EXPLOSIVE REMOVAL

SONIC ENERGY

All of the above mentioned measures are successful to some degree, but the need for more efficient removal of wellbore scale and intruded blocking prompted investigation into other energy forms for scale removal.

For a number of years, sonic energy has been used to remove rust, scale, paint, etc. from various materials. There are two basic principles of application: constant frequency agitation and high velocity shock waves.

Constant Frequency Agitation (Fig. 3)

This method employs continuous application of high or ultra-high frequencies upon the material to be cleaned. This continuous influence causes extreme acceleration of molecular activity; and sympathetic or resonant sonic pockets (nodes) begin to form in the material or transmitting medium. Given sufficient energy dissipation, this agitation can be increased to a point beyond material endurance and destruction occurs, separating and breaking up the scale.

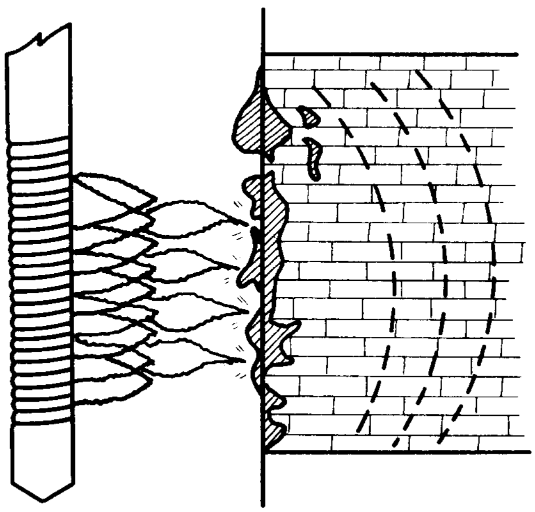

FIG. 3—FREQUENCY AGITATION

Utilizing transducers (ceramic sonic generators) developed by Ohio State University, a sonic tool of this type was developed. It was found that while the high frequency agitation performed well on thin scales, the effects were attenuated rapidly with penetration; continuous power levels sufficient to destroy heavier accumulations caused failure of the transducers. Total energy output was distributed over a five-foot interval of the wellbore and the energy level at any given point was marginal for scale destruction.

High Velocity Shock Waves (Fig. 4)

The velocity of a sonic or seismic pulse through a matrix varies from one material to another. Should a pulse be initiated at or below this speed and intensity it is transmitted normally; but if the pulse or shock wave is imposed at greater velocity and energy than the material can accept, the material is destroyed along the shock path until the wave is attenuated (slowed and dissipated).

These principles were applied to the production of the currently operated E.S.P. tool. A voltage multiplier incorporated in the design furnishes the energy for intermittent high-intensity, ultra-high-frequency pulses. The pulses are discharged from a single-point emitter section developed by Sonics International research, focusing the energy dissipation in a 6-in. vertical, 360° radical pattern. The 48 K.W. pulse is triggered at two-second intervals and has a frequency of 58 Meg H⁄, imposing both high intensity shock waves and high frequency agitation against the scale formations.

SELECTION OF WELLS TO BE TREATED

The multiplicity of problems that may cause declining production from oil wells dictates careful selection of wells for treatment if results are to be rewarding. Well histories, decline rates, reservoir pressures and fluid samples should be reviewed to ascertain the existance of scale or permeability damage. Should damage be confirmed, the type of deposition becomes important to the planning of the treatment. Specific designs of the E.S.P. tool lend themselves to the treatment of harder, more brittle scale; and while the agitation of solvents helps in softer or more soluble deposits, much of the tool's efficiency is lost as a result of attenuation in the softer materials.

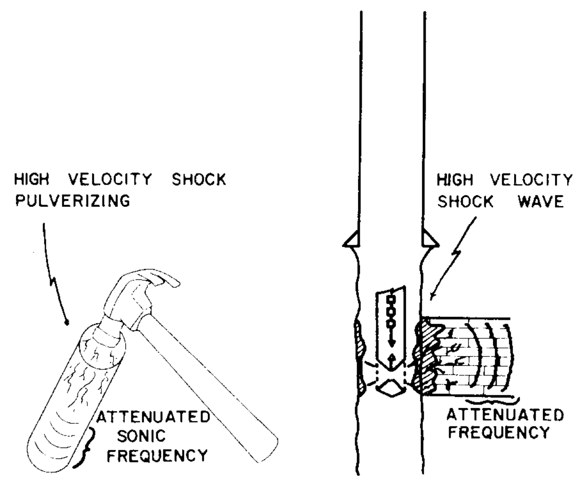

FIG. 4—HIGH VELOCITY SHOCK WAVES

WELL PREPARATION

After selection of the well or wells to be treated, preparation is made by pulling rods and tubing and preparing the wellhead to allow free passage of the 4-in. diameter tool. Should there be doubt that a minimum ID of 4-½ in. is continuous through the zone, a gauge ring or caliper should be run to assure lowering the tool to treating depth. Any restriction must be removed by bailer, scraper or bit before running the E.S.P. tool.

