SPE Thailand Exploration and Production
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Topic **Unconventional Application Pressure Derivative in Pressure test and Sampling in Complex North Malay Basin Reservoirs, Gulf of Thailand**

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Involving Disciplines PTTEP Operations Geology Team/ Corporate team/ Arthit Asset/ Bongkot Asset/ S1 Asset/ Wireline Services Providers

Innovation Feature:

Nowadays, many petroleum fields in the North Malay Basin, Gulf of Thailand have supplied mainly gas and condensate to our country. However, the replacement reservoirs are targeted in more challenging deeper plays; therefore those are low permeability reservoirs, associated with high temperature, and high pressure, mud properties are also easily deteriorated in HTHP environment caused bad hole condition, hence high change to get tool stuck dowhole during ongoing pretest or sampling. Wireline formation data is critical for evaluation and understanding of hydrocarbon bearing in heavily faulted and compartmentalized reservoirs. Resevoir pressure, gradient, and mobility are generally regarded as essential inputs to the reservoir evaluation model. Because of deeper, hotter, and low permeability reservoirs, no stable flowing pressure during pretest, build-up time can be long and confident level of the final pressure is often uncertain, in some cases, invalid results or inconclusive.

The pressure derivative was used flow regime identification on both spherical flow and radial flow during wireline formation testing. Normally, or conventionally derivative pressure developed for well testing and reservoir engineer performed pressure analysis during well test. The derivative pressure was first introduced by Bourdet D., 1951 to improve the analysis of well testing, transient analysis data. PTTEP Operations Geology team thought out of the box and initiated the usage of pressure derivative in realtime to assist operations geology team members to make quicker decision based on spherical and radical flow from pressure regime during ongoing pretest, and currently widely used for both offshore and onshore wireline logging operations. In case of tight reservoirs, realtime derivative pressure will help operation geology team to understand reservoir characteristic and design proper pressure test volume and drawdown rate for spectacular reservoir to obtain valid pretest, It also help to validate pretest faster, especially partially leaked whereas conventional way called it inclusive pretest.

The project has been initiated almost 2 years ago with new WFT (Wireline Formation Tester) arrival which is able to perform pretest and draw down with very small volume, sometime results were inconclusive, therefore those needed to be checked and validated again. We asked reservoir domain champion from Schlumberger come over to work with us on those doubtful result. He had shown us derivative pressure during pretest with software called “InSitu Pro”, how flow regime actually happened around probe during pressure and sampling, some pretest has passed wellbore storage and hence we can be able to call those valid. We can use this software to display realtime derivative pressure at rig site to validate pretest and make decision quicker within few minutes if pressure is tight, dry, supercharge, or partial leak whereas normally or conventionally, pressure test duration is limited 10-15 minutes depend on hole condition and important of the data. First pilot project, rial with one unit in Arthit field, installed software, trained PTTEP Wellsite Geologists, and wireline field engineers how to use this technique, came up with excellent results, great rig time saving, therefore large amount of money saving. This unconventional application also can help minimize WFT down time due to minimal tool/packer exposure to high temperature and high differential pressure in deeper part of the wells, besides that we can also minimize chance of tool/cable getting stuck downhole.

This best practice has been initiated by operations geology team and being applied to offshore fields in North Malay Basin, with great success, later applied in onshore field, also extended to PTTEP international projects. Realtime derivative pressure application unconventionally can save significant rig time from 12-14 hours down to 8-9 hours per well as well as money can be saved about 0.7-1.0 MMUSD per month. With less time of tool stationary during pretest is to minimize chance of tool/cable stuck which may resulted in hours/day of NPT/LT, to fish the tool out of hole which may cost 0.3-0.5 MMUSD. Since project started till now, almost 2 year fully implemented of this application, we can save so far for the company more than 18 MMUSD, and big saving is still accumulating which every well logged in the future.

