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GDUP a Safe and Low-Cost Technique with the Minimum Damage of Formation for Drilling in Oil and Gas Wells

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ABSTRACT

In this study, the theory of Good Drilling Using Piling (GDUP) is raised and it is a new method for drilling oil and gas wells, namely when low depth is considered and lose formations are on it. Piling technology has recent progresses as piling is possible in different depths and areas. In common drilling process, after establishing of rig, at first hole is created, then casing and cementing are performed and this process is repeated to achieve required depth. Thus, different dangers and problem of drilling are encountered including open hole, formation damage and pollution to complete well. However, in the presented method in this study, after exact collection of data of geology and geotechnical of area, a good area for well drilling is selected to design piling (steep sheet piling), pile equipment and execution trend. Then, the oil derrick was established and piling was performed from the surface to depth. After drilling inside the pile to the required depth, production casing is taken and cemented and well is also completed. Thus, firstly a steel wall is created for well and then drilled inside it and experienced an easy and less costly drilling with high security and less damage and pollution of formations.

Key words: Drilling, oil and gas wells, piling, GDUP, low-cost, minimum formation damage

INTRODUCTION

GDUP is abbreviation form of Good Drilling Using Piling and it is a term that have coined for a theory which denotes a modern technique in execution of drilling process in oil and gas wells drilling industry. With respect to high costs, low safety, encountering several problems during drilling in open hole (Bourgoyne *et al*., 1991), the exerted damages and pollutions in formations during current prevalent processes (Bellarby, 2009) for drilling hydrocarbon wells, particularly low-depth wells in which weak and drop formation are exposed for their drilling, application of GDUP may seem necessary and it can remove remarkably the purposed problems. There are several types of pile-driving hammers and some type of them are required for using for various formations on the ground and also any type of hammers can be employed in certain origin and kind of soil. Of these types of hammers which are tasked with providing the energy for pile-driving (Fakher, 2013), one can refer to the following items.

A drop hammer is a metallic heavy weight that is lifted by a rope and then it can fall on the upper point of the given pile. Application of heavy-weight hammer with falling from lower point is better than using light-weight hammer that drops from greater height.

One stroke steam water hammer is a weight that falls freely and it is called press piston or hydraulic ram. These hydraulic rams operate and are lifted by water steam pressure or pressured air on the bottom of piston that is connected to its bar. When piston reaches to the peak point of its course, water steam pressure is removed from its lower point and hydraulic ram strikes freely on the top of pile.

The resultant energy from this type of hammer is exerted with heavy strokes from heavy weight due to falling from low height with lower speed. One stroke steam water hammers operate more slowly in soft places and its speed becomes greater with rising of ground resistance.

In Two-stroke steam water hammer the pressure of water steam is exerted to the lower part of piston in order to raise hydraulic ram. Then also at time of falling, the pressure of water steam is exerted to the piston to move lower with greater speed and to release certain energy at any stroke. Thus, by considering certain weight for hydraulic ram, it is possible to create certain energy level in any stroke with shorter length of stokes than what is seen in one stroke steam water hammers. The number of strokes in this type of hammer per minutes is approximately doubled in comparison with one-stroke type of hammer with the same energy per stroke. The lighter weight of hydraulic ram and greater speed of strokes during driving light and average weight piles by type of two-stroke hammer in the soil with normal friction may be assumed as an advantage for this type of hammer. High frequency of strokes can make pile internal movements uniform and continuous and therefore, it prevents from creation of lateral static friction within the intervals among strokes. Anyway, during the operation of heavy piles driving, especially when soil friction is high, heavy weight and low speed in one stroke steam water hammers transfer the major part of energy to the pile.

Differential acting hammer is a steam water hammer with differential action and in fact an altered two-stroke steam water hammer in which steam pressure is employed to lift hydraulic ram and to accelerate in moving down. Hydraulic ram includes a larger working piston at the top of cylinder and smaller piston at its bottom. Number of strokes per minute can be compared with what it exists in two-stroke steam water hammers while its weight and equivalent amount of drop for hydraulic ram in this type of hammer may be contrasted to one stroke steam water hammer. Therefore, it has been claimed that this type of hammers enjoy both advantages of one- stroke and two-stroke hammers at the same time. It has been reported that such hammers may operate the same action within half of the needed time for one-stroke hammer and by application of 25-35% lesser water steam.

