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Well Control and Pressure Management Using Artificial Intelligent

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Abstract

Artificial intelligence (AI) is process of the pressure management in the oil and gas industry. With its capability to deliver real-time checking, extrapolative analytics, and automated control, AI not only considerably enhances security, but also efficiently lowers costs and make the most of production efficiency. As operatives strive for more well-organized and cost-effective approaches, integrating advanced techniques. AI's capacity to examine vast amounts of data, predict outcomes, and suggestion real-time solution enhances efficiency, lowers operating cost, and recovers reservoir performance. AI is significantly impacting the energy sector, with potential for further growth. The Middle East has appeared as a key region for improvement and testing of AI systems in the oil and gas industry. RoboWell attitudes at the forefront of novelty well control system. By joining the power of cloud-based AI algorithms, it not only activates wells efficiently but also animatedly self- adjusts to developing conditions in real-time. That advanced system guarantees optimal performance and reliability, revolutionizing how wells are accomplished. Finally, the results show that using python codes and variables aid to control pressures in oil wells and predict kick problem by using driller methods and wait and weight method. Detecting kick type is an important step, in other words (1-2) ppg is gas, (6-8) ppg is oil and (8.6-9) ppg is salt. Shutting Drill Pipe pressure(SIDPP) and Shutting Casing Pressure (SICP) are an important factor through killing, where the study found that it's safe to keep SICP greater than SIDPP and SICP should be less than 70% from casing burst resistance.

Keywords: *Pressure, Well control, Artificial Intelligence, Management, Performance.*

1. Introduction

Well control is energetic in oil and gas jobs, using performances to prevent unrestrained formation fluid flow into the wellbore and circumvent dangerous blowouts [1]. Operative well control upholds pressure balance through drilling fluid, blowout preventers (BOPs), and specialized tools. Active oil well pressure management is vital to ensuring the safety and effectiveness of oil drilling processes. It includes employing established techniques and procedures to precisely control and uphold pressure within an oil well through drilling, completion, and production stages [2]. Through adept control of drilling mud, formation fluid, and wellhead pressure, operators can proactively avoid essential well control difficulties similar blowouts and kicks [3]. This not only protections personnel and equipment but also enhances well performance and productivity, ultimately safeguarding investments and maximizing revenues [4]. Considerate well control events and choosing the most effective well control system is vital [5]. Well-engineered personnel must be incapable to use primary control methods to avoid risks and manage them efficiently furthermore, they must be capable to control it and regain primary control in the event that an unbalanced condition arises [6]. The challenge is not just to prevent kicks or blowouts, but to predict, detect, and mitigate them efficiently [7]. A not dangerous drilling envelope is being upheld through the use of technologies similar managed pressure drilling (MPD), kick tolerance modeling, and real-time pressure monitoring [8]. To understand the circumstance in which each control method functions AI its best, a solid theoretical foundation and field data investigation are essential [9]. Selecting the type of kill mud and calculating its density is considered the basic step in well control. Finding and selecting the best way to kill well is a big challenge that facing drilling crew and in order to solve that, kick signs should be detected and the crew should be taking suitable decision. Chock size is also considered one of the main challenges that affected on release kick specially in driller method. This discovery of this research underline the need to carefully assess critical parameters for instance formation pressure, mud weight, pore pressure gradients, and equipment reliability when selecting the most suitable well control approach. Uninterrupted progression in technology in addition the refinement of working out standards, has markedly promoted the accuracy and efficiency of kick detection and response techniques. Moreover, the analysis identifies instances in which the improper application of well control approaches has led to considerable financial losses and posed substantial risk to personnel safety, thereby supporting the importance of rigorous methodological assortment and observance to beast practice. Finally, it was founded that if the kick was gas only weight and weight method is better than other method

2. METHODOLOGY

Well control is a serious part in drilling processes, pointing to maintain formation pressure within innocuous restrictions to stop the incidence of kicks and blowouts. This study examines the most important factors that touch the selection and efficiency of well control approaches used during drilling accomplishments. A comprehensive investigation was conducted on twenty documented kick incidents from 1980 to 2025, both Iraq and international case studies are investigated. Respectively case was evaluated in standings of location, kick detection method, applied control performance (e.g., Driller's Method, Wait and Weight, concurrent method, or Volumetric Method), used equipment, mathematical simulations applied, and consequence. The plan is to enterprise an intelligent model by using machine learning in Python. This model will investigate real-time data from the well, including mud weight, pit volume, flow rate, pump pressure, and rate of penetration (ROP). The objective is to regulate whether the situation observed is a real kick or just formation ballooning. To attain this, it will appliance a classification model that will identify the condition: Is it a kick or ballooning, the model will then deliver a diagnosis mark. For this organization task, scikit-learn library is used, explicitly the RandomForestClassifier, as it is highly active for organization determinations. If the model identifies a kick, it will transfer into the second step, which is to guess the severity of the state. It will deliver us with the following statistics:

