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Characterization and performance enhancement of electrical submersible pump (ESP) using artificial intelligence (AI)

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Abstract

Electrical submersible pump (ESP) technology is the first choice of artificial lift for the operators both in offshore and onshore to increase the rate of production in all types of reservoirs. Even though, the ESP was designed, engineered and fabricated to withstand in harsh subsurface natural and man-made environment such as corrosion, high temperature and extreme pressure but it fails under these circumstances without any prerequisite signal. Even the monitoring systems in place failed to notify the failure of ESP. These ESP failures cut off the production and revenue circulation in the firm. The cost required for the repair and replacement of the ESP is also high and is time consuming. The prevention of ESP failures using machine learning technique is discussed.

Introduction

When the primary energy of the reservoir declines over a period of time and it don't have enough pressure to moves the oil from producing zone to the wellhead, artificial lift is employed to increase the production.[1] In United States, 96% of the wells deploy artificial lift since the beginning of the production to increase the rate of production.

Generally, there are two types of artificial lift systems and are:

a) Pumping system

b) Gas lifts

It uses the gases produced from wellbore, recompresses it and sent it to the formation through side mandrels and valves to build-up the pressure. The injected gas reduces the viscosity of the oil and increases the volume, which makes the oil to move upwards along the surface. It is of two types:

i. Continuous gas lift

ii. Intermittent gas lift

This system is similar to the household hand bore well system and is employed in larger size & scale for getting higher rate of output. The types of pumping system are.

i. Sucker rod pump

ii. Hydraulic pump

iii. Electrical submersible pump

In an average, 82% of wells uses sucker rod pump, 10% uses gas lift, 4% uses electrical submersible pump and 2% uses hydraulic pumps for artificial lift in a well.
ESP is nothing but a centrifugal pump consists of numerous impellers and blades connected with a long electric motor.

The centrifugal pump is kept at the lower margin of the reservoir fluids and is connected with the motor which is located at the bottom of the production casing.

Once the motor gets the electrical power through the electric cable runs along the length of the well it starts the pump. The rotating action of impeller creates a centrifugal force and pushes the reservoir fluid towards the surface. ESP is the highly efficient in all types of artificial lift; it can lift and deliver more than 1000 bbl/hr.

Artificial intelligence is the duplication of Homo sapiens intelligence processes by man-made machines especially computer software and systems. [6] AI includes learning, reasoning and self-correction. [2].

It is of two types:
a) **Weak AI** – It is an AI system which is designed and trained for a specific task

b) **Strong AI** – It is an AI system generalized with the human psychological knowledge of perception, learning and reasoning. When presented with an unknown activity, a strong AI system has the capability of finding a solution without human interference.

The following are some of the common application of AI in various fields such as healthcare, business, education, finance, law and manufacturing.

It is the practical application of AI which allows the systems to learn on its own and out of experience without any external program languages and human intervention. It majorly concentrates on the development of computer programs that can analyze the data for self-learning. [3].

Some of the machine learning methods is supervised machine learning algorithms, unsupervised machine learning algorithms, semi-supervised machine learning algorithms and reinforcement machine learning algorithms. [24] Major applications of machine learning are personalized marketing - where the website offers product to the individuals based on their interest by collecting the details of them from their browsing history, fraud detection, spam filtering, network security threat detection, predictive maintenance and building news feeds. [4].

Deep learning is a subdivision of machine learning and artificial intelligence which was found in 1943 by Walter Pitts and Warren McCulloch whom created a computer model by imitation of the neural networks of the human brain. They used a process called threshold logic which is a combination of algorithms and mathematics for the duplication process.

The deep learning will be successful when it has large number of labelled data and significant computing power. Some examples of deep learning are automated driving, aerospace and defence operations, medical research, industrial automation and electronics.