Hydraulic hammer operates based on fluids hydraulic pressure instead of working with steam and or compacted air (Peurifoy, 2010). These hammers have greater speed in soft places and operate more slowly with rising ground resistance (Fakher, 2013).

Diesel pile hammer includes an apparatus that does not need to external energy like the resultant steam from steam boiler and or pressured air. For this reason, its transport from one point to other point is easier than steam-type hammers. A full apparatus comprises of a vertical cylinder, anvil, fuel and oil tank, a fuel pump, injector and mechanical lubrication system. After lifting the hammer over the pile, system of piston and hydraulic ram are lifted up to the peak point of moving piston and they are released to turning it on. Approaching hydraulic ram to the end of its course causes the pump to spray fuel into combustion chamber that is located among this part and anvil. Continuous moving down the hydraulic ram causes contraction of air and fuel up to the combustion temperature. The resultant explosion causes driving of pile down and thrusting hydraulic ram upward to repeat this action. The amount of energy per stroke that can be controlled by operator of this apparatus may vary within wide range. These hammers have the maximum efficiency on the hard grounds and they operate in soft soil with difficulty.

Vibratory pile-driver hammers have shown their cost-effectiveness and fast operation and efficiency in pile driving inside certain types of soil. These types of pile drivers clearly operate efficiently in pile-driving inside non-stick soil that is saturated with water as well as in sand but they are not efficient in clay and pieces of stone. These pile-drivers may encounter some problems in pile-driving inside the dry sand or similar materials or sticky hard soils which do not react versus vibration.

Pile-drivers are equipped with horizontal axis to which eccentric weights have been installed. With rotation of two pairs of axis in opposite direction and variable speeds this system may rotates 1000 rpm as well and it generates centrifugal vibratory forces which are transferred to the pile and from there to adjacent soil to the pile. Soil vibration, particularly when it is saturated with water, decreases lateral friction among pile and soil. Composition and system of pile and vibratory device that is placed on it may plunge the pile totally with speed into the soil.

Foster pile-driver and vibratory extractor device includes two electromotors which derived their power from a portable generator and with city power supply in order to rotate eccentric axis and its rotary speed can be changed to create the most efficient frequency for a certain type of soil.

Bodine vibratory pile-driver includes horizontal axis which rotate in opposite side to each other and some eccentric weights are connected to them and they rotate by the aid of engine. Through rotation of axis with speed rate 6000 rpm the created coordination horizontal are neutralized with each other, but they strengthen their forces 100 times per second and they cause to intensify the vibration and create downward or upward forces. When the forces are transferred to the device that is placed on them, the elastic and compressional waves are conveyed through the pile. According to Poisson principles, horizontal dimensions of piles will be frequently decreased and increased. Thus, when the pile is under pressure, it repels the adjacent soil outside and when pile is under compression, it is allowed to move down because of reduction in the exerted friction at lateral surface. Composing pile weight with pile driver plunges the pile into the soil with a speed very greater than velocity of driving of water steam hammers.

It is worthy to note that size of drop hammer is determined by its weight while size of either of other types of hammers can be identified by means of the amount of energy for each stroke per kilogram-meter. Similarly, in each of the above-said types of hammers, the amount of energy is prepared by dropping an object that strikes to top of the pile and some of these types of hammers are kind of closed under water drilling type (Peurifoy, 2010).

MATERIALS AND METHODS

For several years, pile-driving is done in development projects and foundation engineering within different depths (up to 100 m) and all types of hammers, piles and functional systems have been used in pile-driving as applied form in foundation engineering (Fakher, 2013) but for the first time it intend to conduct pile-driving up to higher depths in order to achieve oil and gas deposits therefore, in these depths pile-driving requires taking requisite and sufficient thinking as well as design of pile (Tomlinson, 1995), hammer, rig, heavy and ultra-heavy equipments and machineries are employed for the higher depths. Before dealing with drilling process by GDUP technique, it is duly to express some definitions and important points in design of some of the used equipments and tools which need to them in pile-driving in this method.

