An Optimum Bits Selection for a Southern Iraqi Oil Field Located in Basra Region by Depending a New Algorithm

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Abstract:

Even drill bits cost are about 3-5% of the total drilling budget, but bits performance affects as much as 60% of the drilling cost[1] that would explain the necessity of continuous studying and developing this tool to improve drilling performance. Unfortunately, most of Iraqi oil fields managed by states companies does not give the proper attention for bits optimization issues, that would cause insufficient bits used to drill a certain formation due to the absence of a serious dealing with formation hardness and other bit selection criteria while designing, or making bits purchases contracts, or they would satisfy by a minimum rates of penetration.

Unfortunately, the bit selection issue is matched the optimum selection for the drilling parameters issue, it is a matter of tri and error [2].

In this study, a southern Iraqi oil field located in Basra region have been selected to optimize the bits used to drill its wells.

Summarizations of bits selection methods have been reviewed, advantages and disadvantages of possibility to applicant those methods in Basra regions have been introduced. A proper algorithm for selecting bits in Iraq was also presented. An economic evaluation for a different bit type's strategies used to drill holes of Mishrif wells in Basra oil fields region also discussed.

This study improve that using bits holding the IADC code 425, M322 PDC bit with 6th blades and 16mm cutter size and M323 PDC bit with 5th blades and 6mm cutter size are the optimum selection to drill the surface, intermediate, and production holes consequently.

This study is applicable to all Iraqi oil fields and especially for Basra region oil fields due to its large analogous on the lithology column and the drilling problems may combined the drilling operations among the different oil fields in this area.

الخلاصة:

على الرغم من كون كلفة الدقاقات المستخدمة لحفر الابار النفطية لا تشكل اكثر من 3-5% من مجموع كلفة حفر البئر الكلية، الا انها تؤثر على سرعة واداء عملية الحفر بنسبة تفوق 60% من كلفة الحفر[1]. وهذا مايبرر استمرار الدراسات والبحوث لتطوير هذه المعدة الصغيرة لضمان تحسين ادائية عملية الحفر بأستمرار. لسوء الحظ فأن معظم الشركات النفطية الحكومية في العراق لا تولي الاهتمام المطلوب لمسألة الأختيار الأمثل للدقاقات، لذا يتم استخدام دقاقات غير مناسبة لصلابة الطبقات الصخرية المحفورة والاعتبارات الاخرى خلال تصميم برامج الحفر للابار المزمع حفرها او عند انجاز الطلبيات لشراء الدقاقات او قد يتم الاكتفاء بمعدلات اختراق منخفضة لادائية بعض الدقاقات.

ان مسألة اختيار الدقاقة المناسبة حالها حال مسائل اختيار افضل متغيرات لحفر الأبار, فهي عبارة عن مسألة تجربة وخطأ [2].

في هذه الدراسة تم اختيار حقل نفطي يقع جنوب العراق في محافظة البصرة لتطبيق عملية اختيار افضل الدقاقات لحفر اباره. ولقد تمت مراجعة وتلخيص الطرق الشائعة المستخدمة لأختيار الدقاقات المناسبة وكذلك تم استعراض فوائد وسلبيات كل طريقة للمفاضلة بين الطرق المعتمدة لأختيار الدقاقة المناسبة، ومن ثم تم بناء خوارزمية اختيار الدقاقة المثلى لحفر بئر نفطي يقع في الحقول العراقية. ولقد دعمت الدراسة بتحليل اقتصادي لأثبات الجدوى الأقتصادية للدقاقات المختارة.

من خلال نتائج الدراسة تبين ان الدقاقات الحاملة لرمز جمعية مقاولي الحفر العالمية IADC code البالغ 425 هي الافضل لحفر التجويف السطحي وذات الرمز M322 من النوع الماسي المطعم PDC بستة صفائح وقطر 16 ملم للقاطع الواحد هي الافضل لحفر التجويف الوسطي والدقاقة ذات الرمز M323 من النوع الماسي المطعم PDC بخمسة صفائح وقطر 6 ملم للقاطع الواحد هي الأفضل لحفر التجويف الأنتاجي.

تجدر الأشارة هنا الى انه من الممكن تطبيق نتائج هذه الدراسة وسيناريوهاتها على اغلب الحقول العراقية ولا سيما الجنوبية منها بسبب التشابه الكبير في التركيب الجيولوجي وكذلك المشاكل المصاحبة لعملية الحفر في هذه المنطقة.

Introduction:

There are four methods to determine the optimum bit selection for a certain formation; Cost per Foot (CPF), Specific Energy (SE), Geological and Bit Record, and Bit Dullness methods [2]. The advantages and disadvantages of each method have been studied and analysed in order to know the possibility of applying it according to the conditions of the southern Iraqi area on Basra region oil fields. The study was started with a classification of the lithology column for one of the Basra oil fields according to the formations hardness depending on World Oil Drill Bit Classifier 2007, and then the ranges of International Association of Drilling Contractors Code (IADC codes) which describe the bit type, formation hardness, and bit bearing type may be applicable to drill the holes were listed. This method gives the first guess for selecting the bit. Data from six drilled wells have been tested by using SE method which is the easiest and direct method for selecting the optimum bit at a certain formation and its variables are related directly to the formation hardness and drill-ability, and does not depend on estimated variables like tripping time, bits and rig rental costs which are difficult to be determined without an available updated data for a certain bits, rigs types and costs as it is in CPF method. In some cases the necessity of CPF method appears in comparing its results with the SE values number of different bit types that are used to drill a certain, as in drilling the second hole (12 ¼”) on the six wells in this study. The CPF method is useful for Personal whose working at the rig site or who have an accurate and updated data for controlling and minimizing the drilling cost and reflected on maximizing the profit. Finally the data from bit records and dullness of the selected bit (optimum one) were analysed.

Methods of Bits Selections:

Each bit selection method has some advantages and some disadvantages, and the application of a convinced method vary from region to region and situation to other according to the availability of data and the conditions for selecting the bit.

The limitation and constraint of applying those methods for Basra region oil fields can be discussed as follows;

Cost Per foot Method (CPF) :

Most of references mentioned to the CPF method as the main and popular method that used to determine the optimum bit for a certain formations. The principle of this method dependence on optimizing the drilling cost per foot for a certain formation then choosing the bit which give the minimum CPF value by applying the following equation[4];

$$CPF = \frac{C_b + C_R\,(t + t_c + T)}{F} \qquad \text{....................................(1)}$$

Where;

CPF: Cost per foot, \$/ft.

C_b: Cost of Bit, \$.

C_R: Cost of Rig, \$.

t: Trip time, hr.

t_c: Connection time, hr.

T: Rotating time, hr.

F: Footage drilled, ft.

The cost used in this equation are dictated by drilling rig operations and fall into four categories; bit cost, trip and connections time, rotating time, and down time accountable to the drill bit. Continued drilling will result in increased cost although the teeth and bearing are not totally worn[5].

The constraint and limitation of this method can be listed as follow;

1- Its need an exact values for cost of bit itself which is differ from time to time even for the same bit manufactured by a firm company regarding to marketing considerations
2- The daily rate cost of rig which also differ from rig to rig according to the rig types, capacities and marketing consideration.
3- It is worth mentioning, for the same type and properties of a certain bit the supplier companies may submit different quotations and prices may reach to double values according to the company names power and strategies.
4- The difficulties of round trip times determination accurately, it is highly dependent on well site conditions and rig site crew efficiency.

Due to the above reasons the Eq.1 will be difficult to be applied if you are working to perches bits for your company which may have a large rig fleet with different types, capacities, and rig crews efficiency. This method is applicable if you are dealing with a certain rig-well and you have a good knowledge with your crew's efficiency and also you have good updated prices for the bit cost and for your daily rig cost. Any way the application of CPF equation is important for comparison even other methods used to determine the optimum bit.