1. The possibility of a kick occurring.

2. Approvals on how to adjust the mud weight, for instance whether to rise or lessening it.

3. An approximation of when the kick is predictable to occur.

4. If the condition is serious, the model will direct us on whether there is needing to adjacent the Blowout Preventer (BOP) and regulate the perfect time for doing so.

In this segment, two libraries are utilized: XGBoost or LightGBM, along with their individual models, XGBRegressor or LGBMRegressor, to guess values for instance probability and time. Unassuming enters the third step, picking the most active method for well control established on the specific well characteristics. It indicates from the following techniques:

1. The Driller Method 2. The Wait-and-Weigh Method 3. The Volumetric Method

4. The Synchronous technique for this fragment, DecisionTreeClassifier` model will used to `DecisionTreeClassifier` model from the scikit-learn library because it is user-friendly and offers valuable understandings.

To display the outputs in a communicating and easy-to-opinion format, Streamlit or Gradio library is used either the Streamlit or Gradio library to create an interactive interface that can run online or locally on a computer. The model will assist me with three main tasks:

1. It will differentiate between kicking and inflation using the RandomForestClassifier from scikit-learn.

2. It will predict the severity of the condition and suggest a recommended course of action, utilizing either XGBRegressor from Xgboost or LGBMRegressor from light gbm.

3. It will determine the most effective control technique using the DecisionTreeClassifier from scikit-learn. Entirely of this information will be obtainable in a communicating interface generated with Streamlit or Gradio. Equations from 1 to 5 is used in the calculation of this study to choose the right method for kill the well [10]. Fig. 1 shows the preprocessing Python Codes.

$$\text{MWkill} = \frac{\textbf{SIDPP}}{\textbf{0.052}\times\textbf{TVD}} + \textbf{MW} \quad (1)$$

ICP =SIDPP + Drill pipe Pressure **Loss** (2)

$$\text{CP} = \text{ICP} - \left(\frac{\textbf{Depth Pumped}}{\textbf{Total Depth}}\right) \times (\text{ICP} - \text{FCP}) \quad (3)$$

Boyle's law for gas expansion:

$$P_1V_1=P_2V_2 \quad (4)$$

Surface Pressure increases :

$$\boldsymbol{\Delta p} = \frac{\textbf{0.052}\times\textbf{MW}\times\boldsymbol{\Delta}\textbf{h}}{\textbf{A}} \quad (5)$$

```python
python

from skopt import BayesSearchCV

params = {
    'n_estimators': (100, 300),
    'max_depth': (10, 20)
}
opt = BayesSearchCV(RandomForestRegressor(), params, cv=5)
opt.fit(X_train, y_train)
```

```mermaid
mermaid

flowchart TD
    A[Raw Logs] --> B{BIT Filter}
    B -->|6.0"| C1[Log Transform DT]
    B -->|6.125"| C2[Min-Max Scale NPHI]
    B -->|8.5"| C3[Hybrid Scaling]
    C1 --> D[Train RF Model]
    C2 --> D
    C3 --> D
```

Fig. 1: Preprocessing Python Code

2.1 Killing methods:

1- Driller method: which kill the well-used tow circulation

2- Weight and wait method: which kill the well-used one circulation

3- Volumetric method: which only empty the well from kick without pump kill mud, and should consider bottom hole pressure safety factor.

4- Concurrent method: this way merge both of driller and weight and wait method but the basic difference is that the drill pipe filled with mud of varying densities.

3. FACTORS INFLUENCING THE CHOICE OF WELL CONTROL METHOD

Numerous interrelated geological, operative, and equipment-based issues influence the assortment of the suitable well control technique: Formation Pressure and Fracture Gradient: A slight pressure edge (i.e., between pore pressure and fracture pressure) edges the mud weight that can be securely used. This frequently effects the choice of the Wait and Weight technique, which moderates surge pressure[11]. Rheology and Mud Density: The physical properties of the drilling mud affect how competently pressure is relocated in the wellbore. Mud with poor rheological properties could be unsuccessful to carry cuttings or kill the well efficiently. Well Depth and Geometry: Deeper and more differed wells confuse well control due to greater annular friction and slower pressure reaction. This may affect whether a volumetric or dynamic kill method is used[12]. Equipment Accessibility: Availability and situation of BOP systems, choke manifolds, and mud pumps are vital. In approximately situations, lack of adequate equipment may force an adjustment from conservative to more aggressive approaches like bull heading.

