Oil & Gas Research
ISSN: 2472-0518

Khorasgani et al., Oil Gas Res 2022, 8:12

Review Article Open Access

Investigation of Laser Drilling Method

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Abstract

Today, among politicians, the discussion of replacing modern drilling methods with rotary drilling has many supporters. For new methods, several methods have been suggested, among them, steam drilling, water pressure drilling, and laser drilling. Based on numerous tests on the use of laser technology in drilling, it has been proven that laser technology, in addition to increasing the speed of drilling, also reduces time, cost and environmental pollution. The experiments that have been carried out so far have all followed one main goal, that is, the maximum drilling of the rock with the lowest power required by the laser. In this article, logical data and strong arguments have been tried to be presented in this regard using existing devices and limited facilities.

Keywords: Laser engraving; New methods; Drilling speed; Drilling time

Introduction

At the beginning of the 20th century, the towline drilling method was added to drilling with a string of steel pipes and even replaced it in many cases. But both of these methods are very time-consuming, dangerous and expensive for drilling oil and gas wells, which are of the deep drilling type [1]. Research on the use of laser technology in drilling oil and gas wells began in 1997. First, the US Army was reported by Graves and O'Brien under the MIRACL project of a continuous wave (CW) laser system with a wavelength of ¬3.8 micrometers and a laser power of 600 to 1200 kW in 4.5 seconds about 2.5 inches for sandstone, drilling depth. In this experiment, the drilling speed increased by 10 to 100 times. After that, an experiment called COIL was conducted under the supervision of the US Air Force. This laser operates in the CW wave, which has been successfully tracked at a range of 31 miles. Factors affecting laser drilling include: laser power, wavelength, system working mechanism (continuous or shock waves), laser type and radiation profile [2].

Advantages and disadvantages of using laser technology in drilling

With the introduction of the laser system to drilling in the oil industry, this field can take a step towards progress and evolution. The advantages of using the laser system in drilling include the creation of a ceramic wall on the well wall due to the melting of rock, reducing the working days of the drilling rig and the duration of the drilling stoppage, creating the same diameter from the surface to the bottom of the well, reducing the possibility of Clogging of drilling pipes, a significant reduction in drilling costs, the possibility of using light pipes and replacing some heavy pipes with optical fibers, reducing environmental pollution and increasing the drilling speed by 10 to 100 times. Kurdish [3]. Some experts are against replacing laser drilling with rotary drilling. Because some of the problems that arise during laser drilling cannot be largely ignored. Among these problems, the following can be mentioned:

a) The rotation of drilling mud during the drilling operation and its effect on the energy transferred to the rock surface

b) Energy transfer from the laser source on the surface to the laser lens on the surface of the well [4].

Laser drilling steps

When the laser rays hit the stone surface, the stone is drilled through the following steps [3]:

a) Creating micro-fracture

b) Melting

c) Evaporation

When the laser rays hit the stone surface, the rays may show one of the following reactions [Figure-1] [5]:

a) Rays are reflected

b) Rays spread

c) Rays are absorbed

The conducted experiments show that the scattered and reflected rays have less effect on the stone than the absorbed rays. In fact, the mechanism that causes rock crushing and finally drilling is the absorption mechanism of laser rays [6]. In rocks that have a high heat transfer coefficient, laser rays can evaporate accumulated crystalline waters along with minerals dissolved in the rock and cause expansion of the rock and create micro-fractures in the rock structure.

Nitrogen gas is used in experiments along with laser operation. One of the reasons for using nitrogen gas is to burn the gases released during rock drilling and to remove the resulting dust. This gas causes the particles to be removed at each stage of laser work. In rotary drilling, drilling fluid is used to transfer logs from the end of the well to the surface [7].

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Received: 02-Dec-22, Manuscript No. ogr-22-82398; **Editor assigned:** 05-Dec-22, PreQC No. ogr-22-82398(PQ); **Reviewed:** 20-Dec-22, QC No. ogr-22-82398; **Revised:** 26-Dec-22, Manuscript No ogr-22-82398 (R); **Published:** 30-Dec-22, DOI: 10.4172/2472-0518.1000275

Citation: Khorasgani MHG, Bahari AB, Naravi E, Miri D, Avari AA (2022) Investigation of Laser Drilling Method. Oil Gas Res 8: 275.