In this work the CPF values was calculated on estimation principle for comparison purposes with SE method in the second hole when there were a different numbers of bits had been used to drill this interval. Also economic evaluations of optimum bits and for different scenarios of bit types' usage to drill Mishrif well holes by applying CPF equation have been made.

Classification of Lithology Column:

World Oil Drill bit classifier (2007) offers a comprehensive listing of major manufacturers' drilling bits to aid drilling supervisors and engineers in field selection. While this listing has been published annually for many years, changes from year to year are significant. Prior to ordering, users should consult the manufacturer to verify availability and specifications[3].

The tables show six formation categories corresponding to the IADC formation types, as described below. Companies were asked to list any discrete bit in only one formation type, leaving the user to decide about application in harder, or softer, rock. Nevertheless, some duplication of similar bits in multiple formations remains. The formations are[3]:

1- **Soft, including soft sticky**. Low compressive strength and high drill-ability, such as clay, marl, gumbo, unconsolidated sand.
2- **Soft-to-medium**. Low compressive strength, inter-bedded with hard layers, such as sand, shale, anhydrite.
3- **Medium.** Hard with moderate compressive strength, such as shale, chalk, anhydrite, sand.
4- **Medium-to-hard.** Dense with increasing compressive strength but non- or semi-abrasive, e.g., shale, siltstone, sand, lime, anhydrite.
5- **Hard**. Hard and dense with high compressive strength and some abrasive layers, such as sand, siltstone.
6- **Extremely hard**. Very hard and abrasive, like quartzite and volcanic.

This method will determine the ranges of IADC code proper for guess the suitable bit required to drill the formations. Then the selected bit can be re-evaluated with the other methods to reach an optimum selection. This method does not used individually but it give you a hint for predicting the optimum range of bits, and then evaluation with the other methods have to be done.

Specific Energy (SE) Method:

This method introduces an easy and practical manner to determine the optimum bit selection regardless the variables coefficient in equation (1). The Specific Energy (SE) can be defined as: the energy required removing a unit volume of rock; it can take any type of homogeneous units. The equation of SE was driven from the required mechanical energy which used to drilling at the bit position on one minute, so[5];

$$E = W\ X\ 2\pi R\ X\ N \qquad \text{.. (2)}$$

Where;

E: Mechanical Energy.

W : Weight on bit, (Ib), or Work($\frac{Ib\ X\ in}{min}$).

R, ROP: Rate of penetration, ft^3/hr.

N: Number of rotation, round/min.

Then the volume of cuttings drilled at one minute in the unit of cubic inch is;

$$V = \pi\ R2\ X\ ROP \quad (ft/hr.) \qquad \text{...(3)}$$

Where;

V: Rock volume, ft^3.

R: Radius of bit, ft^2.

ROP: Rate of penetration, ft^3/hr.

By dividing Eq. (2) on Eq. (3), get the Eq. of SE;

$$SE = E/V = \frac{W\ X\ 2\pi R\ X\ N}{\pi\ R2\ X\ ROP} \quad \frac{Ib\ X\ in\ X\ \frac{1}{min}}{\left(in^2\ X \frac{ft}{hr}\right) X\ (hr/60\,min)\ X\ (12in/ft)} \qquad \text{............(4)}$$

Then SE in (psi/in^3) is;

$$SE = 10\ \frac{WN}{R\ X\ ROP}$$ ....(5)

Where;

SE: Specific Energy, psi/in^3.

W : Weight on bit, (Ib), or Work($\frac{Ib\ X\ in}{min}$).

N: Number of rotation, round/min.

R: Radius of bit, ft^2.

ROP: Rate of penetration, ft^3/hr.

By changing the radius of bit by its diameter (D/2) then Eq. 5 become;

$$SE = 20\ \frac{WN}{D\ X\ ROP}$$ .... (6)

Where;.

D: Bit diameter, in.

Eq.6 by metric system unit will become;

$$SE = 2.35\ \frac{WN}{D\ X\ ROP}\quad MJ/m^3$$ ....(7)

Where; W in Kg, D in mm, and ROP in m/hr.

Since the ROP is the footage drilled (F) per rotating time (T), then Eq.6 will be;

$$SE = 20\ \frac{WNT}{D\ X\ F}$$ ....(8)

Rabiaa H. (1985) [5] clarify that the SE is not main property of the rocks have been drilled, so it is depending mainly on type and design of bit. That's mean to drill a certain rock formation with a known compressive strength; the drilling bits which may be used to drill the soft formation will give absolutely different values of SE from that one's which may drill the hard formation. Hence, these features of SE introduce an easy and accurate method to select the optimum bit fitting the formation. The bit which gives the minimum values of SE in a certain formation is the optimum one.

Bits selected by this method is not enough clearly to be dependent alone from the economic aspect, especially in case of existence of high clearance in prices among many types of bits, for example the PDC bit cost is higher than tri-cone bits by 400%-600%. But most of this prices duplicate are occupied by highly increases in ROP which improve and clarify the reasons to use those costly bits.

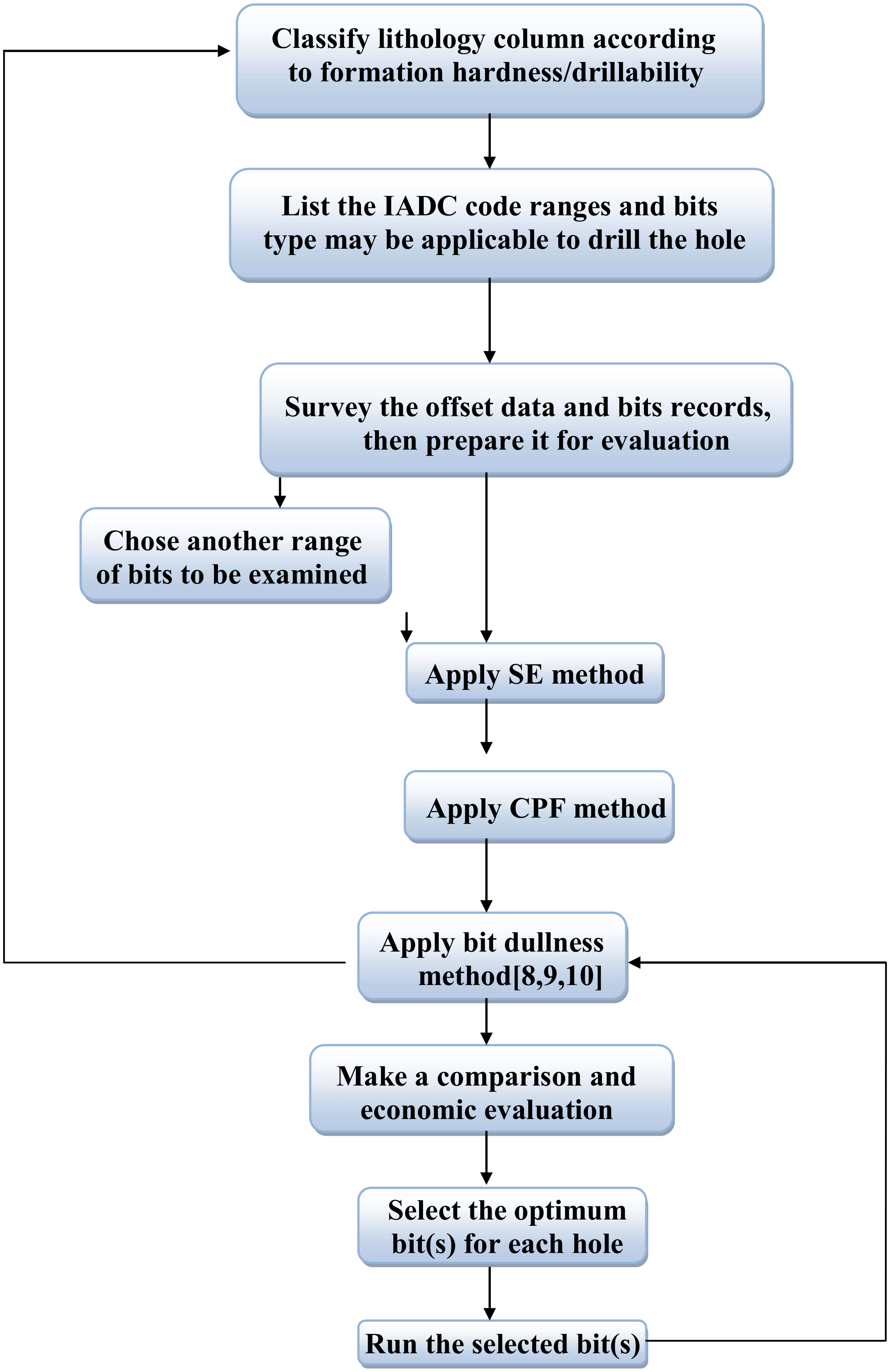
Bit Dullness Method:

