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Analysis of Oscillating Fishing Tool Efficiency for Stuck Assembly Recovery in Field X

Pratama Bayuartha*[1], Rahmat Sinaga[2], Tomi Sugiarto[3], Kristoforus Widyas Tokoh[4], Bonifasius Muryanto[5], Ardho Fidiansyah[6], Dasa Manalu[7], Dyan Faksilanto[8], Boby Hendarno[9] and Taufiq Ardiansyah[10]

[1]Drilling Solutions Engineer, National Oilwell Varco
[2]Drilling Engineer, PT. Pertamina Hulu Mahakam
[3]Lead Drilling Engineer, PT. Pertamina Hulu Mahakam
[4]Completion Engineer, PT. Pertamina Hulu Mahakam
[5]Well Construction-Intervention Offshore Manager, PT. Pertamina Hulu Mahakam
[6]Head of Well Construction Department, PT. Pertamina Hulu Mahakam
[7]Head of Completion Specialist, PT. Pertamina Hulu Mahakam
[8]Fishing Specialist, PT. Pertamina Hulu Mahakam
[9]Well Construction Operation Superintendent, PT. Pertamina Hulu Mahakam
[10]Operations Manager, Wellbore Integrity Solutions
* Email: pratama.bayuartha@nov.com

Abstract. As conventional fishing assembly offers a degree of recovery chance, such chance can be increased by utilizing an Oscillating Fishing Tool (OFT). The OFT is a fishing Bottom Hole Assembly (BHA) component that delivers low-magnitude; high-frequency oscillation. The continuous motion that the tool provides complements the impact generated by the fishing jar. This paper reviews the successful case history in Field X, which was in fact the first utilization of OFT for a fishing application in the field.

Method of analysis involve comparing fishing sequence without and with the OFT. The OFT was used in Offshore Field X to recover a mechanically stuck 550-meter long Tubing Conveyed Perforating Gun assembly inside 9 5/8” casing that could potentially lead to loss of access into the 6 oil reserves candidate perforation zones. Initially the assembly had been stuck for two days, during which conventional fishing BHA was used to retrieve it to no avail, even after jarring for most of that time. OFT was then incorporated in the final fishing BHA and operated in combination with jarring operation.

After around twelve hours of oscillating and jarring, the fish was able to be released from the initial stuck point. When tripping the string out, however, the assembly was stuck at high dog-leg severity area near the surface. At that point, in combination with applying substantial overpull, OFT was utilized further to recover the entire string. Upon fish retrieval, it was evident that post detonation, the TCP gun had swelled into 8.6 inches in diameter. In summary, oscillating and jarring for thirty-six cumulative hours successfully released the swelled TCP gun assembly from the stuck occurrences. In conclusion, the operation showed that the OFT serves as a higher level of fishing tool option that offers a particular excitation mode to the stuck assembly.

Stuck assembly in a cased hole presents potential loss of oil reserves. Particularly in offshore application, the situation can also be costly. With reduced chance of recovery as time passes by, operation is hindered from being able to proceed to the next completion phase. The case proved OFT to have played an important role in improving fishing probability of success and should be considered as standard fishing BHA in the future.

Keyword: oscillating; fishing; offshore; stuck; mechanical

1 Introduction

Offshore wells present costly operations with daily rates in the range of several hundred thousand dollars. An instance of stuck assembly in the hole would increase cost associated with sidetracking the well or losing the well altogether. At the same time, retrieving a stuck assembly is a time-sensitive operation, with chances of retrieval decreasing as time passes. Such considerations present inevitable requirement of efficient fishing operations.

Conventional fishing BHA's and fishing techniques provide a degree of success of retrieving stuck assemblies. However, different factors may increase the difficulty of the operation. These factors may include the size of the fish, as well as the complexity of the well trajectory. With such challenges, an alternative method is to be considered.

This paper highlights the use of a technology to complement a conventional fishing BHA that contributed in retrieving a stuck Tubing-Conveyed Perforating (TCP) Gun assembly in Field X. Utilization of OFT, which provides continuous axial oscillation at low magnitude in the fishing BHA proved to make retrieval possible, where conventional method was previously unsuccessful.