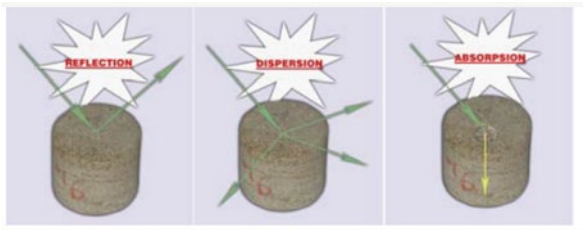

Figure 1: the reaction of radiation rays when they hit the stone surface.

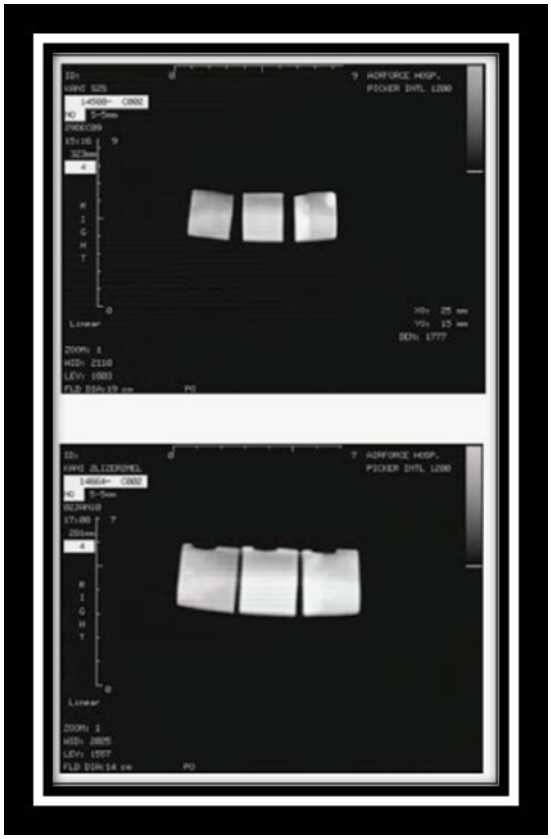

Figure 2: CT scan images before and after laser treatment.

Discussion and Test Method

In this experiment, three rock groups, sandstone, limestone and shale, which are the most encountered during excavation, have been used. Three samples of each stone with different depth, porosity and saturation have been used. From each of these three groups, one rock sample is saturated with water so that accurate comparisons can be made. In order to observe the changes before and after the laser, all 9 samples were imaged using a Picker1200 CT scanner with a voltage of 130kw and a current of 80MA for 2 seconds. In this experiment, the laser with a radiation speed of about 10 Mm⁄S used 100% of its power, and in a period of 66 seconds, a diameter of 1 cm was drilled and after that the samples were photographed again. [Figure 2].

After the tests, the parameters of the amount of specific energy (SE), drilling rate (ROP), comparison of drilling rate and specific energy for saturated and unsaturated samples, the effect of laser drilling on drilling costs and the impact of drilling It was investigated with laser on environmental management.

According to the following relationship, drilling speed has a direct relationship with the amount of laser power entering the surface (SP) and an inverse relationship with the amount of energy required for rock drilling (SE): [8]:

$$ROP=SP/SE \quad (m/second)^* \tag{1}$$

Observations

Specific energy (SE)

Considering that the specific energy depends on the rays that are absorbed, reflected and scattered, the results of Table-1 show that the amount of absorbed rays in sandstone is more than other stones. Of course, according to the results of the experiments, this article is reversed for saturated samples. According to the results obtained for saturated samples, it can be concluded that the highest drilling rate for and keeps more water in its building. Therefore, during laser radiation on the surface of sandstone, the maximum amount of laser power is used to evaporate the water in the petrified building and the energy transferred to the stone is reduced. This causes a decrease in the drilling rate in saturated samples compared to unsaturated samples. Of course, this article is an exception for shale; because with shale saturation, its drilling speed also increases so that the laser drilling rate of saturated shale is higher than the drilling rate of unsaturated sandstone [Table 1]

* SP: Power Per Unit Area,

SE: Amount of Energy Required To Remove A Unit Of Rock

Drilling speed (ROP)

After measuring the drilling speed for each rock sample, it was found that the highest drilling rate and displacement heat coefficient are related to sandstone. With the increase of the heat transfer coefficient, the micro-fractures that are caused by the laser radiation on the stone increases, and with the increase of these micro-fractures, the drilling speed increases and the stone is drilled in less time. Also, the increase of micro-fractures increases the permeability of the stone. Therefore, by improving and increasing the power of the system, the drilling speed can be increased.

