

THE TECHNOLOGY OF OIL OUTPUT AND OIL RECOVERY ENHANCEMENT BY SEISMOWAVES IMPACTS

Introduction

We have worked out and developed the Technology of Seismowaves Impacts, T-SWI, to intensify oil production and increase oil recovery “The methods to intensify oil extraction”. The Technology has been awarded Patents by Eurasian (No. 001474 dated 18 December 2000), European (No. 1266121 dated 21 December 2005) and Canadian (№ 2406794, February 17, 2009) regulatory bodies (authors I. H. Kerimov, S. I. Kerimov).

Implementation of T-SWI fully had reviewed all the modern concept of search and exploration of the oil and gas fields, the use of techniques to maintain reservoir pressure and with completely new positions to approach to the environment protection problems caused by the large-scale industrial activities.

The application of the Technology leads to both economical and ecological benefits such as:

- increase of percentage rate of oil in extracted liquid;
- increase of layer pressures;
- reduction of environmental pollution;
- decrease in water-cut of oilfields.

And the following results can be achieved depending on the geological and geophysical conditions and parameters of oil:

- increase in oil output by 15 – 35%;
- decrease in water-cut of the output liquid by 5 – 20%;
- increase current coefficient of oil recovery up to 45%;
- increase in final oil recovery up to 70-80% or more;
- maintenance of oil output on high level during long period of time and prolong oil-field lifetime;
- prevention of oil reservoir distraction and rehabilitation of its damages.

Experimentally proved that the Technology can be applied practically on all geological structures and on oil reservoirs of a wide range of depths and thicknesses of the layers and characteristics of reservoir pressures and water cut.

Each oil field is treated as a single heterogeneity in the medium and the vibrational impacts are carried out on all its volume. The Technology does not require an additional pumping of water or other chemical reagents for the purpose of its own implementation.

Thus, due to correctly organized impacts the vibrations are restoring the natural state of the environment, fractured on large and small disruptions caused by the uncontrolled oil field exploitation in previous years and bring it into energetically homogeneous state.

The effects exceptionally interesting for the T-SWI additional use have been identified, as the development recommendations for the correct selection of sites for drilling production and injection wells for increasing their efficiency and durability of exploitation.

The most important economic indicator of the effectiveness, relevance and uniqueness of T-SWI is a huge cost savings by reducing the volume of injected water into the reservoir to maintain the layer pressure. For water injection should be used on the oilfield only wells situated by geophysical data in sensitive places because in same periods of time the injections of water in other wells undesirable and can lead to increasing of watercut. Gradual implementation of the developed water injection new tactics to maintain reservoir pressures with 20-60% less than before volumes of the injected water will result in together with the vibration exposure to a significant reduction of watercut.

The T-SWI is environmentally friendly and can be used as the sole method of enhanced hydrocarbon recovery, or be used in conjunction with other methods of enhanced recovery. And during the T-SWI application the process of the oil field exploration and all other kinds of works and methods concerning it are going on in the former regime. The Technology has no adverse risks, but gives tremendous added value. The period of time until the first profit, which, in fact, will compensate all expenses, takes 3-4 months.

New learnings concerning geological media that contain hydrocarbon fields, and the physical states, processes and conditions in them, have led to an enhanced oil recovery technique. The latter involves inducing subsurface vibrations from the ground surface over whole hydrocarbon fields. These controlled vibrational impacts can result in sustained increase in medium's stressed state and oil reservoir pressure, in volume of hydrocarbon output, and reduction of associated water-cut in produced fluids.

Thus unlike the conventional methods of oil production the Technology increases and maintains productive stratum pressure from the outside of oil reservoir. Its effectiveness as an enhanced hydrocarbon recovery technique has been demonstrated over fifteen years and at numerous oil fields.

The T-SWI has been used for a single, or for a group of oil fields situated on area from 500 to 2000 sq. km. According to geophysical data the T-SWI may be purposefully implement on area of 10 - 15 thousands sq. km to increase oil production at all fields in the area. Also T-SWI can be successfully implemented for offshore using vibro impacts from the land, which will be quite effective if the oil fields are located in 15 - 50 km from the coastal zone.