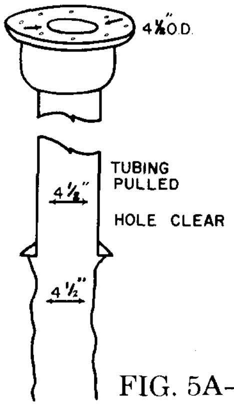

FIG. 5A—WELL PREPARATION

Treating chemicals or solvents, if desired, are spotted over the desired interval before running the sonic tool. These may be placed by dump bailer just prior to service or spotted before pulling tubing if larger volumes are indicated.

FLUIDS IN THE WELL

The tool operates in any conductive environment but efficiency is lost in fluids that froth or produce bubbles during reaction. Some converters form emulsions that tend to absorb the shock waves and their use should be avoided. Entrained gas and air are quickly dissipated, however; and as the fluids de-gas and become more nearly noncompressible, shock effectiveness increases. The tool has been run in a large variety of fluids but best results have been observed using water, or 15% HCl in most carbonate reservoirs.

OPERATION OF SERVICE

The E.S.P. tool is 4-in. OD and 14 ft long. It is designed to be lowered to treating depth via conductor wire line. Operation of the tool is actuated and monitored through surface electronic panels; the power source is a portable generator carried on the mobile service unit.

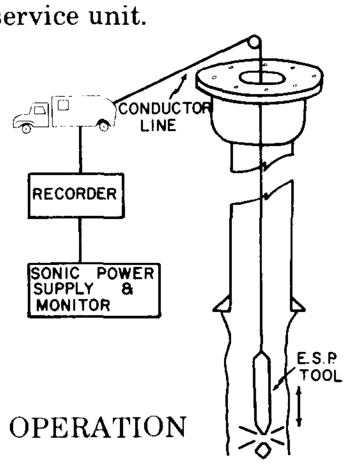

FIG. 5B—SERVICE OPERATION

The tool is not presently equiped with a casing collar locator and if extremely accurate depth control is desired a "dummy" run is made with a gauge ring and CCL and the line "flagged" or indexed to depth.

The tool is then lowered to treating depth and energized. The 6-in. vertical influence dictates that the tool be moved during operation to cover the entire zone. This is accomplished by treating "stations" (holding the tool stationary for a period of time, then lowering with the hoist to a new setting). Normal time of treatment is one minute per station or two minutes per foot. Treatment is normally initiated at the top of the zone to preclude "sticking" or wedging the tool in the wellbore by possible debris from above and/or the loss of treating fluids should the removal of scale expose a low-pressure "thief" zone.

After treatment the tool is removed and the well bailed or circulated to remove debris and treating fluids which may be produced back if desired. However, good production practice indicates removal before placing well back on production.

ADDITIONAL CONSIDERATIONS

Removal of fines and debris by reverse-circulating should be considered with care since the newly exposed formation may not support a column of fluid. Fluid loss into these zones will carry the suspended fines with it and the resultant plugging may be worse than the original problem.

Zones treated should be confined to net pay intervals instead of wholesale cleaning of gross intervals. Unwanted intervals (i.e. water-producing zones) may be opened, and treating costs rise with increased footage.

The tool should not be operated full power in blank or unperforated sections. No casing damage has been reported, but there has been evidence of cement sheath damage outside the pipe when this precaution was not observed.

Lower energy levels (controlled at surface) can be used for cleaning inside casing if desired.

RESULTS

History on treated wells is still limited and, as with the introduction of any new device, producers are hesitant to test results on wells with good production potential. Applications to date have been on prospects with relatively poor chances for improvement (with notable exceptions). An examination of the first 25 wells treated showed production increases beyond expected results. The first three were in the East Texas area and results are not available; one well is an injection well, (injectivity increased over 300% at same pressure). Therefore, results discussed will cover the first 21 producers in the West Texas area.