Bit-Dullness degree (Bit Wear) can be used as an indicator for bit selection[8-10]. Generally the bits with rapid dullness considered less sufficient in comparison with other bits in the same category and it need to be pulled out of hole and changed for many times which reflected on cost increasing [2]. The hopes are to select a bit sufficient to drill the hole with one or minimum run times. i.e. get a minimum dullness degree to be sufficient to complete the entire hole with the minimum cost and highly penetration rate.

This method is necessary for evaluated the selected bit after running in hole. The dullness evaluation with the SE curve will optimize the selected bit for the next well(s).

Bits Selection Algorithm:

The procedure to select the optimum bits manually for a certain wells to be drilled in nominated field in Iraq with the absence of the required software's to evaluate formation and calculate the accurate compressive strengths of formations can be scheduled as follow:


Classify lithology column according to formation hardness/drillability
List the IADC code ranges and bits type may be applicable to drill the hole
Survey the offset data and bits records, then prepare it for evaluation
Chose another range of bits to be examined
Apply SE method
Apply CPF method
Apply bit dullness method[8,9,10]
Make a comparison and economic evaluation
Select the optimum bit(s) for each hole
Run the selected bit(s)

Classification of Lithology Column of The Basra Region Oil Fields Till Mishrif For Mation :

In Basra region oil fields (to the Mishrif formation target) the lithology column is highly similar in the sequence of beds and hole problems, always consists of thirteen beds starting from Dibdiba formation which composed from Sandstone till the Mishrif formation which composed from Limestone. All the formations graduated from the Soft to Medium-hard formation with one hard formation (Rus formation, its gross thickness approximately 70 m).

There are two mud loss regions falls in the second section 12.25” hole, those are Dammam and Hartha. They are consisting from Dolomite buff porous and vuggy. And in some other regions there is a Marl which may cause pipes stuck problem in Lower Fares, and Shiranish formation.

The following Table (1) illustrate the lithology column with the formation description and the classification of beds.

Table (1) Basra Region Oil Field Lithology Column

Formation	Description	Classification of formation	Approximated top depth (m)
Dibdiba	sand& gravel, quartzes gypsies, calcareous cement	Soft	0
Lower faris	Marl, grey, plastic locally sandy. Anhydrite. Limestone Shelly	Soft to medium	230
Ghar	sand& Gravel lose some sandstone	Soft	368
Damam	Dolomite, bf-light grey at top, bf, beige porous vuggy.	Soft to Medium	508
Rus	Anhydrite, white, massive intercalated dolomite buff, porous, vugy	Hard	742
Um alrudoma	Dolomite buff. Brown some. Grey towards bottom porous& vugy saccharoidal in part anhydrite	Medium to Hard	898
Tayarat	Bituminous shale Dolomite, grey, buff saccharoidal porous& vugy anhydrite locally	Medium	1359
Sharanish	Marl ash grey plastic	Soft	1616
Hartha	Dolomite buff. brown porous, locally vugy Limestone, grey, arg.	Medium to hard	1719
Saadi	Limestone white chalcky, fine, compac	Medium to Hard	1933
Tanoma	shale black-brown fissile	Medium	2198
Khasieb	Limestone grey shaly	Medium to Hard	2244
Mishrif	Limestone white beige detritus, porous, ruddiest.	Medium	2445

Casing Setting Depth:

The wells to be drilled in Basra starts with a Conductor Pipe set at a shallow depth no more than 50 m in Dibdiba formation, its diameter is 20” Casing, and drilling with 26” bit. The surface casing 13 3/8” diameter to be drilled with 17 ½ “ bit through Dibdiba, Lower Faris, and Ghar formations to the top of Dammam formation, approximately 500 to 600 m depth. The intermediate casing 9 5/8” diameter to be drilled with 12 ¼” bit through Dammam, Rus, Um alrudoma, Tayarat, Sharanish, and Hartha to the top of Sadi formation approximately 1900 m depth. The production casing

7" diameter to be drilled with 8 ½" bit through Sadi, Tanomma, Khasieb and Mishrif formations to the total depth at 2500 m approximately, the top of Rumaila formation.

Ranges of Iadc Code Could be Used For Basra Fields Lithology Column :

Regarding the classification of the lithology column in Basra fields, and since all formations there graduated from soft to hard, the following schedule of IADC code range can be considered as a tri-cone bit (milled teeth or insert teeth)[5,7] or as a fixed cutter bits[2,7] ,Table (2).

Table (2) Ranges of IADC codes suitable for Basra region oil wells

hole	formation	Classification of formation hardness	IADC code range	
			Tri-Cone bit	Fixed Cutter bit
17 ½"	Dibdiba, Lower Faris, and Ghar,	Soft and Soft to Medium	1-1-1 1-2-1 1-2-3 1-3-7 4-1-5 4-2-5 4-3-5 5-2-7	Not Required
12 ¼"	Dammam, Rus, Um elraduma, Tayarat, Sharanish, and Hartha	Soft, Medium, Medium to Hard, and one layer Hard (Rus formation)	2-4-3 3-1-3 3-2-3 6-3-7 6-4-7 7-1-7 7-2-7 7-3-7	M 3-2-2 M 3-3-3 M 4-2-2 M 4-2-3 M 4-3-3
8 ½"	Sadi, Tanuma, Khasib, and Mishrif	Medium and Medium to Hard	2-1-1 2-1-3 2-3-1 2-3-3 6-1-7 6-2-7	M 3-2-2 M 3-3-3 M 4-2-2 M 4-2-3 M 4-3-3

Bit Selection of Surface Section (17 ½" Hole):

As it was mentioned in Table (1), this section consists from soft and soft to medium formation, it forms from sand and gravel and from marl with plastic locally sandy in one layer. The values of SE were calculated for this section in five wells had been drilled in our selected field. The two bit types (GSI01BVC) manufactured by Smith Company with (4-1-5) IADC code and holds numbers (1-1) and (2-1) which had been used in drilling of two holes in different wells in the field gave an average SE values 93,000 and 30,000 psi/in^3 respectively; even the second one no.(2-1) gave the lowest SE avg. value but it takes the great share from the bits dullness percentage, figure (3). There were another Smith bit types (GS05BVC) with (4-2-5) IADC code had been used also to drill another individual hole in the same area. They gave 40,000 and 25,000 psi/in^3 SE avg. value respectively, the first one of this kind bit already used to drill another hole, so it was re-run bit, therefore it gave SE avg. value more than the other. All those bits were insert type. The milled teeth bit were tested also, a Russian bit type (U-KL-S111TG) holding the IADC code (1-1-5), and it gave a 53,000 psi /in3 SE avg. value. Here let us say that the usage of the softy IADC code may drill the section but it's not recommended if the interval so long, due to the bit dullness occurs and the bit has to be pulled out of hole before finishing the drilling of the whole section as it was happened in bit no.(5-1).