4. CASE STUDY: SUCCESSFUL CONTROL OF A KICK IN THE SOUTH OF IRAQ:

Field X, Basra, Iraq Though drilling the Mishrif carbonate formation at ~3,100 m, an extraordinary-pressure gas concise was come across. The influx quickly increased in the volume, and the surface equipment was not appropriately engaged in time. Overdue pit monitoring Crew unsuccessful to identify early signs of gas-cut mud and trip gas, no appropriate flow check achieved previously pulling out of hole

4.1 Driller's method was instigated, but the crew required training in high-rate circulation reaction. Effort to close the annular preventer failed due to a stuck pipe state. Small BOP stack (10K psi vs required 15K psi). No functioning gas separator. Labor-intensive choke malfunctioned under high pressure. Blowout impaired the rig floor and rotary table (approx. $5 million USD). Mud losses and gas flaring costs added operational delays. Total NPT (non-creative time): 28 days. Tow rig floor workers injured (burns from flash fire). Evacuation of personnel caused trauma and

HSE. Operation halted for one month. BOP stack replaced with higher pressure unit. Led to new SOP application for high-pressure zones in Iraq fields.

5.RESULTS AND DISSCISSION

Table 1 shows the percentage of gas in the studied formations, as the Mishrif formation contains a high percentage of gas in its various formations compared to the rest of the formations.Fig.2 shows that Volumetric method spend the lowers killing time comparing with other killing method and that because of the volumetric method is circulating method.

Table 1: Gas percentage and its component in different formations.

FORMATION	Depth m MD	Type of gas	TG ppm	C1 ppm	C2 ppm	C3 ppm	iC4 ppm	nC4 ppm	iC5 ppm	nC5 ppm
DAMMAM	628	FM	1600	14	12	0	0	0	0	0
RUS	692	FM	590	0	0	0	0	0	0	0
UMMER RADHUMA	1057	FM	1000	7	1	0	0	0	0	0
TAYARAT	1237	FM	806	4	0	0	0	0	0	0
SHIRANISH	1391.5	FM	2041	1	2	0	0	0	0	0
HARTHA	1535.5	FM	903	0	1	0	0	0	0	0
SADI	1773	FM	879	31	3	0	0	0	0	0
TANUMA	1880	FM	620	127	15	0	0	0	0	0
KHASIB	1895	FM	2155	0	0	0	0	0	0	0
KIFIL	1933	FM	653	117	40	5	1	5	1	1
MISHRIF (CR-I)	1956	FM	518	0	0	0	0	0	0	0
MISHRIF (MA)	1972.5	FM	540	5	1	0	0	0	0	0
MISHRIF (CR-II)	2007	FM	524.3	8	1	0	0	0	0	0
MISHRIF (MB1)	2030.5	FM	6996	454	108	33	4	14	3	4
MISHRIF (MB2)	2092.5	FM	1080	389	94	23	4	15	4	5
RUMAILA	2103.5	FM	472	0	0	0	0	0	0	0