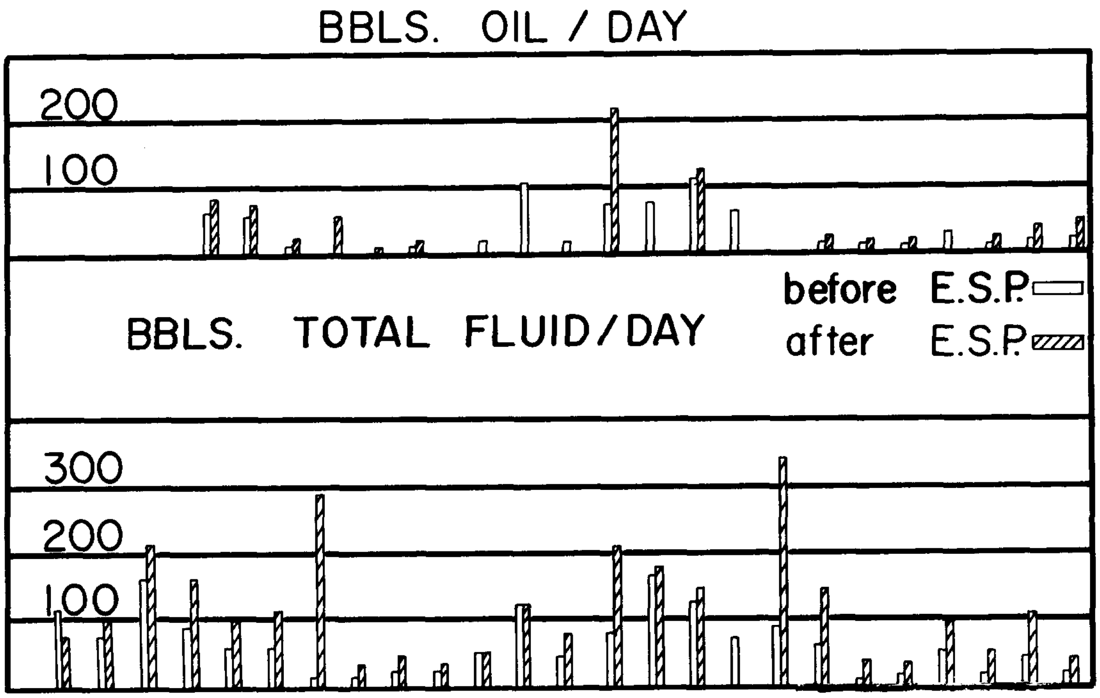

FIG. 6—PRODUCTIVITY BEFORE AND AFTER E.S.P.

The tests were made in nine separate producing areas within a 150-mile radius of Odessa, Texas headquarters. Producing reservoirs treated were both sand and carbonate formations. Total production from the 21 wells before E.S.P. treatment was 774 BOPD. Total production from the same 21 wells after treatment was 1098 BOPD or a net increase of 324 BOPD.

Using a rather steep 0.40 decline rate factor, the year end barrels of additional oil from these wells approaches 70,000 bbls. The conservative price of $5.00/bbl applied to this is $350,000 additional oil revenue from these 21 wells.

Total cost of treating the 21 wells was estimated at $40,000.00 with a return on investment of $7.75/$1.00:

Annual Revenues from new oil	$350,000.00
Cost of treatment	40,000.00
Annual Net gains 21 wells	$310,000.00
Return on investment	$7.75/$1.00

Lest this information be misleading, a study of individual well responses is not as gratifying as the overall picture. The total oil increases were realized from only 14 of the 21 wells and in 3 of these, the increase in produced water offset the slight increase of oil production. A significant increase in total fluids was observed in 17 of the 21 wells, indicating 86% success in removing wellbore restrictions.

The treatments were conducted in a variety of treating fluids and with various reservoir conditions with no common denominator except the E.S.P. tool; therefore, no specific information concerning efficiency of various treating fluids or chemicals is available. Subsequent efforts to evaluate this condition indicates HCl acid is the better all-around treating additive for carbonate reservoirs, should one be desired.

Several abortive attempts have been made to dislodge asphaltines and paraffin-base deposits from screens and perforations. Only 20% efficiency was observed, indicating that shock wave and frequency agitation are very inefficient in these environments. A modification of the emitter section is presently being studied to consolidate the energy release and increase effective power output approximately 400%. This power level is intended to generate a pressure wave behind the initial shock wave to assist in dislodging unpulverized deposits and make the tool more widely applicable.

Physical size (4-in. OD) limits the conditions for application. More advanced and smaller-diameter tools are being researched at present, but will not be available until early 1975.

CONCLUSIONS

Primary and secondary recovery efforts are hampered by localized permeability damage caused by deposition of scale and other plugging materials. Today's methods of removal are inadequate and the results usually short-lived.

Sonic energy application can be used to remove deposits that are relatively unaffected by previously used methods, but misapplication is possible if conditions are not evaluated properly.

Sonic treatment, like all other methods, is not the "panacea of the oil patch" and can succeed only if the production potential exists.

The application of sonic energy can result in increased production efficiency; and continued testing and refinements of tools and techniques will increase the versatility of these tools.