This paper covers the design concept and mechanism of the tool, the theory behind the technology, and ultimately how they relate to operational considerations that was made. The successful case of stuck TCP Gun retrieval in Field X is presented.

2 Methodology

2.1 Tool's Concept and Theory of Application

The first stage of methodology looks at the theory behind the design of OFT and how its mechanism can contribute to a fishing operation. Delivering impact using a fishing jar is a widely known method in most fishing operation. Continuous axial motion that's presented by the OFT is to complement the jarring impact to induce fish displacement.

2.1.1 OFT Design Concept and Mechanism

The OFT is comprised of a power section, valve system and oscillating system. The power section consists of a rotor-stator combination, with a similar concept to a Positive Displacement Motor (PDM) or a Progressive Cavity Pump (PCP), configured at 1-lobe rotor and 2-lobe stator (i.e. 1:2 lobe configuration). This power section drives the valve system, which is a series of two orifices, while the oscillating system is a shock sub. The layout of these sub-assemblies of the OFT is shown in Figure 1.

As fluid is pumped through the power section, the cavities between the stator and the rotor progressively move the rotor, effectively rotating the rotor. The frequency of the rotor movement is directly proportional to the rate of which the mud flow is applied, typically in the range of 15 – 26 Hz. The lower end of the rotor is attached to an off-center orifice called the Oscillating Valve Assembly (OVA).

Adjacent to the OVA is another orifice called the Stationary Valve Assembly (SVA). Due to the 1:2 lobe configuration of the power section, when the rotor moves, the OVA nutates over the SVA, causing cyclical restrictions in the Total Flow Area (TFA). The TFA shifts from small area during choke position when the OVA and SVA is offset from each other, and large area during open position when the OVA and SVA overlaps one another. This continuous change in the TFA creates upstream pressure pulse as shown in Figure 2.

Generated pressure pulse alone would not create mechanical oscillation. A way of turning the upstream pressure pulses into mechanical oscillation is needed. The shock sub is a spring-loaded stroking tool that has a Pump Open Area (POA). The series of pressure pulse that’s generated act on the POA of the shock sub, turning hydraulic energy into mechanical oscillations by way of axially traveling mandrel. The displacement is typically in the range of 3/8 inch during operation.

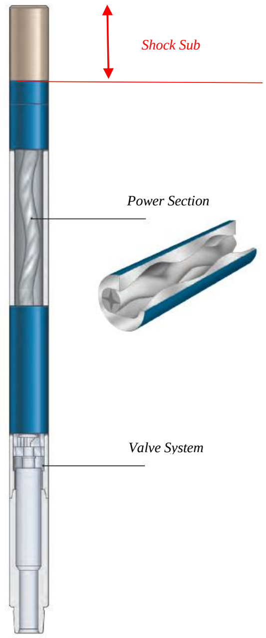

Figure 1. OFT Sub-assemblies

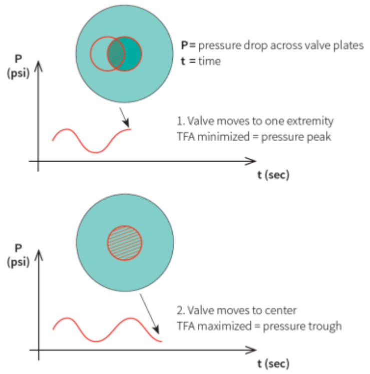

Figure 2. OFT Pressure Pulse Signal

2.1.2 Theory of Application

Fishing jars delivers high impact to the fish. The amount of impact is dependent upon operating conditions such as well trajectory, string design and mud density. Such value can reach higher than 1,000,000 lbs for some applications. While impact value can be high, it takes place for a short duration. And considering the need to re-cock the jar after each jarring instances for another cycle, only one occurrence of impact can be obtained at one time, resulting in a low frequency of application. Figure 3 shows typical jarring impact signature with respect to time.