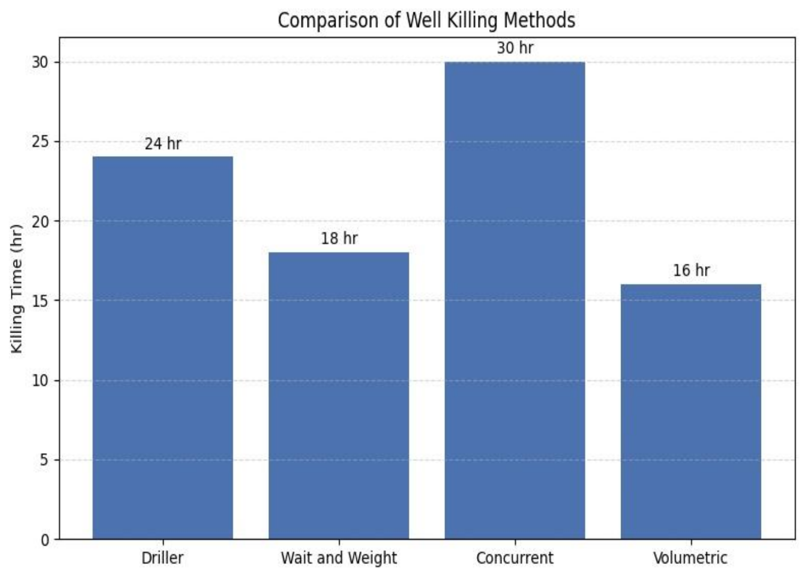

Fig. 2: The effect of killing method on time of killing

Fig. 3 shows the comparison between driller and wait method, which is clear that the driller method has high annular pressure than wait method because the driller method has two circulations. Fig. 4a shows the relation between bleeding mud volume and annular pressure for volumetric method which is un stable because of there is no killing mud. While Fig.4 b shows the relation between Time and mud bleeding volume, which is direct proportional relation with least time. Fig. 5 shows the Drillers method action sequence. Table 2 shows the best method used for choosing the best killing method and circumstances. Fig. 6 shows the model output for choosing appropriate killing method. Fig. 7 shows the 3D topographical renderings and measureable unevenness parameters specifically an arithmetic mean height (Sa) of 1.10 nm and a supreme peak-to-valley height (Sy) of 17.08 nm—designate a heterogeneous surface occupied by distinct nanoscale overhangs and depressions. Fig. 8 represents a well N64 classified as a development well. The well drilled as per planned TD of 2117m MD/TVD. It's clear that the well has increased about 20 days above planed days because of kick that happened.

