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PROJECT OF A DIDACTIC BENCH: ENHANCED OIL RECOVERY BY ULTRASONIC STIMULATION

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Abstract. *The present study aimed to evaluate the oil well stimulation methods that are most commonly used nowadays, aiming to understand the proceedings, techniques, advantages, and disadvantages. Stimulation in saturated wells has lower costs compared to the construction of new fields. Socio-environmental movements and bibliographic surveys, point out that conventional stimulations techniques (fracking and acidization) damages the environment and threatens public health, thus giving more opportunities for research involving less invasive methods. Therefore, a technical detailing of an experimental ultrasonic stimulation will be carried out in this project, intending to reveal its performance, in addition to this new and less-known technique that causes none or less impact for the environment.*

Keywords: *stimulation, ultrasonic, saturated wells, mature fields*

1. INTRODUCTION

The word petroleum, from the Latin petrus (stone) and oleum (oil), can be interpreted as "the oil that is born from the stone". This oil, composed of complex combinations of hydrocarbons, has been imposing itself as one of the main sources of energy worldwide over time since its discovery (Thomas, J.E.; Triggia, A.A.; Correia, C.A. et al.,2001). Due to the sustenance of the prospecting process since the beginning of modern society, there has been a growing demand and exploration for petroleum, resulting in a decrease in the amount of petroleum extracted, requiring new techniques that can supply this demand (Thomas, J.E.; Triggia, A.A.; Correia, C.A. et al.,2001).

Although it is an extremely valuable resource, the process of obtaining petroleum presents a major challenge that is the extraction from reservoirs deep underground (Aquino, G. S. de; Lana, M. da C.,1990). Such reservoirs can be accessed by drilling wells through a variety of engineering methods and calculations. During the extraction processes, it is recurrent that oil well obstruction occurs, leading to economic and material losses. One of the possible alternatives to solve this problem is to drill new wells, however, this would happen at the expense of a very high project budget. On the other hand, the resolution of the obstruction by stimulating already saturated oil wells (Meribout, M., 2018; Vladimir O., 2013; Rehman, M.M., Meribout, M., 2012) would employ less project capital in relation to drilling new wells, thus becoming the focus of study of this study, as to its innovative ultrasound technique.

Therefore, this work aims to perform a laboratory bench design, which allows the study intended to simulate the unblocking of oil wells through ultrasonic enhancement.

2. METHODOLOGY AND MATERIALS

For the development of this project, an analysis study of the current petroleum scenario was conducted within the area of well stimulation. In this way, the most used techniques and their benefits were understood, also their methods, advantages, disadvantages, and processes were compared. A portion of the sources were acquired through the internet, and through websites that address issues involving the stimulation of oil in various countries, for example, the Energy Information Administration (EIA), the official energy and statistics website of the United States government.

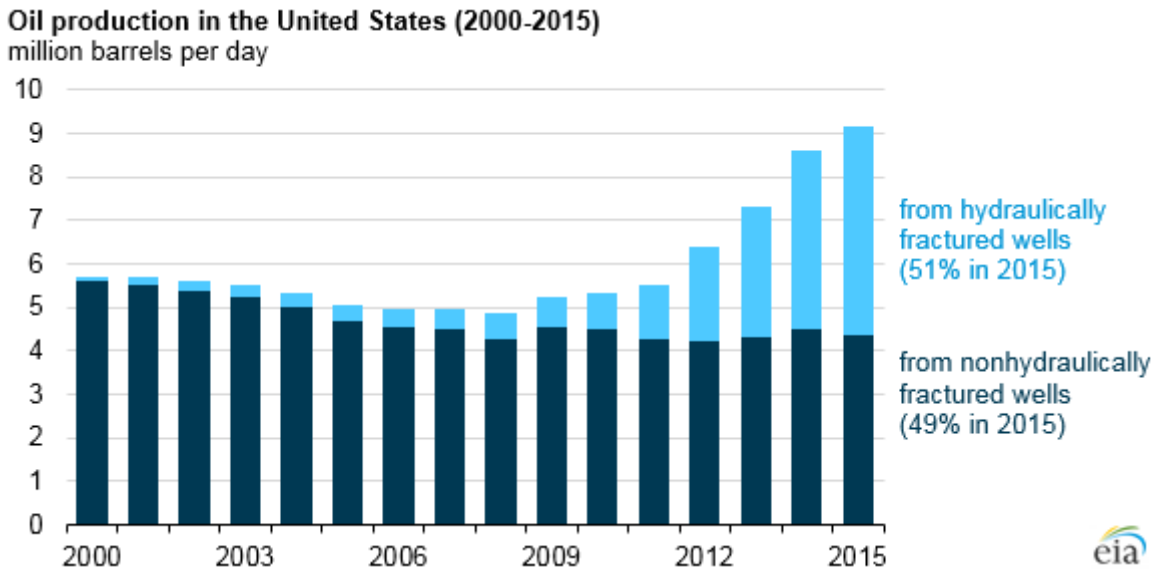

Figure 1. Oil production in the United States per year. Available from: https://www.eia.gov/todayinenergy/detail.php?id=25372

The study will also be based on the use of various bibliographic references, such as books, scientific articles and theses. Furthermore, an unblocking simulation will be conducted to analyze and verify the development, using a bench project.

The project will consist of the following stages:

- Literature review: data and literature analysis (statistics related to oil&gas well stimulation; current methods in place; operation and components; environmental impacts).
- Detailed analysis: in-depth details of the oil well unclogging processes by ultrasonic enhancement.
- Study of vibrations: theory and calculations related to vibrational mechanics and acoustics, focused on the application area in the ultrasonic enhancement process.
- Parameters: definition of criteria, measures and factors for bench design.
- Didactic bench design: project for well stimulation by ultrasonic stimulation.