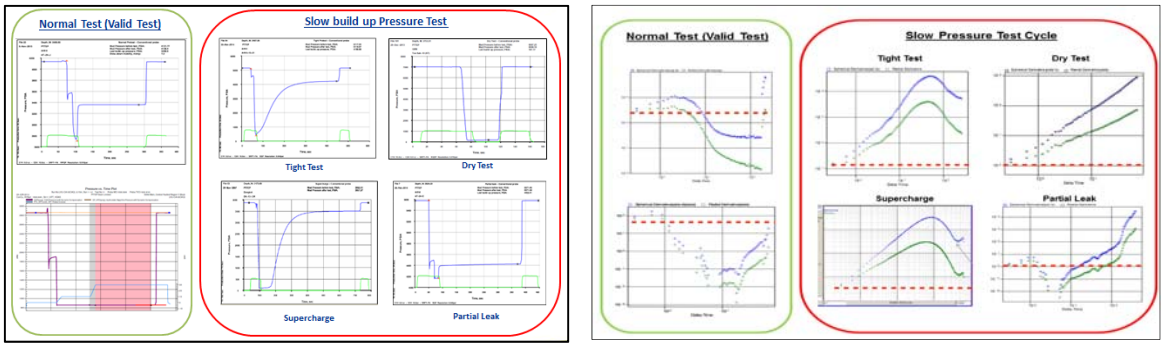

Figure A – (Left) Pressure versus time plot in each type of pressure test in conventional. (Right) Realtime derivative pressure, valid test (normal test) need to pass wellbore storage which the end of pressure derivative point is below the first point (below dash line). In slow build up pressure test, realtime pressure derivative are not pass wellbore storage except partial leak.

Thailand E&P industry impact and values:

Wireline Pressure Test Optimization with Realtime Derivative Pressure

Currently, oil and gas are difficult to discover. The appraisal and exploration wells (AE wells) in Arthit and Bongkot field are targeted at greater depths and high compartmentalization reservoirs which are lower porosity/permeability or tight reservoirs. In addition, those reservoirs are also associated with hotter downhole environments because the portion of North Malay Basin in Gulf of Thailand (GoT) is known to exhibit a high temperature gradient, 5.5-6.5 deg C/100m whereas is double than other basins. Due to targeting in deeper reservoir, AE wells, with most of them drilled deeper than 3000 mTVDSS. Furthemore, AE wells will tend to be deeper in the future to find new deeper play for reservoir replacement; development wells also have given great challenges in wireline logging operaions due to spider well design/scoop the faults, longer reaches, high differential pressure, depletion, small margin of fracture gradient.

According to high temperature exposure, electrical board inside WFT is probably burnt or failed due to long explosure during pretest, especially in tight resevoirs with slow build up pressure. In case of tool failure, it is needed to pull out for change new back up tool which taken at least six hours to pull out and run back in hole to continue operation. In addition, pressure testing in high differential pressure condition, chance of tool and cable stuck is higher during ongoing pretest, especially tight, supercharge, and dry tests. Moreover, several times, packers were leaked due to long pretest in low permeability in high differential pressure zone. In case of packer failed or damaged, wireline pressure test is unable to continue operation and have to pull out tool for packer change as well.

In low permeability reservoirs, the pressure drawdown needs to be optimized by selecting a smaller flow rate and a smaller volume. However, the selected volume needs to be enough to decompress the pretest flowline. Different WFT will have different flowline storage volumes. The higher temperature, WFT was designed with a smaller flowline volume, offering more advantages in lower mobility ranges. In case of not success to get valid pretest, realtime derivative pressure help to design proper pretest volume and drawdown rate based on realime flow regime for higher chance to succeess.

Many wells have been drilled deeper, hotter which create lots of challenges/problems during wireline pressure test. To avoid tool or cable stuck in downhole, realtime derivative pressure can help assist to make quicker decision based on flow regime, especially tight and dry results. Realtime derivative pressure was utilized to minimize tool explosure in high temperature and differential pressure during ongoing pretest. In the conventional methodology, have to wait pressure build up until stable even tight test about 10 or 15 minutes depend on downhole condition. Realtime derivative pressure can help to estimate time of pressure stable based on flow regime plot pass well bore storage. For low mobility reservoirs, tight test was identified within few minute after started pressure test by using derivertive plot, which demonstrate flow regime all both spherical and radial flow are not passed wellbore storage within 10 or 15 minutes by projection or prediction from flow regime plot.

In case of sticky hole condition, HPHT etc., wireline logging tools or cable need to be minimized time exposure to avoid being stuck. Many fishing operation was performed after tool or cable stucked in 2011-2012 about 30 jobs, especially SRFT which was fished more than 50% of all cases. Since 2014, Schlumberger wireline and PTTEP operation geology teams started to apply realtime derivative pressure application during wireline pressure test, together with drilling team also improved drilling mud properties. According to results from realtime derivative pressure application, tools or cable stuck has been significantly decreased since 2014 until now.