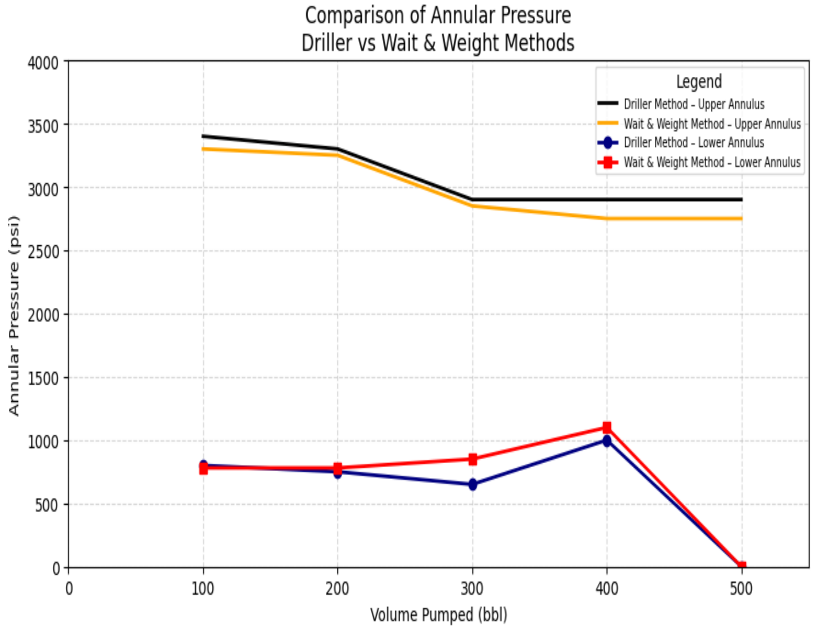

Fig. 3: Comparison of annular pressure by drillers method and wait method

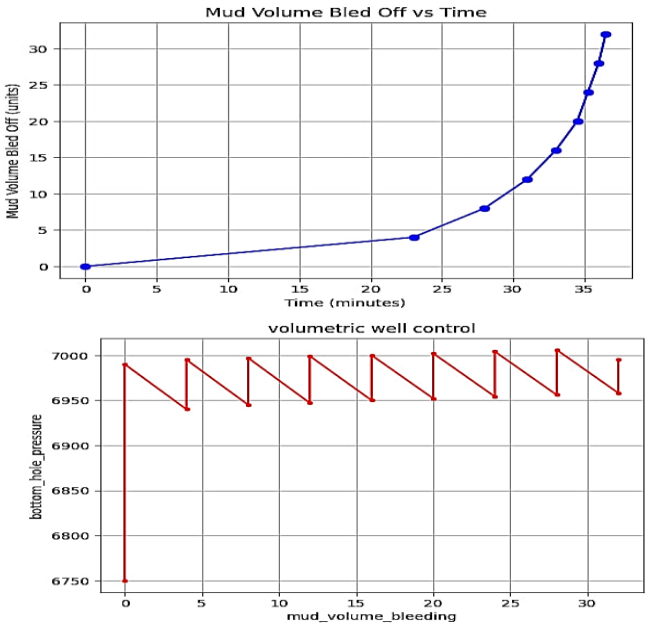

Fig. 4: a. Volumetric well control b. Mud volume bled off verses time

Table .2: Choosing the best killing method

Method	Using and Circumstances
Drillers Method	In the majority of occasions
Volumetric Method	Shallow gas , Drill stem test, Water influx
Concurrent Method	Deep gas influx
Wait and Wait Method	Good casing shoe

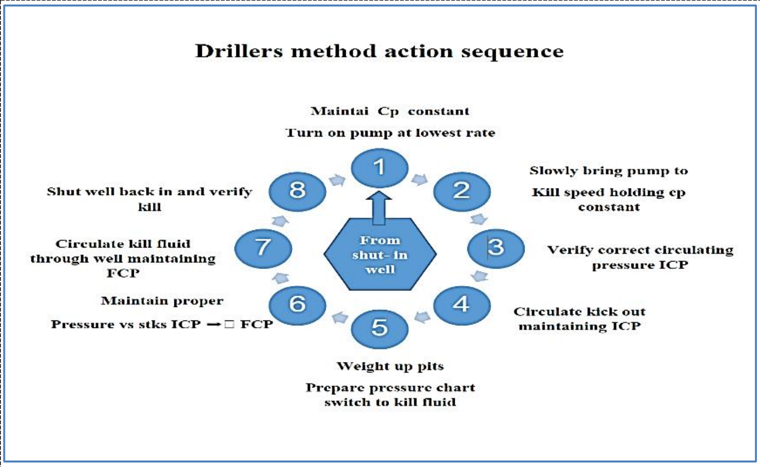

Fig. 5: Drillers method action sequence.