3. STUDIES OF ULTRASONIC EFFECTS

3.1 Temperature and viscosity

The intensity of the applied frequency has an intrinsic relationship with the viscosity, applied to an ultrasonic system. Studies involving the use of cavitation for oil well stimulation, reveal its influence on the temperature in the liquid medium under analysis, as the frequency increases it is possible to notice an increase in the average temperature due to frictional forces that occur between different methods (Lopuchov, 1999; Xiao et al.,2004).

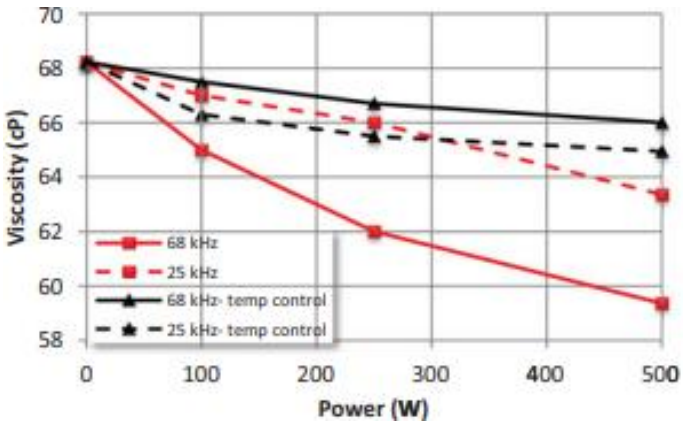

Figure 2. Synthetic Oil Viscosity and Ultrasonic Power. Available from: https://www.tandfonline.com/lpet.

As reported by Hamidi et al. (2012), under non-isothermal conditions, lower viscosities are obtained when applying a frequency of 68 KHz. In contrast, during condition of controlled temperature, lower viscosities were obtained at a frequency of 25 KHz , as presented in Fig. 2.

Heat is known to be generated by boundary friction, and it is a consequence of differences in the vibration velocity of the fluid and the solid. These differences maximize the energy transfer from the ultrasonic waves to heat at the boundary of the fluid and solid, while the dissipation of acoustic waves is an energy decay whereby the energy coming from the ultrasonic waves, is converted into thermal energy within the fluid and thus increasing its surrounding temperature (Poesio and Ooms, 2005).

Thus, the frequency-temperature interaction in bench test analyses becomes evident, and this point brings us significant interest in applied studies around the ultrasonic oil well stimulation.

3.2 Cavitation

During the application of an ultrasonic wave, occurs the phenomenon called acoustic cavitation, which is the formation followed by a growth and collapse of micro-bubbles forming the so-called micro-jets (fig. 3). During the collapse of these micro-bubbles, a huge wave of energy is released and can reach temperatures near 5075K and speed of 1500 m/s (Kenneth and Edward, 1992).

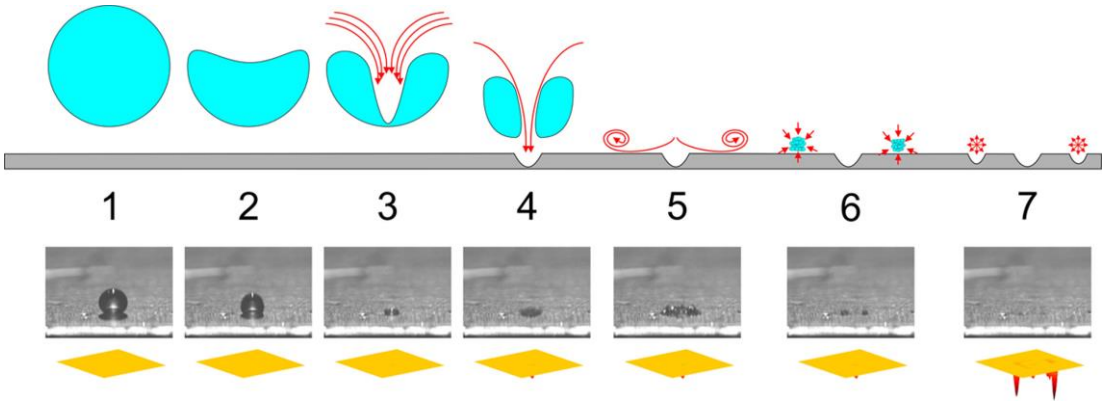

Figure 3. Cavitation phenomenon and damage caused by the formation of microjets. Available from: https://www.sciencedirect.com/science/article/abs/pii/S0043164818308044?via%3Dihub.

Ultrasonic cavitation is the main phenomenon responsible for the temperature rise in fluids exposed to ultrasonic waves (Hamida and Babadagli, 2007). As the frequency intensifies, it generates smaller diameter cavitation bubbles, thus increasing the density of bubbles that are formed and imploded. On the other hand, at lower frequencies it was noticed that bubbles formed with smaller diameters (170μm). Lastly, at low frequencies (20~30 KHz), higher energies are released in the implosions of the larger diameter bubbles (Award, 1996).

4. RESULTS AND DISCUSSION

This work is still in the beginning of its project, therefore there are not enough results and data yet.

5. CONCLUSION

Given the growing demand for oil worldwide, the obstruction of well plugging intensifies the decrease in the amount extracted. Therefore, this project presents an immense potential at stimulation, since it associates low implementation costs with low environmental and ecological impact, collaborating positively with the Brazilian oil industry.

6. ACKNOWLEDGEMENT

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