According to above information and bit tests, the suitable and optimum bit for drilling the first section is that one which hold the IADC code (4-2-5). Figure (1) shows the

$SE_{avg.}$ values for five bits used to drill five different holes.

Bit Selection of The Intermediate Section (12 ¼" Hole) :

The second hole consists from six layers, one of them is soft formation and the others are graduated from soft-medium to medium-hard formation. This hole is the most complicated one due to its length and many hole problems associated to drilling operations. Those problems making constraints for drilling this hole, starting with a probability of happens of lost circulation problem at the first layer Dammam formation (dolomite porous and vaggy). The drilling process faces the second challenge at Rus formation which consists from white anhydrite, massive intercalated dolomite which can be considered as the harder formation in the well profiles for such kinds of target depth. After that, the drilling progress goes smoothly till a tight hole problem probability when drilling Shiranish formation which forms from marl. Finally the same scenario of probability of lost circulation problem happens at the first layer can be repeated at the last layer in this section, in Hartha formation (dolomite porous and vuggy).

Regarding to all previous problems, there are many programs and solutions were made and tested to avoid those hole problems, some were succeed from one aspect and failed from the others, so the researches still work to introduce the optimum program for drilling this section faster and safely. This study deals with the most common strategy for drilling this section by a tri-cone bit for the first layer Dammam formation (stage one) and then pull it out of hole and then run a PDC bit to drill the rest interval (stage two), but some companies pull out the PDC bit when it reach the Hartha formation and run in hole a tri-cone bit again in order to reduce the risk of fracturing this weak formation by the higher recommended flow rate occupied the PDC bit.

A comparison among many bit types has been made in this study on a six wells drilled in a field located south of Iraq in Basra. The scenario of drilling Dammam formation by a tri-cone bit was applied on all the six wells. In some of those wells the bit was did not pulled to the surface when it finish drilling the Dammam formation, but going ahead to drill the Rus formation which give a high value for the SE since they were unsuitable to drill the hard formation as it appeared in figures (4 & 5) bit no.(5-2) and (6-2).

Two different bits had been used to drill this stage in the first well. One of those bits was PDC bit with 6 blades and 19 mm cutter size and it was unable to complete the hole, its age was finished before complete drilling the section; and the other one was (QD606X) have been used to finalize the hole. The second well also needed two bits to finalize drilling of the hole, one of them was Smith with (6) blades and 19mm cutter size but also it was unable to finalize drilling the hole and then a Smith tri-cone bit have been used. In the third well a three tri-cone bits have been used to finish it. They were 447, 517, and 437 IADC codes and manufactured by Reed and Hughs.

The bits no.(2-2) and (3-2) which were manufactured by Smith and Reed Companies and take the IADC code (1-1-7) gave the minimum values for drilling the stage one of the second hole, and acceptable bit dullness in comparison with its SE values, then they were pulled out to the surface and run in hole PDC bits to drill the rest interval of this hole.

In the second stage of drilling of this hole, PDC bits have been used in some wells and tri-cone bits in the others. Also some holes were drilled by one bit run and the others with more than one. Practically it's favourite to drill the hole with one bit run in order to reduce the drilling cost per foot. So, the principle of CPF was applied there and compared with the values of SE for the hols which drilled with more than one bit run. The results of the comparison proved that, drilling the wells with one perfect PDC bit is the optimum decision to drilling this hole, figure (7).

Figures (8 & 9) show the SE values for the six wells, this values represent the SE for the second stage of the second hole.The first thing that may take attention is the high value of SE in the fourth well (bits no.4-4 and 4-5), its values reached to 54,119,000 and 78,561,980 psi/in^3 respectively which are out of graph scale. The type of those bits were (GSi04BVC) and (Si619HEBPX) manufactured by Smith company, and in this hole the previous bit no.(4-3) used to drill the hole and made an unacceptable inclination in the well path verticality, then this bit was pulled out of hole, that is the explain of the SE maximum value for this bit, so the drilling parameters had been controlled when using bit no.(4-4) for correction purposes. The other bit no.(4-5) faced a high torque while drilling. All the rest bits in the other wells gave nearly close SE values, but the number of bits which were required to complete drilling the entire hole was different from well to well in the first fourth wells. Well no.(5) and no.(6) were drilled with one bit run for this stage in this hole.

The optimum bit can be selected to drill this section according to the SE avg. values and bits dullness is the PDC bit with 6 blades and 16 mm cutter size and take M3-2-2 IADC code which was used to drill the wells no.5 and no.6 and manufactured by NOV and Smith company respectively.

Bit Selection of The Production Section (8 ½“ Hole):

The PDC bit is the favorable type that used to drill this section in a little time with one run. This principle is common to be used by the drilling contractors in Basra. This manner has been applied on the sixth wells, and all of them were drilled with one PDC run. Those bits were Smith PDC bit with 7^{th} blades and 16mm cutter size, HTC PDC bit with 5^{th} blades and 6mm cutter size, Smith PDC with 6^{th} blades and 16mm cutter size, Smith PDC with 6^{th} blades and 16mm cutter size, Smith PDC with 7^{th} blades and 16mm cutter size, and Smith PDC with 7^{th} blades and 16mm cutter size in each individual well respectively. It is obvious that the PDC bits with 7 blades did not give the optimum ROP. So the optimum bit can be selected to drill this hole is the one with 5^{th} blades and 6mm cutter size which hold the IADC code M 3-2-3. Otherwise the PDC bits with 6^{th} blades and 16mm cutter size and hold the IADC code M 2-2-3 can be selected.

From our practical experience we can say that the usage of tri-cone bit is insufficient and take a more long time which maximize the CPF.

Economic Evaluation:

The main objective from optimizing the bits and all other drilling operations is to reduce the CPF or the total well construction cost. Regarding that an economic evaluation for the selected bits and the various scenarios of drilling the Mishrif wells in Basra region oil fields had been made by CPF method. The following considerations are applied for Eq. (1);

1- Cost of rig rental is 1000$/hr,
2- Updated bits costs from one of the biggest bits manufacturer company were applied.
3- Cost of bit is the summation of bits costs used for drilling the whole section,
4- Ttripping time is 6 hrs/8000 ft,
5- Average connection time is 10 min/1 stand,
6- Rotating time is the summation of rotating times of all bits used to drill the section, and
7- Footage drilled represents the length of section.

To drill the 17 ½" hole section (interval length is 500 m) there are three scenarios; by using one tri-cone bit, by using one steel PDC bit or by using one matrix PDC bits. In this section (surface section) as it have been mentioned earlier in Table (1), formations are soft, so the problems of wash out, non-stability in well bore and cumulative cuttings in annulus restrict the improvement of ROP, these factors make the usage of PDC bits meaningless. CPF equation was applied for all those scenarios as it showed in fig. (14). The results proved that usage of one tri-cone bit showed the lowest CPF as it were made in the sixth wells.

To drill the 12 ¼" hole section (interval length is 1400 m) and according to the drilling problems associated in this hole, there are three scenarios;

1. by usage of four tri-cone bits

2. by usage of one tri-cone to drill Dammam formation and one matrix PDC bit for the rest interval
3. by usage of two tri-cone bits and PDC bit (one tri-cone bit for Dammam formation, a matrix PDC bit from Rus to the top of Hartha formation and other tri-cone bit to drill Hartha formation and finishing the hole to TD).

By many drilling contractors, the second scenario is the common one in the Basra oil fields, and the optimum bit to drill this section was one from this scenario by SE results.

According to the above and the assumption of the expected ROP for each scenario the CPF equation showed that the usage of the first scenario may save 12 $/ft (39.36 $/m). In other words, the usage of the first scenario will require 3-4 additional days operation with an extra 50,000 $ for rig expenditure, and for 4592 ft (1400 m) interval length this scenario will save 55,104 which is more than rig expenditure. This what hit the dependence on just SE method to select the optimum bit when the difference in ROP for the tri-cone or PDC bit is not large enough as it showed in figure. (15).