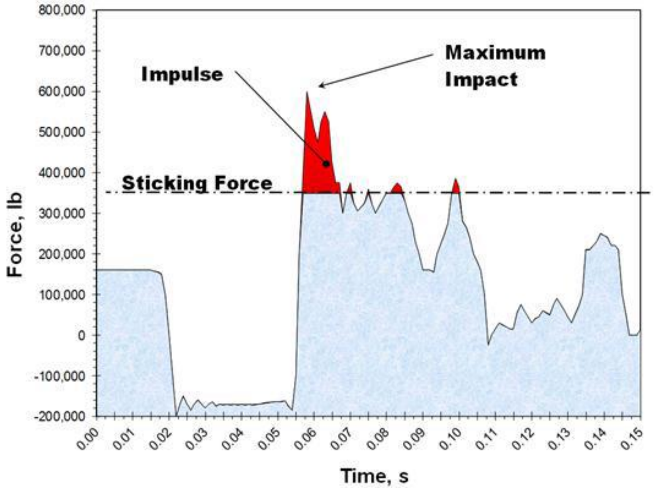

Figure 3. Typical jarring force signature

The typical pressure drop across the OFT is 700 psi, which correlates to around 4 g of acceleration. At this acceleration magnitude, up to 27,000 lbs of impact can be generated. The actual magnitude of force would depend on the POA of a particular tool in use. While the impact value is significantly less than that created

by a jar, the impact that's generated by the OFT is continuous and hence operates at a much higher frequency, up to 26 Hz. Figure 4 shows the typical acceleration signature that's created by an OFT.

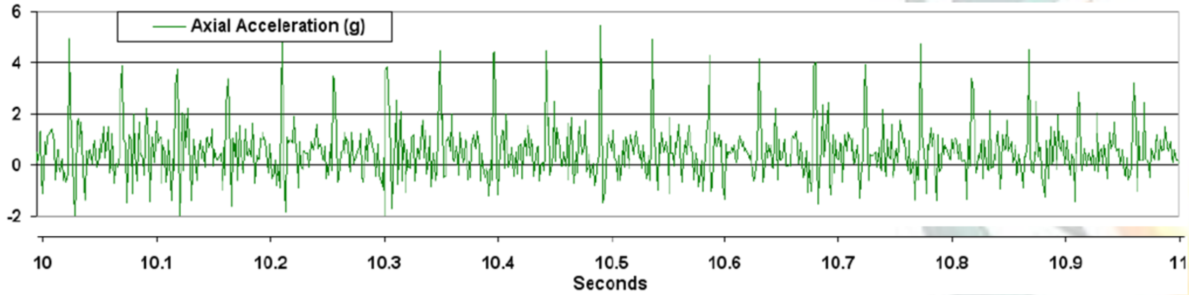

Figure 4. Typical OFT acceleration signature

The axial oscillations created by the OFT travel down the string to the stuck point. This axial excitation on the string reduces friction between the stuck fish and the hole. The oscillation as illustrated in Figure 4, complements the jarring force as illustrated in Figure 4, ultimately increasing the chances of fish recovery.

2.2 Fishing Application in Field X and Related Software Modeling

The next phase of methodology is to observe the OFT application in Field X. The subject application involved fishing out a 7" TCP Gun assembly that was stuck inside 9 5/8" casing. For the purpose of tool run optimization, pre-job modeling using a proprietary software was done using related input data to determine optimum run parameters.

2.2.1 7" TCP Gun Stuck Inside 9 5/8" Casing Situation

Figure 5 illustrates the construction of the subject well in Field X. The well has three casing strings (30", 13 3/8" and 9 5/8"). Whilst, the trajectory of the well is 3D J-shape with the maximum inclination of 31.33^0 , final inclination is 27.8^0 . The total depth for the well 2796 mMD. The well had been completely drilled with 9 5/8", 47 ppf, L80 casing (ID: 8.68") string in place and had been cemented, and hence the well was ready for completion phase.