Pile-driving rig: Since some of tasks of a perfect pile-driving rig comprise of tolerance of hammer weight, coordination of hammer axis with pile as well as having conductor for appropriate conducting operation of pile without deviation into the ground and driving it in suitable direction (Fakher, 2013), thus it can be noted that drilling rig may also provide such conditions very easily. Therefore, by exertion of some partial changes, drilling rig can be used as pile-driving rig at the same time and this may cause drilling rig to be available at necessary times.

Design of pile and practical strategies for its design: Like design of casing, pile design includes identifying all factors which cause failure in pile-driving and drilling operations and also safety and economic aspects should be taken into consideration in order to employ the best type of pile for a certain operation. The pile plays the role of loading in foundation engineering. In this technique, a pile is design in such a way that it can play all casing roles rather than loading role (Zamani *et al*., 2008). A pile should be able to tolerate all internal and external stresses, pressures and all the exerted strokes by hammer while it can create the minimum frictional force with the adjacent formations. One could refer to some of paramount practical strategies in pile design as follows: (1) The required and adequate information about geotechnical conditions of site, (2) The accurate recognition of the exerted forces and moments in terms of type, amount, direction and their order preference, (3) Identifying the environmental factors on pile in terms of short-term and long run effects, (4) Recognition the condition surrounding the project for making decision regarding way of pile execution, (5) The review of feasibility of pile manufacturing and production for the project and dimensional constraints, (6) Determination of pile burial depth with respect to soil conditions, the existing loads and execution facilities, (7) Identifying pile usability potential by means of valid static analyses, (8) Pile structural design, (9) Conducting static and dynamic experiments in order to make sure of accuracy of execution and lack of damaging the pile during execution and (10) Determination of safety level (Peurifoy, 2010).

Pile: It is a steel pipe with circular section that is derived in the ground with open hole and then drilling is done inside it so this type of pile is of that group of piles which have their installation in the ground is followed by soil replacement at low level. The relatively high resistance of these piles allows them to be partially replaced where the major part of the resultant energy from strokes of pile-driving hammer is transferred to the bottom of pile and as a result these piles can be derived into a soil in which other types of piles could not be plunged. The given pile may be produced with various diameters (depending on design for certain operation) which should be installed in the ground by means of pile-driving hammers after removal of rust and sandblast (Fakher, 2013). Likewise, with respect to rig structure and way of pile-driving here, the piles considered as 40 feet branches for ease of pile-connection operation on the top of pin (screwed outside) and on its bottom as box (screwed inside) where after driving any branch, the next branch is welded to that branch in order to be water-tight and pile-driving process is continued so forth (Peurifoy, 2010).

Tapered pile: It is a title that has been selected for the first 40 feet pile which is driven and this pile should be designed in tapered from (conical) (Tomlinson, 1995), namely with sharp plunging reinforced diameter in which the diameter of its bottom i.e., box should be designed with the minimum diameter in order to be able to pass drilling bit or the next pile string easily.

Pile-driving systems: Two systems are observed for pile-driving including first system that is called top drive hammer system in which pile driving hammer should be placed on a rail on the rig body like top drive (power swivel) and rather than possessing the needed maneuver power in vertical moving (Bourgoyne *et al*., 1991), it should be able to connect the screwed joint among the driven pile with the pile that is lifted by this system from mouse hole (diameter of mouse hole should in such a way that it can embed piles with several sizes). In the second system that is called transporter system, a hummer should be hang from the connected hook to traveling block where several feet-sized steel work pieces under title of transporter is also connected to the hammer. This work piece that is connected from one end to the hammer and other end forms as pin may prepare its connection with the driven pile by connection to pile box inside mouse hole and at the same time it is used to prevent from direct exertion of pile-driving stresses in order to minimize pile battering or tearing. By insertion of a work piece inside master bushing that can keep the pile at the center part and lead it along with appropriate axis, it can play role as a conductor in this system.