For drilling the production hole 8 1/2" for interval of 600 m (1968 ft) and composed mainly from Limeston with medium to hard hardness there are two scenarios; by using 1.5 tri-cone bits or 1 PDC bit. Figure (16) shows the economic evaluation of those two scenarios, and it is obvious that the cost is reduced by 40% by using the second scenario.

Conclssion:

1. This study prove that using bits holding the IADC code 425, M322 PDC bit with 6th blades and 16mm cutter size and M323 PDC bit with 5th blades and 6mm cutter size are the optimum to drill the surface, intermediate, and production holes consequently.
2. In case of big difference in price among types of bits as in PDC in comparison with tri-cone bits and a little difference in SE values, SE method is not enough to be rely on bits selection method an economic evaluation is required.
3. Softy insert bits gives a better performance than softy milled teeth bit for drilling the surface section size 17 ½ “.
4. Avoid using the softy IADC codes lower than 1-3-7 and 4-2-5 in drilling the surface section due to the possibility of happening bits failure before finishing drilling the whole section which may required a trip plus and in the result maximize the cost.
5. The second section is dividing into two stage; first stage starts with tri-cone bit in order to minimize the flow rate and pass the region of lost circulation at Dammam formation and then pull it out of hole, the second stage running a PDC bit is able to finalize drilling the whole hole, and this scenario consider the common one in Basra oil fields.
6. Making a control for the rate of penetration ROP should be at drilling the first stage of the intermediate section in order to minimize the equivalent circulation density ECD and avoid fracturing the weak formation, so the SE values and ROP are not the highest values.
7. Drilling the second stage of the intermediate section and the production section should be done with one PDC bit run. It would be practical and less cost as it proved by the comparison made by CPF method.

8. For drilling the production section it's sufficient to use a PDC bit with 5th blades and 6 mm cutter size otherwise by using the one with 6th blades and 16 mm cutter size.
9. Other ranges of IADC codes needs to be checked and re-evaluated for this work according to the checking results.
10. Usage of PDC bits to drill the third hole with one run has been reduced the drilling cost by 40%.
11. A redesigned bit testing is required. For example the side rack, back rack, hydraulic design and bits profile for PDC bits and journal angle, offset angle, cone profile, angle of teeth, length of teeth, number of teeth, spacing of teeth, shape of teeth, and tooth hardfacing for tri-cone bits should be redesigned and tested.

Nomenclatures:

C_b: Cost of Bit, $.

CPF: Cost per foot, $/ft.

C_R: Cost of Rig, $.

D: Bit diameter, in.

E: Mechanical Energy.

F: Footage drilled, ft.

N: Number of rotation, round/min.

PDC: Polycrystalline diamond bit.

R: Bit Radius, ft^2.

ROP: Rate of penetration, ft^3/hr.

SE: Specific Energy, psi/in^3.

T: Rotating time, hr.

t: Trip time, hr.

t_c: Connection time, hr.

V: Rock volume, ft^3.

W : Weight on bit, (Ib), or Work($\frac{Ib\ X\ in}{min}$).

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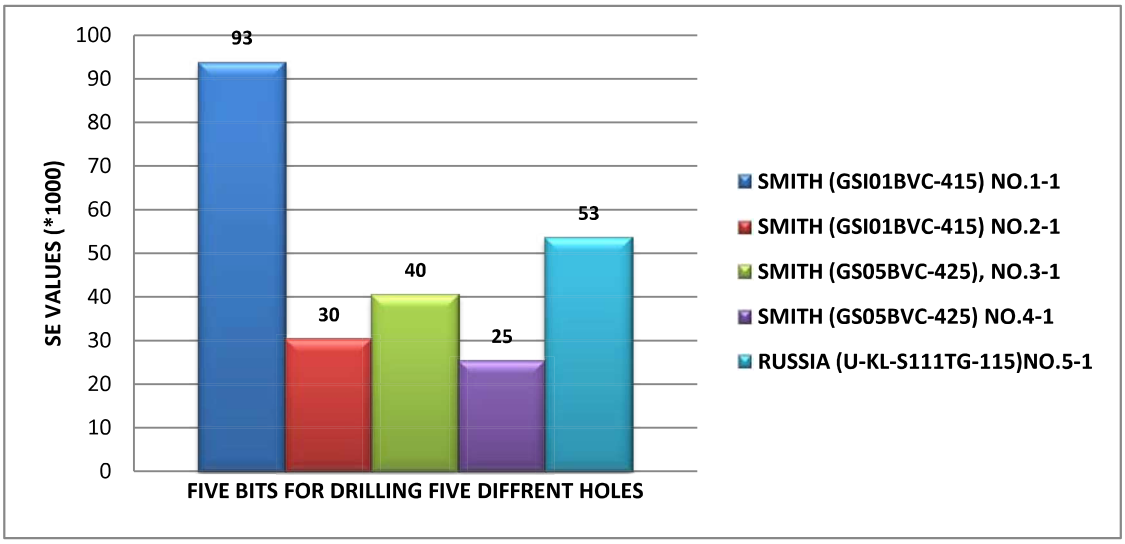

Fig. (1) SE $_{avg}$. for five bits used to drill five holes, size 17 ½ "

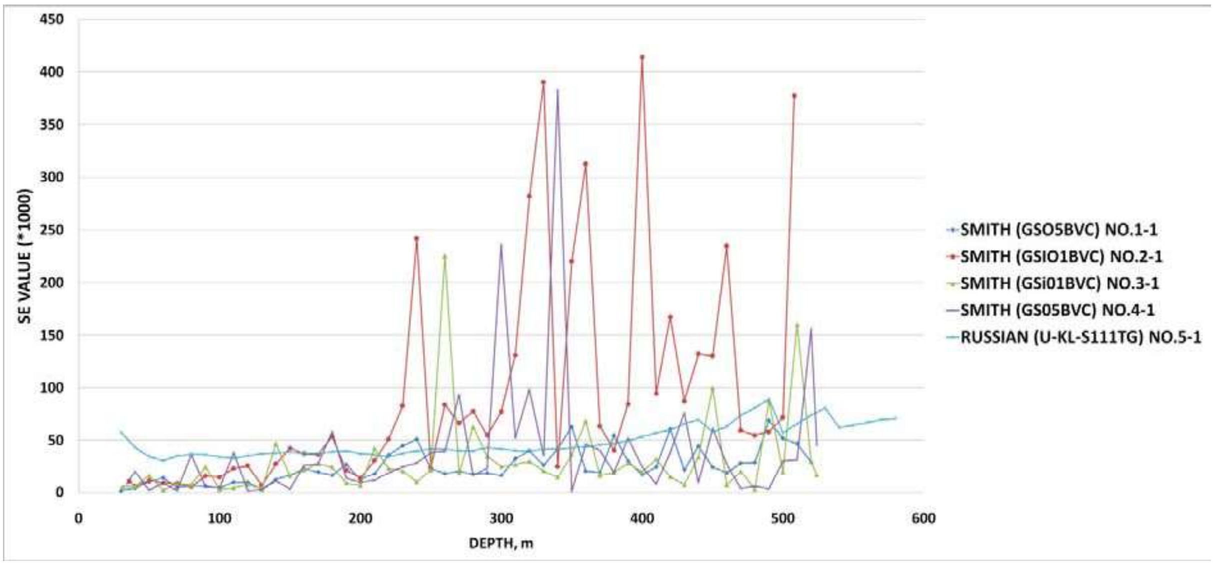

Fig. (2) SE values for five bits used to drill five holes, size 17 ½ "