The well was selected as a gravel pack completion. It was designated in a single trip multi zones (6 zones) inside the 9 5/8" casing section. Those zones are listed below:

- ZONE # 1: 1508 - 1510 & 1515 - 1520 mGR,
- ZONE # 2: 1549 - 1554 mGR,
- ZONE # 3: 1651 - 1654 mGR & 1656 - 1658 mGR,
- ZONE # 4: 1683 - 1685 mGR,
- ZONE # 5: 1962 - 1966 mGR,
- ZONE # 6: 2049 - 2051 mGR & 2055 - 2058 mGR.

7" Tubing conveyed perforating gun (TCP) was run in the hole on April 25th, 2020 to desired depths. The next day, the perforation was performed as per procedure and the assembly was ready to pull out of the hole. However, it was found that the string had been stuck although the circulation was going normally. Figure 6 describes the TCP assembly which is purposed for 6 (six) zones in a single run.

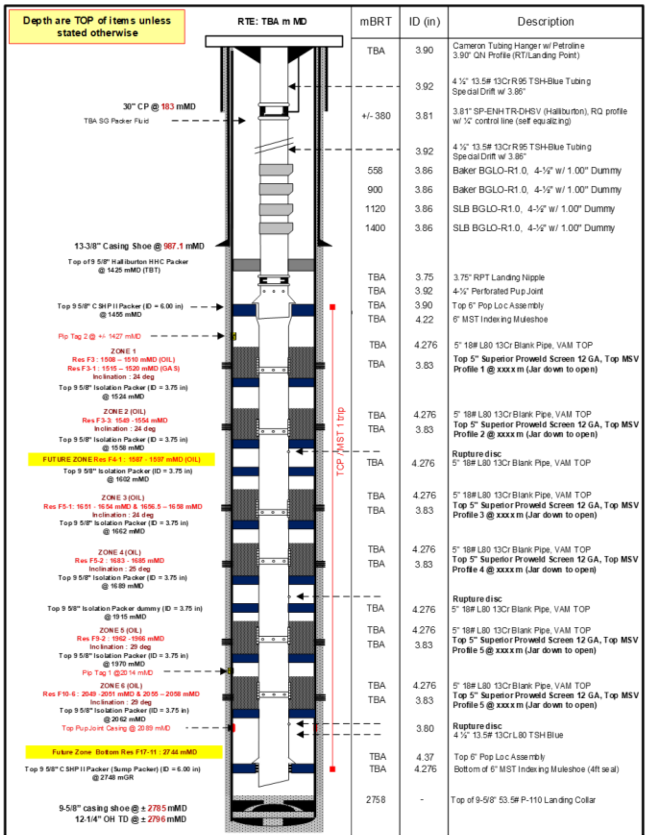

Figure 5. Well Schematic

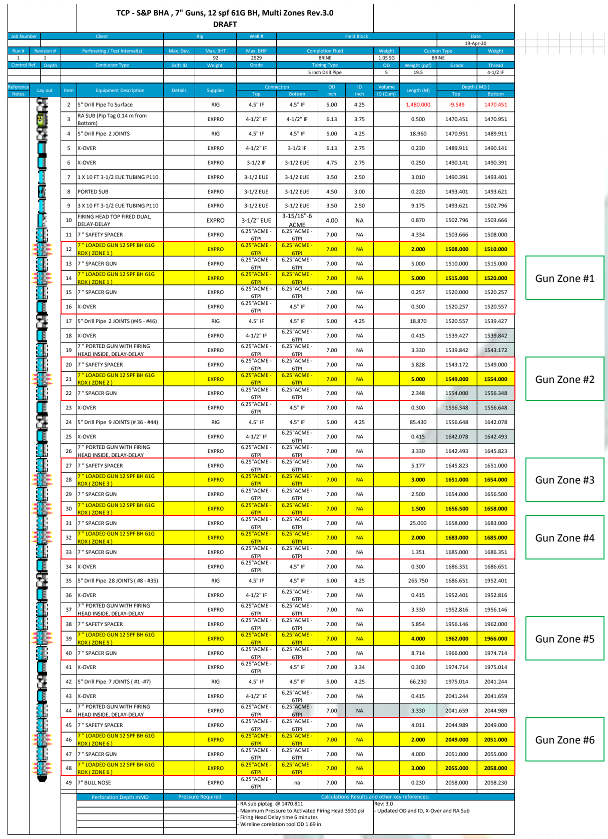

Figure 6. 7" TCP Assembly

2.2.2 Stuck Assembly Software Modeling

The objective of the software modeling is to provide guidelines in terms of optimum operating parameter for the OFT. The software simulates various operating frequency of the OFT and plots the resulting oscillation profile at the fish at those respective frequencies, in the form of g force vs. time stamp (in 0.01 second). As the frequency of OFT is directly proportional to the applied flow rate, correlation to recommended flow rate can be made for field application. OFT frequency that results in the highest oscillation at the fish means said OFT frequency induces the natural frequency / harmonics of the fish, essentially increasing the chances of fish recovery. The simulation also produces oscillation profile generated on surface to help ensure vibration on surface is not excessive.

Input data for the simulation includes the following:

- Well trajectory
- Fish configuration
- Fishing Bottom Home Assembly (BHA) configuration

- Mud weight
- Friction factor

The following figures show simulation results at OFT frequencies of 12 Hz, 15 Hz and 18 Hz, where the x-axis represents time stamp, and y-axis represents generated g force.