RESULT AND DISCUSSION

The drilling rig is transferred to the site and installed by civil engineering group, after acquisition of accurate geometrical and geotechnical information in site and comprehensive data from oil field and determination of drilling site coordinates and preparation of site (Zamani *et al*., 2008). To make this issue more tangible, pile driving process is briwfly explaimed by means of transporter system and drilling. To install the first pile (tapered), it is required lifting by air

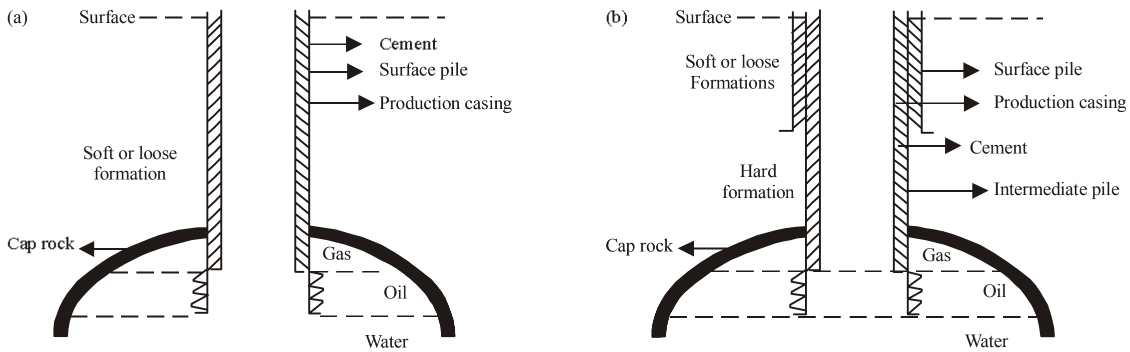

Fig. 1(a-b): Well completion in GDUP technique, (a) Completion for loos formation and (b) Completion for loose and hard formations

hoist from pile rack and to enter it in the rig via cat-walk and ramp from v-door and to place it into mouse hole (Adams and Charrier, 1985). Now, lift the given pile by the connected transporter to hammer and lead it down into master bushing. Pile-driving is start after connecting tapered head with pile-driving ground level and continue to pile driving up to the depth where bottom of tapered pile is available to connect the next pile from rig floor. Currently, transporter is separated from the tapered pile by tongs and lead it toward the next pile which have already brought into mouse hole (by means of the already explained method). In the following, given pile is connected to transporter and extract it from mouse hole and after connecting it to tapered pile by tongs, welding operation is conduct according to standards. Afterwards, pile-driving begin again and continue this process as it explained until reaching to the given depth. If there are soft and or weak formation before this process along with this course or moreover the tank has been placed in lower depth as well (Dake, 1978), continue pile-driving by a pile string or the same surface pile up to the given depth (efficient formation) (Dake, 1978) and then prepare and activate rig for drilling and continue drilling internally from the surface up to the given depth in tanks by selection of appropriate drilling fluid and bit (Adams and Charrier, 1985) (almost the same size with pile internal diameter) and complete the well after repulsion of production casing and cementing behind it (Bellarby, 2009) (Fig. 1a).

Some hard formation may encounter during pile-driving so there are some strategies for pile-driving in these formations out which, pile internal drilling is refer by means of jetting action and tetrapan (Fakher, 2013). Similarly, due to these hard formations, the tapered pile or pile string may be subjected to tearing and damage during operation of pile driving and a pile sting up could not use to reaching to the given depth so this point should be considered in design as well. Under such condition, after driving surface pile and its deficiency, drill inside it and then continue pile-driving by means of the methods of exposure to hard formation by intermediate pile up to efficient formation and then this process can be continued from the surface by pouring cement slurry among surface pile and intermediate pile and drill inside intermediate pile up to the given depth and repulsion of production casing and conduct cementing behind it and finally well is complete (Bellarby, 2009) (Fig. 1a-b).

One can refer to some advantages of GDUP technique compared to current well drilling methods as follows.

If several formations with various pressures are through this path, a pile string may separates all of them as a result it does not need to repulse various casings for separation of layers with different pressures for design of appropriate drilling fluid (Bradley and Gipson, 1987) in drilling next formations and consequently while creating the minimum level of formation damage, especially in efficient formation (Bellarby, 2009), steel pipe may be use with shorter length in order to separate formations from each other and less cementing operation id needed so this can accelerate speed in well drilling and lowering the costs of cementing operation.

Due to changing drilling bit, tripping operation does not need to several casings installation or we do it lesser and as a result drilling speed will be also accelerated as well.