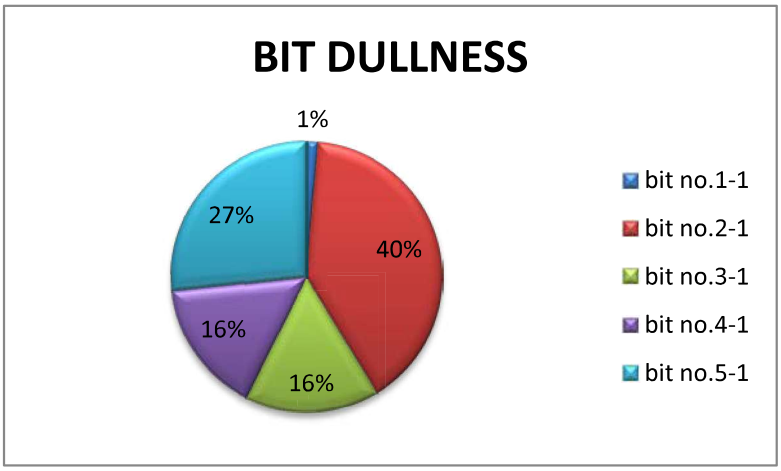

Fig. (3) bit dullness for the five bits used to drill five holes, size 17 ½ "

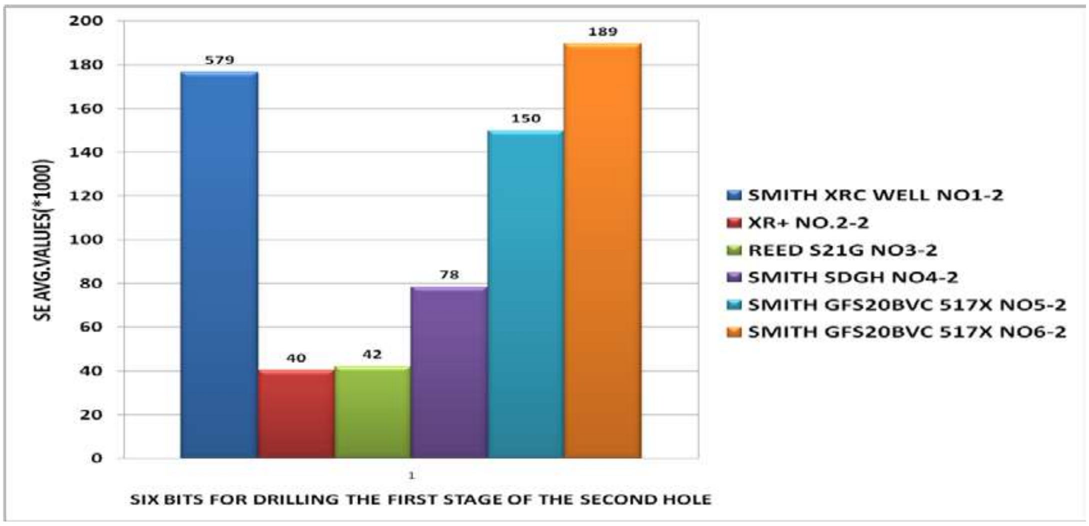

Fig. (4) SE $_{avg}$. for six bits used to drill the sixth holes, size 12 ¼ " – stage one

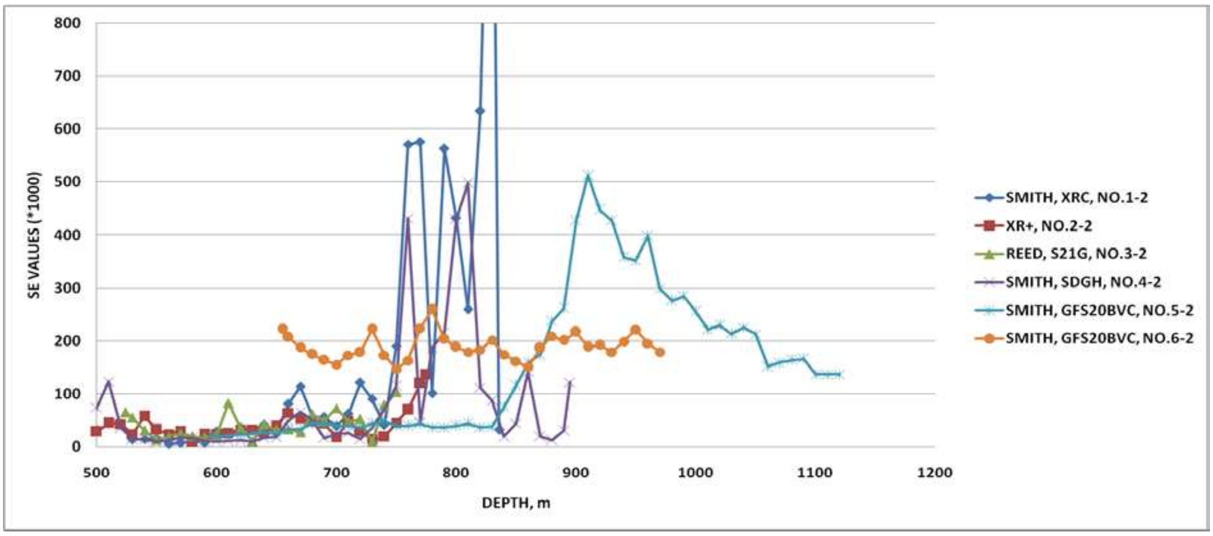

Fig. (5) SE values for six bits used to drill the sixth holes, size 12 ¼ " – stage one

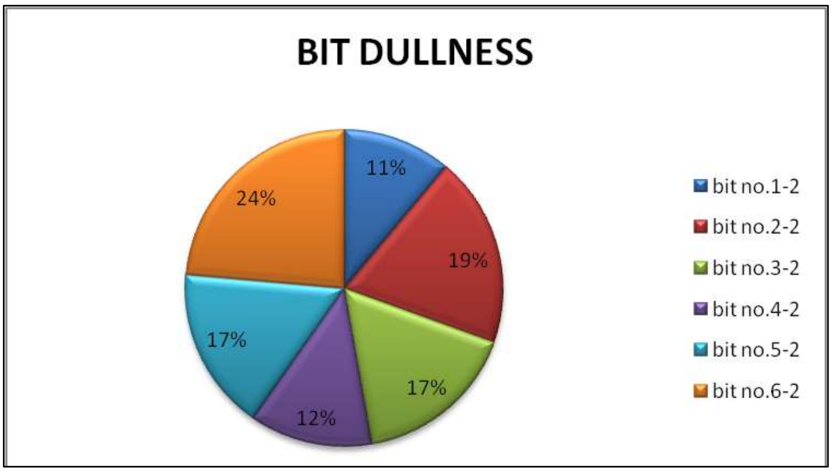

Fig. (6) bit dullness for the sixth bits used to drill six holes, size 12 ¼ " – stage one

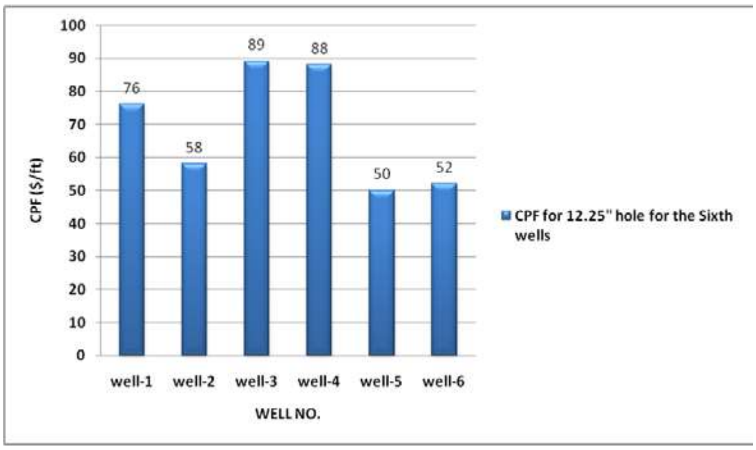

Fig. (7) CPF values for six bits used to drill the sixth holes, size 12 ¼ “ – stage two