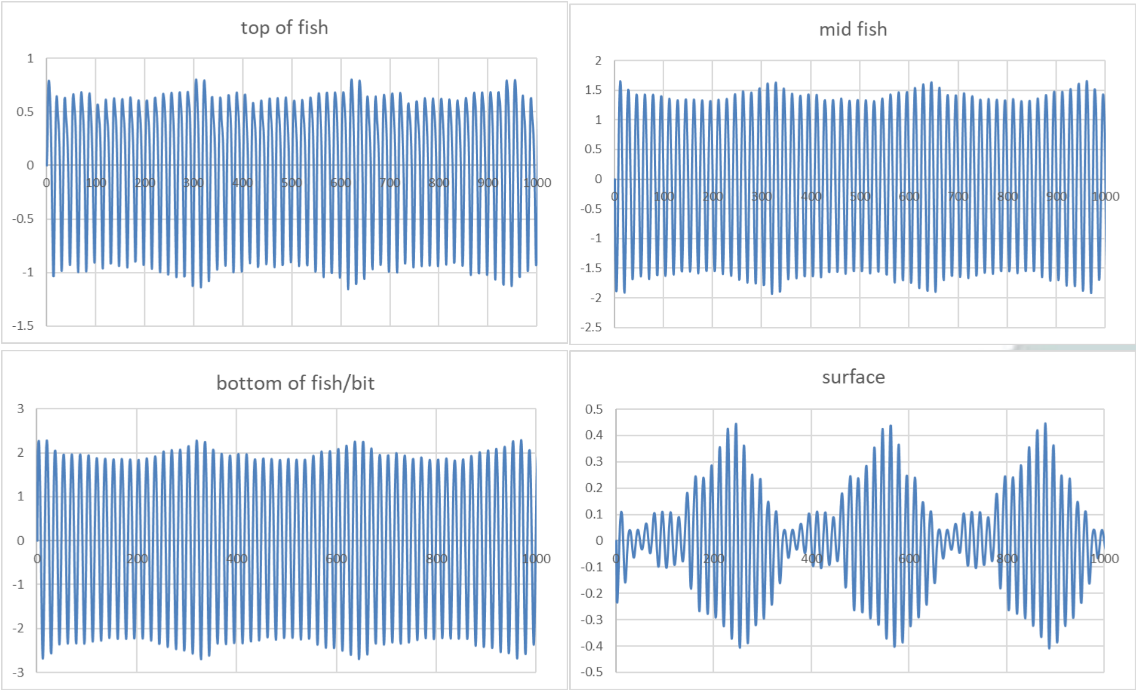

Figure 7. Simulated oscillation results for 12 Hz OFT frequency

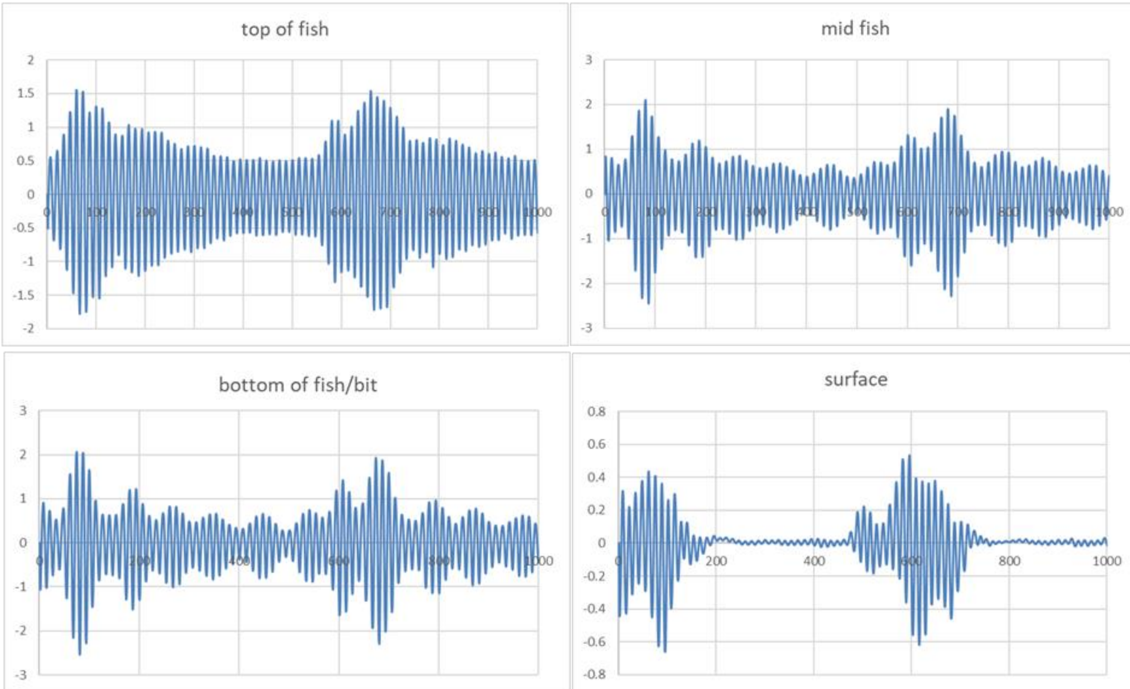

Figure 8. Simulated oscillation results for 15 Hz OFT frequency

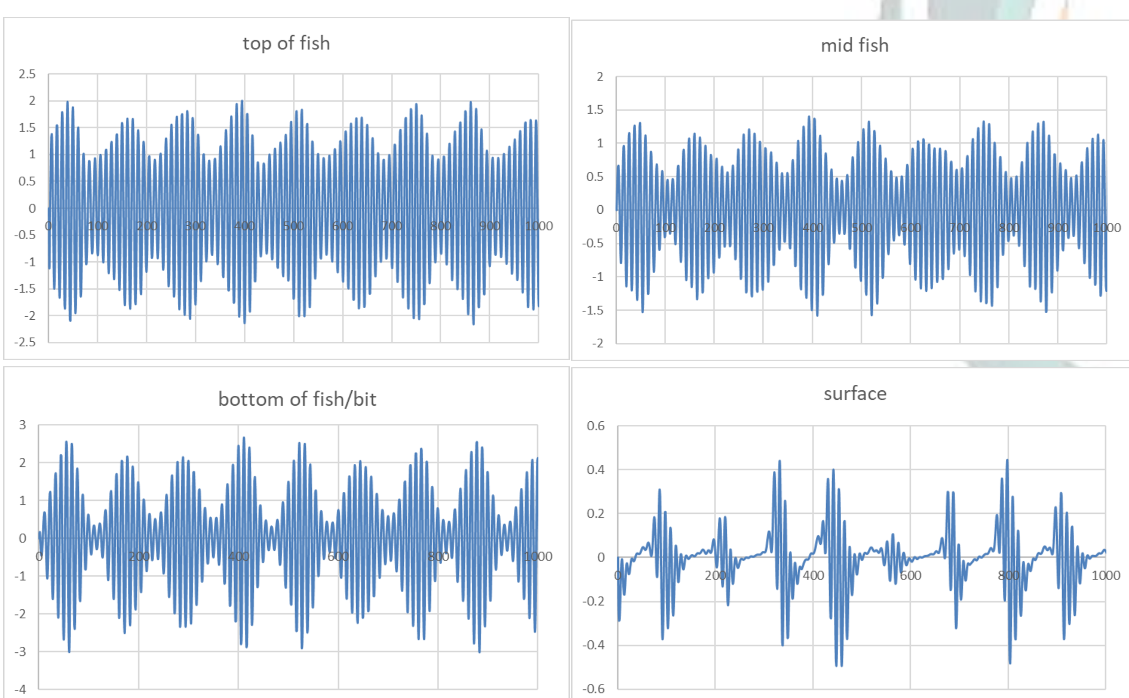

Figure 9. Simulated oscillation results for 18 Hz OFT frequency

Simulation results as illustrated on Figure 4 – 6 are summarized below,

Table 1. Summary of Simulation Resulted Peak-to-Peak G Force Values

OFT Frequency	Bottom of the Fish	Middle of the Fish	Top of the Fish	Surface
12 Hz	4.5 G	3.5 G	1.6 G	0.8 G
15 Hz	4 G	4.3 G	3.25 G	1.1 G
18 Hz	5.5 G	3 G	4 G	0.9 G

Simulation results suggests an upward trend in generated G Force at the bottom of the fish once 15 Hz is exceeded. Therefore, it is deduced that a higher operating frequency of the OFT may be able to increase the chance of fish retrieval.

3 Result and Discussion

3.1 Comparison is made between fishing attempt prior to utilization of the OFT, and with the OFT. This section discusses the sequence of operations of those attempts

3.1.1 Fishing Attempt without OFT