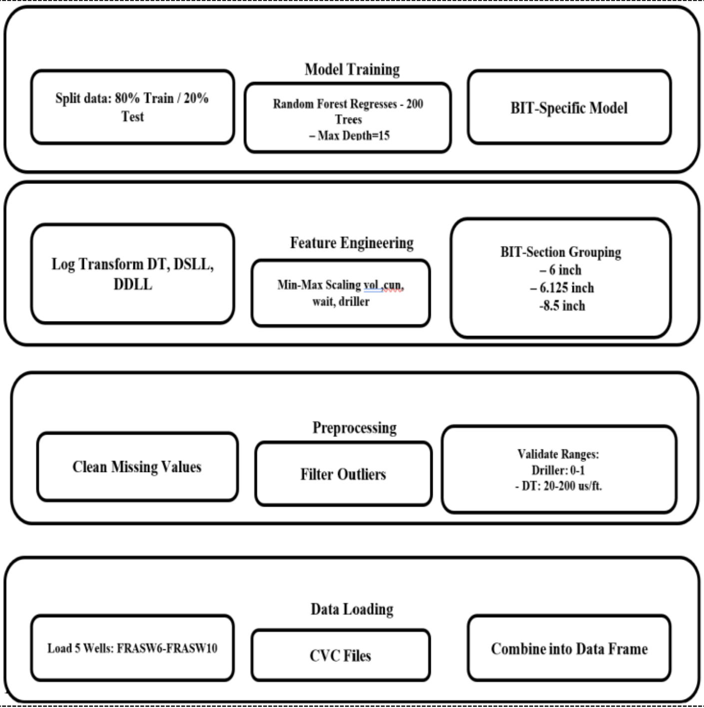

Fig. 6: Model output for choosing suitable method

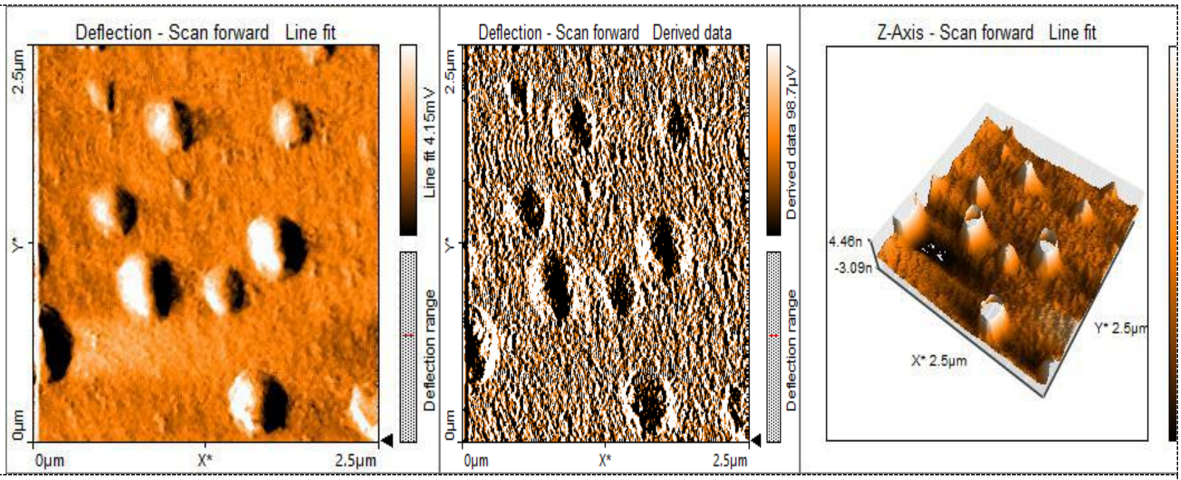

Fig. 7: Atomic Force Microscopy for Nano Barite as kill mud.

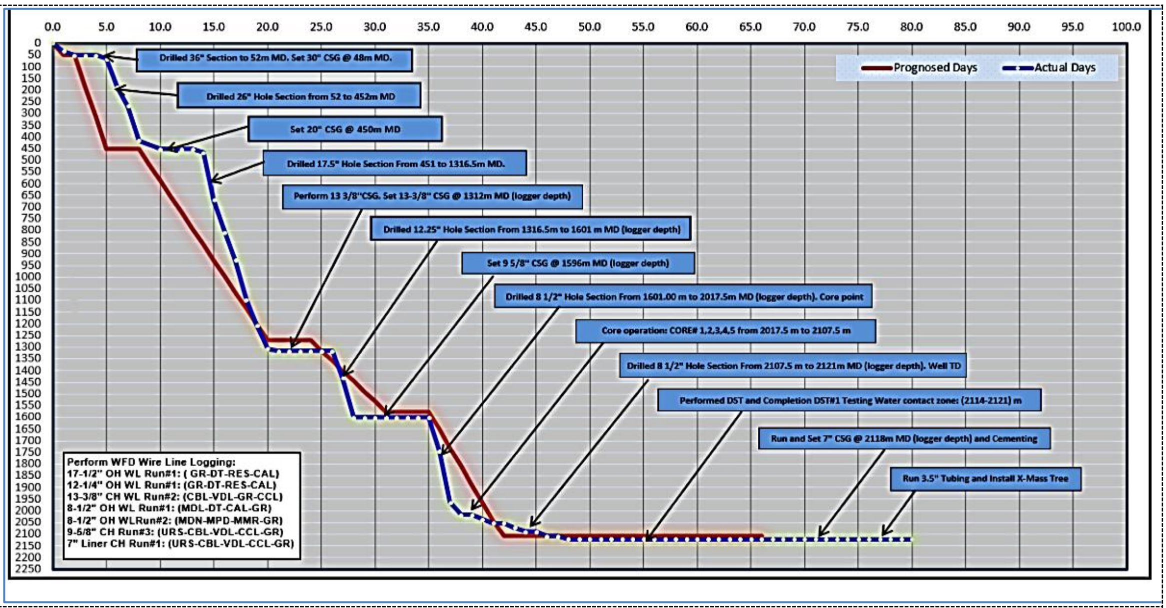

Fig. 8: Planned and actual days for well N-43 south Iraq.

6.CONCLUSION

An innovative approach to developing operational productivity and advancing industry decision-making utilizes the integration of Python with AI to efficiently make critical well-control selection data in oil wells. AI is revolutionizing data compression algorithms, authorizing them to achieve unprecedented levels of sophistication and efficiency. These advancements enable more intelligent data compression methods that preserve both quality and usability. This comprehensive framework strengthens data integrity and supports more informed and reliable decision-making during critical operations. The article demonstrates that a robust predictive model can be developed to determine and select the most appropriate well-killing technique. Leveraging state-of-the-art AI methodologies, the proposed model attains an accuracy exceeding 95%, even in scenarios where portions of the input data are unavailable. This breakthrough suggestion an authoritative explanation for treating data gaps in critical requests.

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