It does not necessitate to design the fluids for good wall construction and to form appropriate mud cake on the wall because of the existing pile that has created steel wall for the well and we will not encounter some problems including wash-out, wall dropping and tightening and stuck of drill string, dog leg, loss, kick, clay swilling and other problems (Bourgoyne *et al*., 1991) which are caused by drilling with open hole and as a result with safety, confidence and higher speed and without polluting formations and damaging them, a drilling operation will conduct by spending lower cost for design of drilling mud.

After drilling with a bit which its size is approximately the same as pile internal diameter, depth of well in which pile-driving is done lacks tortuosity (skewness) (Bourgoyne *et al*., 1991).

Until now, the piling operation in oil and gas wells is only conducted for placement of conductor pipe to play the roles of stability of well wall in drilling of loose formations, avoiding the pollution of surface water and the deviation of drill. conductorpipe study is limited to the investigation of the role and its improvement for surface layers but in GDUP method, piling is for the first time used for the aim of achieving the required depth in reservoir to achieve the goals and benefits, namely when reservoir is in low depth and upper layers are lose.

Reduction of elimination of formation damage arising from the contact of fluid and drilling cement as despite current drilling methods, at first steel wall is created in well namely in productive formation in this method and then drilling is started and besides protecting reservoir, its productivity is increased.

Reduction of drilling operation costs due to the increasing speed of low tripping and not needing a fluid creating muk cake and no problems as wash out, falling, wall thinning and stuck of drilling string.

Dogleg, loss, kick, clays willing and finally by high security, reliability and speed, without polluting the formation and damaging it, with less costs for drilling fluid design, drilling operation is done.

GDUP foremost applications: The most basic application of this method of drilling is drilling of vertical well in tanks which are placed in shallow areas, especially when the surface formations on the tank are weak and dropping types.

The slant well can be drilled by slant rig (Bourgoyne *et al*., 1991) and deviated well up to Kick-Off Point (KOP) by this drilling technique.

Drilling of relief well can be done by the aid of slant rig, particularly when the fired well lacks survey (Bourgoyne *et al*., 1991) so that KOP high potential can be considered as target. Under this condition, it can be drilled with higher confidence and speed and control the well in least possible period of time.

It is possible to operate drilling in formations with different kinds of layers because of the various existing hammers.

As a result, drilling in higher depths can be also done by design of heavier pile-driving hammers and tools (Fakher, 2013).

In deep wells in which it is not possible to operate pile- driving due to presence of hard layers and high depth up to the efficient formation, the soft and weak formations can be drilled by GDUP technique and in exposure to hard formations, one could use rotary method of drilling and at last in order to prevent from pollution of efficient formation, hammer and connected pile to them, we can bring it to the given depth like under the situation when we take liner to the aforesaid depth by fastening it to drill pipe (Zamani *et al*., 2008) and from that point we may operate file-driving in efficient formation and then complete the well.

CONCLUSION

With respect to low safety, damaging due to formations, higher costs and encountering several problems in drilling based on the current processes (creating hole and then casing installation), Good Drilling Using Piling (GDUP) can employ, since initially the steel wall is created in well (pile) and it is drilled from inside. In addition to providing more safety for personnel in rig and better financial security for drilling company, this method can omit the major part of pollutions and the exerted damages to underground formations, especially efficient formation and it may delete and in some cases reduce the costs such as costs due to exposure to the barriers and encountering problems during drilling due to creating open hole, cost of design of drilling fluids and several cements in facing with various formations and at the same time shorter length of steel casings are used and this is also followed by reduced costs. As a result, employing GDUP technique in drilling of oil and gas wells, especially when tank is placed in lower depth with soft and drop formation on the top seems necessary. Although, with respect to various hammers in which each of them are used more efficiently in certain kind of soil and with presence of various techniques to treat with hard formations, it can be implied that it is also possible to employ GDUP technique with design of appropriate pile and hammers for higher depths and with various kinds of soil. It is suggested that to conduct studies in the future regarding pile-driving only in efficient formation within deep wells for higher safety and with the absence of problems and by reduction of damaging to efficient formation more than ever with sending hammer and pile to the bottom of well.

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