Section snippets

Selection criterion for artificial lift

The following are the major factors in the selection of artificial lift for a well and are.
i. Well conditions and well geometry…

ii. Production characteristics…

iii. Location of the field…

iv. Cost and performance of the system…

(i). well conditions and well geometry…

a. Well depth – Shallow, Deep, Ultradeep…

b. Type of well – Horizontal or Vertical…

c. Presence of aquifer…

d. Size of casing – Production…

e. Type of completion – Open, cased hole completion…

(ii).production characteristics…

a. Rate of production – High, Low…

b. Bottom hole pressure – High, Medium,…

…

Artificial intelligence in oil & gas industry

Since 2006, AI helped in increasing the business of online retail sellers to 1600 folds. [19] Now AI entering into the Oil & gas industry and is the promising technology which has enough potential to unlatch productivity in oil & gas industry. E&P operators started adopting manufacturing models accompanied by huge electrification, automization and digitalization. The AI in oil & gas industry is expected to reach the growth of Rs.20,500 crore at the end of 2022 and then it will progress at a…

Why artificial intelligence is needed in selection of artificial lift?

Artificial lift selection by humans is based on consideration of the various parameters and by analogy. The accuracy of the selected artificial lift method is liable to the experience of the engineer and the quality & quantity of the available well data. The engineers look out only to the previously failed artificial lift methods and successfully installed methods. But they don't see the operational expenditure and performance analysis of the artificial lift system.

After collecting data from…

Electrical submersible pump (ESP) in oil field

Electrical Submersible Pump system is one of the best artificial lift methods to lift oil from the subsurface [20]. Currently 10 lakh wells in the world have artificial lift production, out of which one-fifth of wells uses ESP technology because of high volume handling capacity and operational performance at greater depths. [18] It can be used in wells having. (See Table 3.).

- Low bottom hole pressure (BHP)…
- Low gas-oil ratio (GOR)…
- Low Bubble point…
- High water cut…

…

Artificial intelligence in ESP

AI was introduced in the ESP operation with an aim of reduction of production costs less than $10 per barrel. Siemens conducted a pilot test in a mature onshore field employing 30 ESP upgraded with AI technology. [19] The result shows the reduced maintenance, increase in performance and low disruptions during production. It fails at sometimes which disrupts production and cash flow of industry. It can be overcome by right mixture of newer technologies namely AI, Internet of Things (IoT) and…

Surface variables

- P_1 – Annular pressure…
- P_2 – Production oil pressure…
- E – Motor current…
- S – Speed of motor…

…

Subsurface variables

- P_3 – Inlet oil pressure at pump…
- T_1 – Inlet temperature of oil at pump…
- T_2 - Temperature of motor pump…

The variables are mentioned in Fig. 1. Fig. 2. Fig 3.

Once the ESP is deployed for operation, the distributed control system (DCS) & supervisory control and data acquisition (SCADA) system transmits the data in 5 to 10 sec interval to the recording unit. The data is stored in a mother board and can be used in the future for the error detection. This have a limitation that it cannot simultaneously…

Recent advancements in ESP

ESP is widely used in the production of oil due to its higher efficiency and reliability. Depending upon the wellbore parameters such as payzone thickness and volume of oil present in the reservoir condition the operating parameters vary accordingly and simultaneously the power required by the ESP also changes accordingly. If there is any failure in the operation of ESP that leads to increase of NPT, loss of production and high cost for replacement. The operational failure is due to the…

Conclusion

This AI enabled ESP will deliver production for a long range of time without any malfunction. The advantages of this system are as follows:

- Less maintenance…
- No loss of production days…
- Minimum damage to the equipment…
- No need of SCADA and DCS monitoring system…
- Automatic problem identification and rectification…

AI technology is safer to environment and is compliance with the HSE policy. It automatically plans the shutdown procedure of a well for a certain period of time because each unplanned shutdown…

CRediT authorship contribution statement

M. Panbarasan: Conceptualization, Methodology, Writing – original draft. **Subhashini Sankar:** Visualization, Investigation. **S. Venkateshbabu:** Validation, Supervision. **A. Balasubramanian:** ….

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.…

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