The T-SWI is the result of many years of research and experiments to develop methods to effectively control and manage geodynamic processes. Its scientific background is a discovery of the new physical law of weak high frequency seismic signals propagation and interaction with medium, registered by the State Committee on Discoveries and Inventions of the former USSR in March, 1988, with a priority from May, 1979 (author – I. H. Kerimov).

In the previous years on this base various aspects of the monitoring and management the stressed state of the medium were studied in many seismically active and non-active regions,

as well as in the oilfields of the former USSR: of Belarus (1979); Azerbaijan (1982-1984); Yakutia (1984); Central Asia (1985-1988); Ukraine (1989-1990) and the Caspian Basin (1989-1993). A significant role was played the results of our researches conducted from 1993 as the main organization in Azerbaijan by Presidential Decree and Order of the Government of the Republic for study, monitor and control the negative environmental effects caused by major industrial activity on land and at sea, at the exploitation of oil fields in the Caspian sea. The Technology has been developed and improved by us as a result of these studies. Various aspects of the Technology T-SWI have been presented at international meetings in Singapore (1998), Lisbon (1999), Tulsa (2002), Kazan (2003), Jakarta (2008), Shiraz (2009) Sochi (2012), Almaty (2012).

The main features of the Technology are as follows:

1. Quantitative characterization of:
 - the stress state of a hydrocarbon field;
 - distribution of local internal volumes in the medium;
 - sensitivity of these volumes to externally induced mechanical disturbances;
 - distribution of intensity level of background seismic noise.
2. The methodologies of the monitoring of the variations on the earth surface the seismic noises and the developing of the model of vibration impacts.
3. The method of inducing vibrations using surface seismic vibrators in a spatially and temporally targeted manner over the hydrocarbon field.
4. Vibrations induced at the surface can cause intense seismic emission, leading to redistribution of the stress state within the sedimentary rock containing the hydrocarbon reservoir, to increase of the reservoir pressures, and consequently to oil productions.
5. This in turn causes an increase in horizontal and threshold reservoir pressure, leading to increased fluid flow and recovery.
6. The effects of vibration impacts on hydrocarbon-bearing rocks that may lead to enhanced hydrocarbon flow and recovery and may cause as a result of the following changes of geological media and oil strata:
 - creation of new drainage channels;
 - dilatancy of reservoir rocks;
 - opening of pores;
 - significant decrease of fluid viscosity;
 - intensification of capillary effects;
 - increase in filtration processes (particularly in finely-dispersed thin and poorly permeable volumes of rock).

However, it should be noted that in our case is difficult to quantify the relative contribution of each of these mechanisms to enhanced fluid flow. It is the cumulative effect of these various mechanisms that result in enhanced hydrocarbon production during application of the technology.

Work on the implementation of the Technology T-SWI is held by company "Seismotech Globe" BV, Netherlands, which has the rights to its use given by the authors. Employees of the "Seismotech Globe" BV only are controlling the quality of measurements and their further analysis.

The whole range of activities carried out by local organizations with which "Seismotech Globe" BV shall make appropriate contract:

- carrying out of geological and geophysical measurements;
- estimation of the background level of oil production on all wells and on the whole field;
- the realization of the vibro impacts program.

Application of the Technology proceeds in the following manner:

1. Analysis of various existing data for the field (geological, geophysical, engineering, etc) and collection of new data including the following:

- conducting microseismic activity surveys over the field and surrounding area (dimensions of the total area is 1.5-2 bigger than dimensions of the oilfield);
- conducting gravity, electromagnetic, and topographical surveys over the field and the surrounding area;
- performing reservoir pressure measurements.

2. Development of a model characterizing the energy state of the medium containing the field, using data from the microseismic activity, electromagnetic, gravimetric and topographical surveys and results of data analysis.

3. Development of a vibrational impact model, which is based on the energy model for the medium.

4. Performance of surface vibrational impact tests to calibrate and validate the energy and vibrational impact models for the medium.