The impact of laser drilling on drilling costs

Drilling costs have an inverse relationship with the drilled length per drill. When using a laser system instead of a drilling drill, the length drilled by the laser system increases. Therefore, most of the drilling costs are reduced. It seems that due to the use of electrical energy instead of mechanical energy in the laser system, the amount of damage to the drilling string during drilling is reduced. Also, by using the laser system, the length of working days of the drilling rig is reduced and the life of the drilling rig that uses the laser is increased.

The effect of laser drilling on environmental pollution

The effect of laser drilling on environmental pollution

A) Effluents produced as a result of using old equipment and incorrect technologies

Table 1: Comparison of specific energy of saturated and unsaturated samples.

	sandstone (saturated)	limestone (saturated)	shale (saturated)
specific energy (SE) (J/Cm²)	84	59	31
	Sandstone	Limestone	Shell
specific energy (SE) (J/Cm²)	32<X<36	39<X<42	42<X<45

B) Oil-based mud that is used for drilling wells, especially for Chilean formations, which use harmful chemicals for the environment.

By replacing the laser system in the oil and gas well drilling industry, it is possible to use air fluid instead of oil-based mud in dust drilling and reduce environmental pollution. Also, in laser drilling, by replacing the electronic system with a mechanical one, much environmental pollution is prevented [9].

Laser drilling methods in the oil industry

Mechanization technology in the oil industry refers to the removal of materials and work parts and the use of optical power chips which refers to rock cutting in the oil industry, which is drilling. which are divided into two categories:

A) Grinding: which includes grinding, engaging in an action that causes the removal of materials by the action of rubbing and with the release of abrasive particles.

B) Cutting: This process involves converting the drilling from the metal part into a rotary tool and turning it into light, which is a new tool, and vice versa. It is used to replace non-traditional techniques such as electricity and chemicals with lasers or the use of cut water, such as laser, which stands for light amplification by induced emission of radiation. One of the features of laser light is having divergence, low beam and carrying high energy. The meaning of high-speed lasers is to create very short pulses in a long time to weaken the surface and send very powerful pulses to destroy the materials on the way to reach the desired depth.

Shot means drilling at a high speed compared to the dimensions of the object or usually it means the method of drilling compared to the pulse power. Tri-pinning laser drilling is the method used to remove a circular cylinder or disc from a layer. Trippinning is the standard method for large excavations called EG. One of the advantages of trippinning is stable holes and very high ability without drill friction Deposits and wear, as well as the position of the launch bed in relation to the approved bed, overlap the beam to achieve the quality of the desired edge and the ability to produce displacement. Snail drilling is a new type of drilling technique, in this method tripping lasers with short pulses cause erosion of the layer and gradually break them, which is to increase the accuracy and speed of the operation, which is called drilling. It is also called spiral. Auger drilling has the following desirable effects:

Further deviation from the circular geometry can be reduced in trippinning and the load on the opposite walls can be reduced to its minimum level, and most importantly, the design of the layers in percussive drilling using nanoseconds on the observation pulse. It can be reduced to a great extent and takes much less energy than the direct mode. But one of the disadvantages of spiral drilling is that it is efficient when the diameter of the spiral is very close to the focal diameter of the laser beam. Another problem of trippinning and spiral drilling, although it is very useful, is much more expensive and time-consuming than percussive drilling [10].

Conclusions

Considering that most of Iran's formations are shale or sandstone, it can be concluded that the introduction of the laser system into the drilling industry will bring about a great revolution in this industry. To enter the laser drilling system in the drilling industry, it is necessary to perform many field tests. To begin with, you can start by digging specific layers, especially the layers that are problematic in drilling, and with the passage of time and the stabilization of the system expanded it. According to the obtained results, increasing the speed of drilling in rock depends on reducing the amount of energy required for drilling rock. Of course, for better conclusions, different samples such as carbonate, dolomite or granite should be used. In the early stages, when the soil is loose, it is cost-effective to use the laser system instead of drilling use it periodically. Also, considering the greater radius of the well in the initial stages, the amount of energy required for rock drilling increases, as a result, the drilling speed will decrease. In the lower layers, where the volume of drilling cuttings is less, it is possible to guide the cuttings out of the well with the help of air fluid. This prevents the use of oil-based fluid and results in less environmental pollution. The operation of finding residues inside the oil and gas well using laser will be useful when the residues are small and worthless and there is no need to remove them. In this case, instead of removing these remains, we will melt them there and continue the drilling operation. Also, today, the improvement of meshing of oil and gas wells using laser is under investigation and research.

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