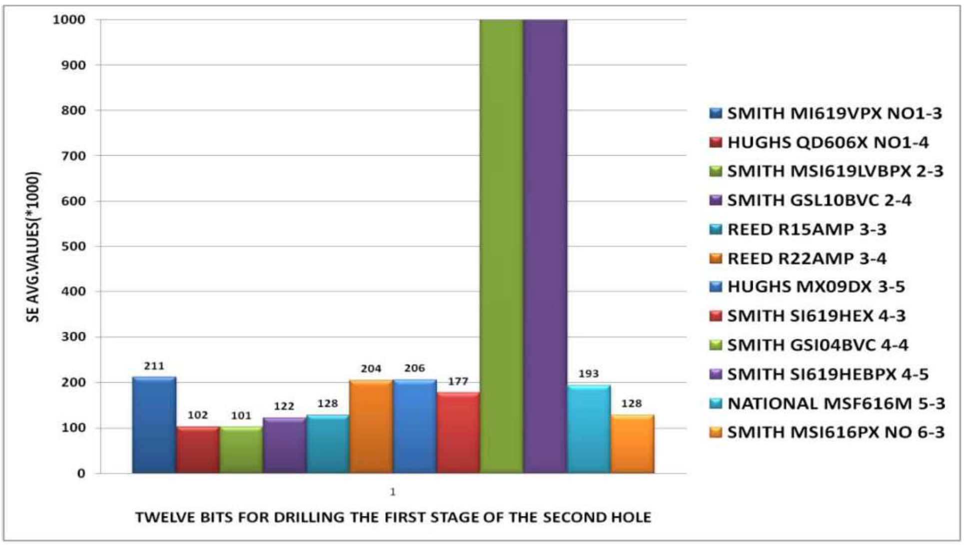

Fig. (8) SE avg. for twelve bits used to drill the sixth holes, size 12 ¼ “ – stage two

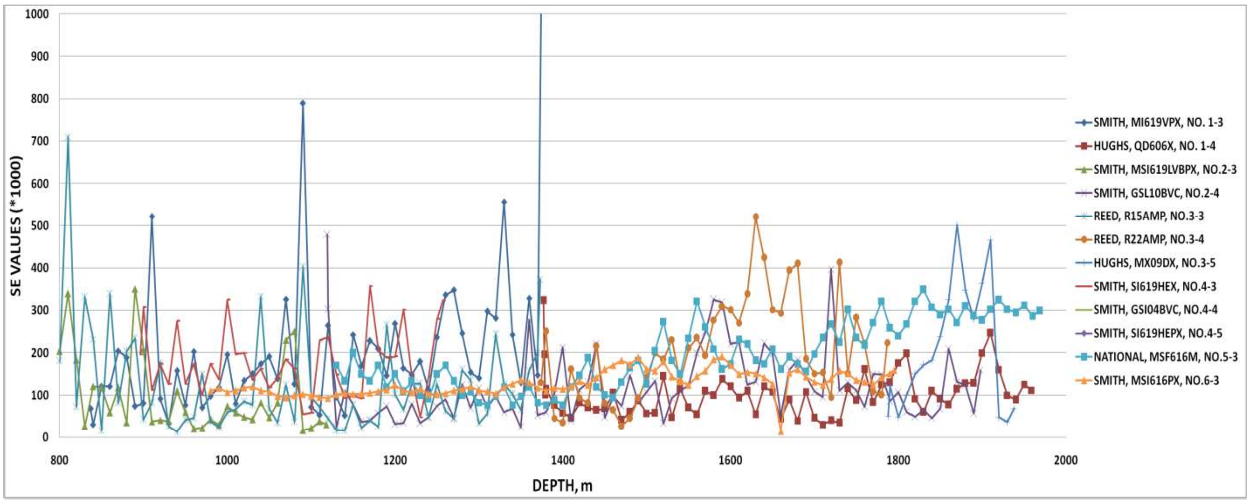

Fig. (9) SE values for twelve bits used to drill the sixth holes, size 12 ¼ “ – stage two

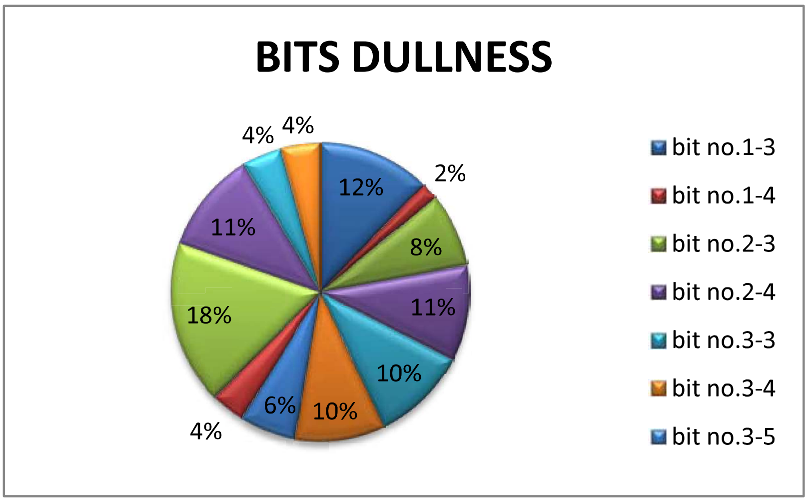

Fig. (10) bit dullness for the twelve bits used to drill six holes, size 12 ¼ " – stage two

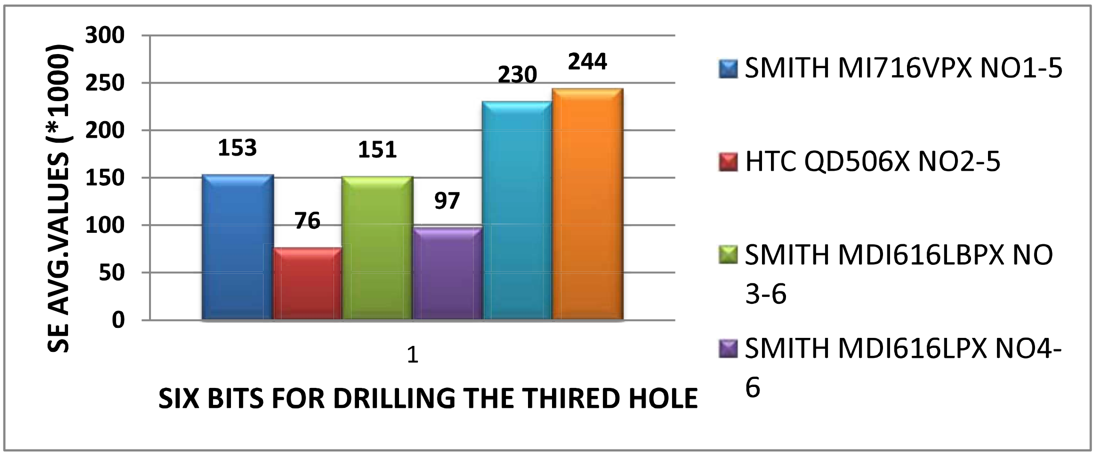

Fig. (11) SE avg. for six bits used to drill the sixth holes, size 8 ½ "