Following the TCP string becoming stuck post-perforation job, and before having the OFT onboard the rigsite, conventional attempt in freeing the fish was conducted. Initial attempt involved working the string with torque of up to 4000 lbs·ft and overpull of up to 63 tonnes. Overpull was gradually increased to 172 tonnes while applying lubricant into annulus in the volume of 5 m^3, after which the fish was parted, and 33 meters of fish was retrieved.

The next operation was to run a conventional fishing assembly consisting of the following BHA components:

- 8 3/8” Overshot
- Fishing Jar
- 9 joints of 6 ¾” Drill Collars
- 12 joints of 5” Heavyweight Drill Pipes
- Drill Pipes to Surface

Using this conventional fishing BHA 9.5 hours of jarring was conducted, but the fish was not released. Overpull was then increased to 95% of grapple tensile limitation at 210,000 lbs and additionally, up to 15,000 lbs·ft of torque has applied to no avail. Mechanical backoff was then done, upon which 31 meters of fish was retrieved. Cumulative time between fish engagement and BHA trip out was around 18 hours.

3.1.2 Fishing Attempt with OFT

The next fishing BHA run incorporated the OFT in the string. The following is the configuration of the OFT-equipped fishing BHA:

- 8 1/8" Overshot
- 6 ¼" Bumper Sub
- 6 ¾" OFT
- 6 ¼" Fishing Jar
- 6 joints of 6 ¾" Drill Collars
- 6 ¼" Fishing Jar Intensifier
- 15 joints of 5" Heavyweight Drill Pipes
- Drill Pipes to Surface

The sequence of procedure involved alternating between jarring and agitating, referring to the concept of complementing jar's impact with OFT's impulse as explained in Section 2. In particular, the following was the sequence that was conducted after engagement with the fish,

Table 2. Sequence of Operation Using OFT

Sequence	Operation	Duration
1	Oscillating	1.5 hours
2	Jarring	1.5 hours
3	Oscillating	3 hours
4	Jarring	1.5 hours
5	Oscillating	0.5 hours
6	Jarring	0.5 hours

Referring to the simulation results that suggested higher frequency may help in increasing chances of retrieval, 2300 lpm flow was applied when oscillating. Such flow rate correlates to 20 Hz of OFT operating frequency. It should be noted that tension was also applied each time oscillation took place. After the sequence as listed on Table 2 was completed, the string was released from the stuck point, approximately 9 hours after initial engagement of the subject BHA with the fish.