5. Administration of the vibrational impact program.

6. Periodically conducting surveys of microseismic activity, electromagnetic, and other monitor surveys, and updating the medium energy and vibrational impact models following the administration of vibrational impact program.

7. Repeated, (modified as necessary) administration of the vibrational impact program according to results of the above studies.

Application of the technology can cause enhanced hydrocarbon production to be sustained over a period of 2-6 months depending on the particular geological and geophysical properties of the medium and its pore fluids. During this period enhanced hydrocarbon production will gradually decline to the background output level (level of output prior to induced vibrations). In order to mitigate this decline, the induced vibration program has to be repeated regularly. Our previous experience suggests that repetition over a 2-3 month cycle optimizes the benefit versus cost. It allows maintenance of high reservoir pressure with additional hydrocarbon production at stable levels.

The Technology is more environmentally friendly in comparison with other enhanced recovery methods. Increase in the stress state of the medium inhibits intrusion of subsurface water from external sources into the reservoir, and its subsequent deterioration and distraction.

New tactics of water injection into wells

The dynamic processes in the medium identified during the T-SWI implementation have shown that the generally accepted principles of water injection do not take into account the rapidly changing factors such as the state of the environment and its sensitivity.

It has been shown that the medium at different times react differently to water injection, may enhance its impact on the reservoir pressure, be neutral or even cause the opposite effects.

As a result, the effect of the injected water impact on the reservoir pressure is very small and on the contrary, leads to an increase of watercut and adversely affecting oil recovery.

On this basis, the qualitatively different approach to the problem and the new water injection strategy have been developed and proposed, using the following data:

- the state of the medium and its variations after several cycles of vibro impacts;
- the current volume of water injected into wells;
- the study of the distribution at the oil field the sensitive and non-sensitive areas;
- analysis of the possibility of water injections positive or negative impacts on the stress state of medium.

Thus the T-SWI possibilities of use turned up to be incomparably greater than expected in the early stages of its implementation.

On the OGPD "Prikamneft" oilfields the positive effects of T-SWI implementation due to pressures growth in layers, have occurred within 6-8 months after the start of work. And by reduction of injection on 16-18% - to 60 thousand tons, have been covered all OGPD oilfields which brought savings of \$ 900 thousand monthly. It showed that the pressure increasing in layers happened in all oilfields OGPD distributed on a large territory.

In general, in results of the T-SWI use, the OGPD took in JSC "Tatneft" first place on all economic parameters.

However, the analysis of the above parameters after 4-5 cycles of vibro impacts has led to some unexpected conclusions.

It became apparent that in some periods OGPD can reduce the volume of injected water into the reservoir even by 80%.

And for water injection can be used only a some part from the total number of wells.

The geophysical data showed that in some periods of time the injections of water in other wells undesirable and can lead to increasing of watercut.

More unexpected was the following conclusion that in order to maintain the required level of reservoir pressure injection should be carried out not during one month, as it is practiced, but it would be sufficient to carry out them periodically, intermittently, for three - seven days.

This would provide not only great savings (in addition to increasing of the oil production), but gradually would significantly reduce watercut.

As the T-SWI implementation the water injection process should be accompanied by the monitoring of geophysical fields to obtain data for the development of the program for the next month.

The Implementation Expenses and Profit of the T- SWI

The expenses for the SWI Technology implementation do not depend on the level of daily oil production in the field. They depend only of the works area and, correspondingly, of the number of geophysical observation points and vibroseism machines.

The expenses of the first cycle of works – 3-4 months for an area of 1000 sq. km (40 km x 25 km) before receiving the first profit may reach 200-400 thousand Euros, depending on the cost of certain services in the region of works. For example, daily oil production in fields located within this area may vary in a widest range, from 100 up to 10 000 tones and more, but the T-SWI costs will remain unchanged. Accordingly, the higher the level of daily oil production in the area, the more profitable use of technology SWI.

But even if daily production is 150 tons and T-SWI will increase it by only 10%, the very first profit will cover all expenses.