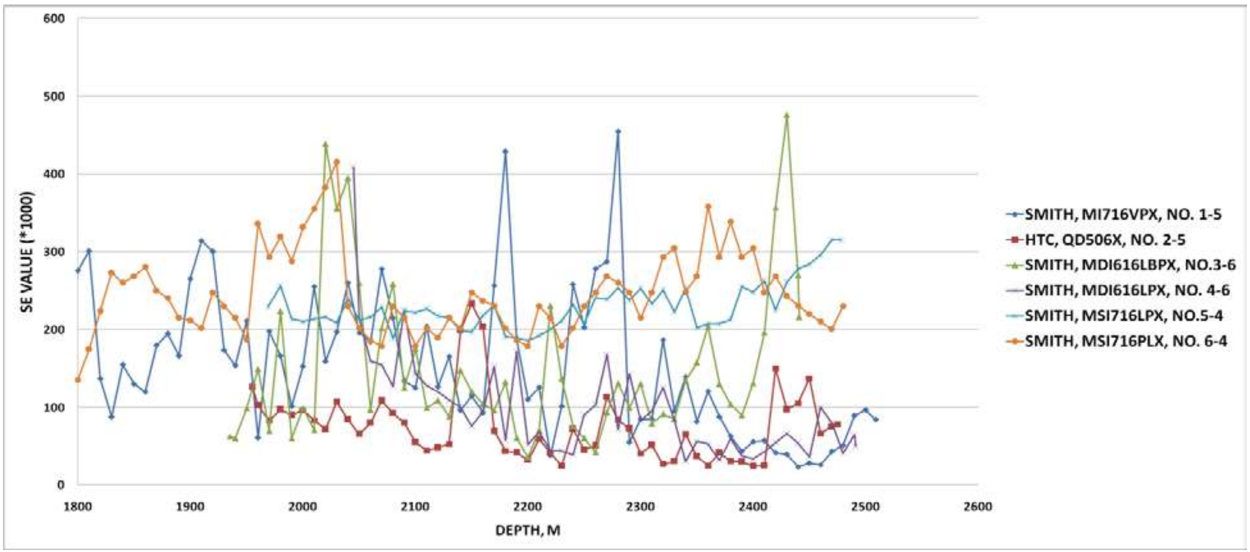

Fig. (12) SE values for six bits used to drill the sixth holes, size 8 ½ "

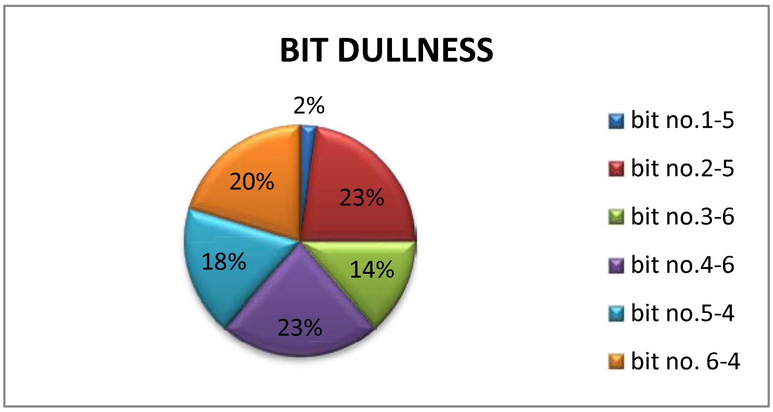

Fig. (13) bit dullness for the six bits used to drill six holes, size 8 ½ "

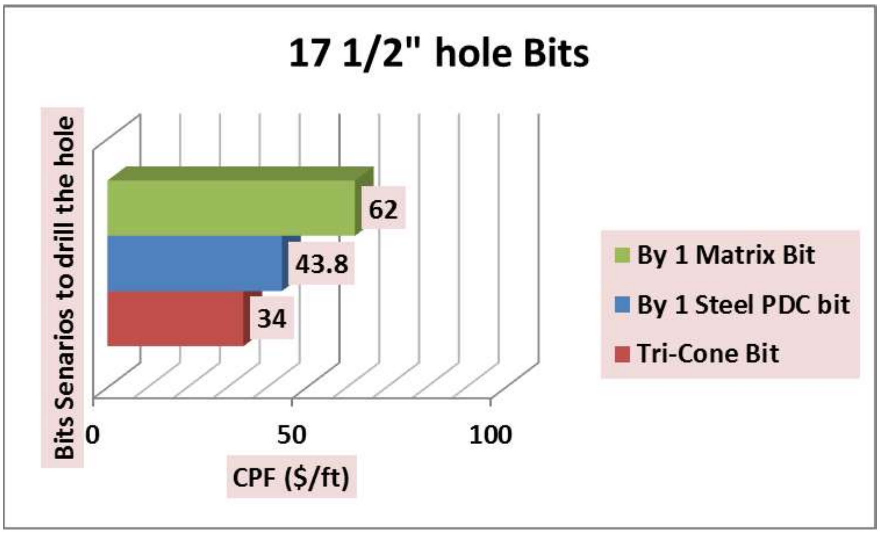

Fig.(14) economic evaluation of bits scenarios for drilling 17 ½" hole

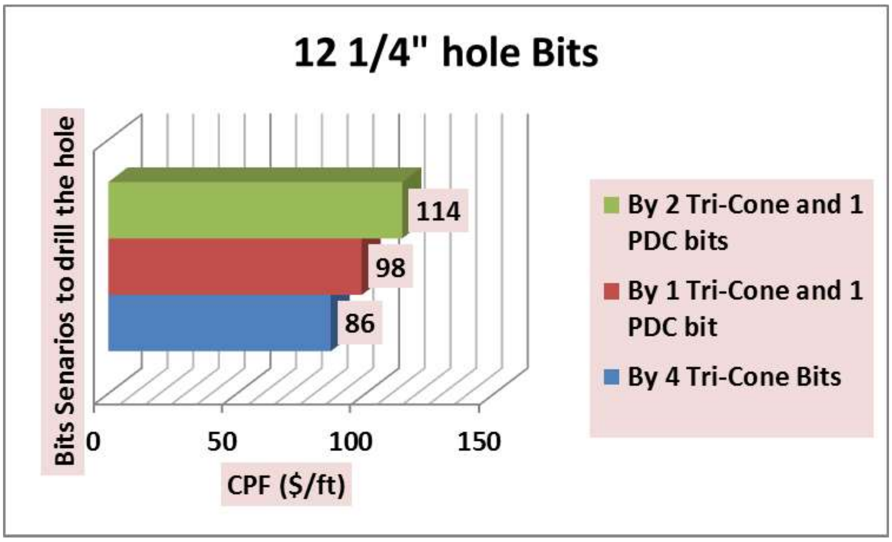

Fig. (15) economic evaluation of bits scenarios for drilling 12 1/4" hole

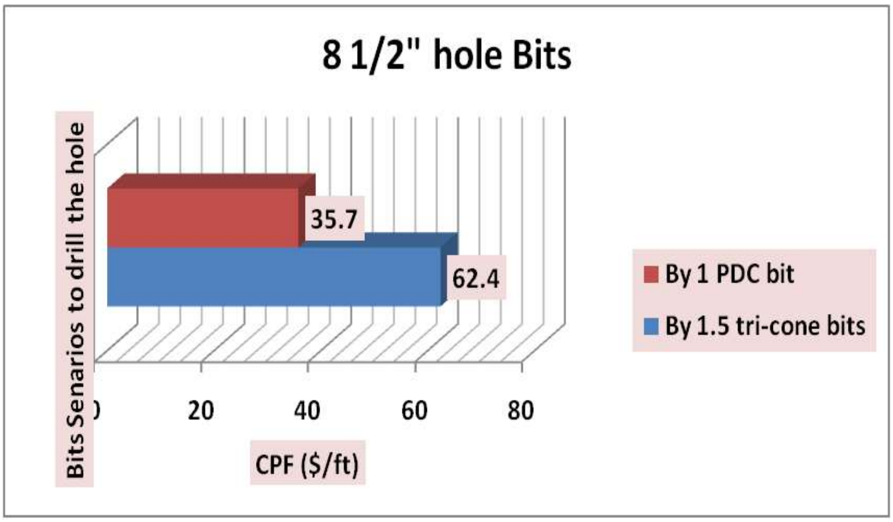

Fig.(16) economic evaluation of bits scenarios for drilling 8 1/2” hole