Figure 10 illustrates the summary of sequence conducted with the two different fishing BHAs,

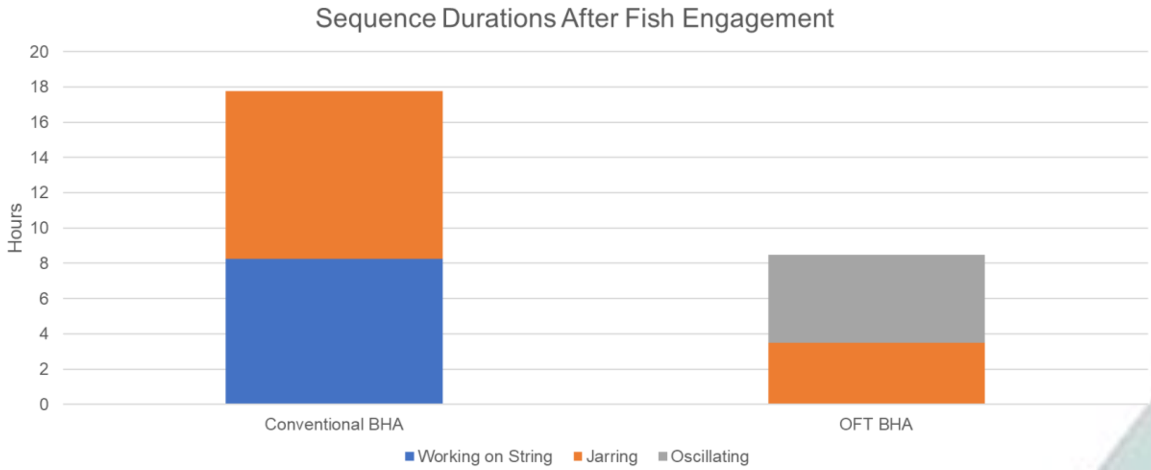

Figure 10. Summary of Operations Duration

It was evident upon the stuck fish's completed trip out of the hole, that the stuck situation occurred due to TCP Gun swelling. The OD of the gun measured at surface was 8.6" as shown below,

Figure 10. Retrieved TCP Gun

4 Conclusion

The Oscillating Fishing Tool (OFT) presents a step change in fishing efficiency. While conventional fishing BHA utilizes jarring impact, overpull and torque in an effort to release fish from stuck point, OFT offers another form of force to help dramatically increase chances of fish retrieval. Furthermore, the results in Field X shows that utilization of OFT can dramatically reduces duration of fishing operations. Such concept becomes crucial with the fact that retrieval chances that naturally reduces with time.

The mechanism of OFT presents low amplitude, but high frequency oscillation to the fish to complement the high impact forces presented by the fishing jar. The combined energy from the fishing jar and OFT proves beneficial in stuck assembly conditions, with the application in Field X being one successful case.

Considering the successful operation of stuck assembly retrieval in Field X, OFT presents value that should put the tool in consideration to be included in any fishing BHA by default. The increased energy presented by the OFT can substantially reduce non-productive time and ultimately saving the operator cost associated with well recovery.

References

[1] Alali A, Mohanna A, Barton S, Voghell M, Bakir R, Al-Mousa A. 2012. A Step Change in Fishing Efficiency: Recovering Stuck BHA Using The Fishing Agitator Tool. Rio Oil & Gas. doi: IBP2059_12

[2] Voghell M, Mohanna A, Hanley C, Al-Khiriseh C, Al-Mousa A, Al-Amri A. 2013. Downhole Vibration Analysis: Fishing Agitation Tool Efficiency in Stuck Pipe Recovery. SPE/IADC Drilling Conference. doi: SPE-163516-MS

[3] National Oilwell Varco. Agitator Technologies. Retrieved 1 September 2020, from https://www.nov.com/products/agitator-technologies