With current down turn of oil prices, many companies in oil and gas industry have been struggling to survive by restructure organization, optimize operations, minimize expenditure, Thailand E&P is also not an exception, we have been working hard to survive, any initative to optimize operations by change in work process, new technology deployment to possible maxmimize efficiency are good in anyway to help Thailand E&P to sustain. This unconventional application is one of these; we are willing to share and other operators can use this best practice to optimize wireline operations and possible saving big money and better data

quality for their company, and for Thailand E&P bussiness as a whole.

Benefit Values & Businees Impact

Realtime derivative pressure can help to optimize pressure test and sampling, saving rig time and overall cost. In addition, the unconventional application is potential time saving if problematic pretest can be identified early. The application is applied to minimize pretest tools stationary time which chance of tool and cable stuck is greatly reduced. According to realtime derivative pressure, tools or cable stuck has been significantly decreased since 2014 until now. Prior to applying this technique, many times that packer failures and electronic board burnt due to exposue to HPHT condition, which may take up to 6 hours for one round trip for packer/tool change (cost about 80,000 USD for rig cost and 50,000 USD for electronic board replacement), since the project started until now, have not seen any packer failures due to exposure to high temperature and high differential pressure.

This unconventional application realtime pressure derivative is considered of the best practice implemented to PTTEP, which currently applied to four rigs in offshore and two rigs in onshore that directly saved about 0.7 to 1.0 MMUSD per month as well as 6 to 8 MMUSD per year. Since realtime derivative pressure was applied to PTTEP wireline logging operation, cost for operations and rig time were saved about 18 MMUSD.

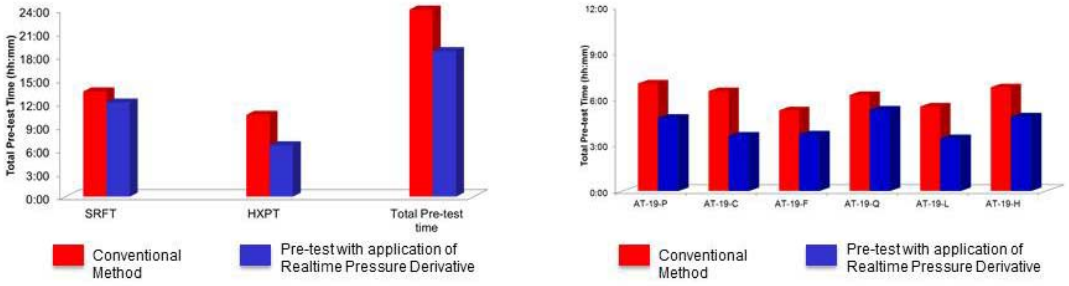

Figure B – (Left) AE well, example, total pressure test time comparison between conventional method and pre-test by using realtime derivative pressure which is saved operation time about 5 hours. (Right) Arthit infill development wells, example, total pressure test time comparison between conventional method and pre-test with realtime derivative pressure which is totally saved operations time about 12 hours.

Why this project should win the award?

Nowadays, oil and gas are rarely discovered, especially in Gulf of Thailand where both AE and development wells are planed to drill deeper and more challenges in HPHT. In order to optimize wireline pressure test operations in HPHT envirionment, we need to sourcing new technology or application which can help to get smooth operations, obtain good reservoir data and save overall cost. Currently, realtime derivative pressure is great technique that has been applied to PTTEP wireline logging operations. Realtime derivative pressure is unconventional application have been initiated and used by PTTEP wireline operations and no any other operators had developed or applied this technique before as larg scale as PTTEP do. This technique is vey practical and workable with any wireline services provider.

Realtime derivative pressure can provid flow regime plot during ongoing pretest which can help to understand reservoir properties in dynamic condition. To make quicker decision based on realtime derivative pressure for canceling dry, tight, or invalid pretest are faster. Pretest volume and drawdown rate for next pretest station are able to be adjusted which is maximize chances to get better data quality for company, especially partial leak. Currently, realtime derivative pressure application can save significant total wireline pressure test time from 12-14 hours down to 8-9 hours of each job. In addition, this application help to minimize the pretest stationary time and hence reduce chance of tool or cable stuck which counted as NPT or lost time. Fishing operations of wireline tool and cable stuck downhole posed very high risk, since apply this best practice, especially HTHP wells, we have not seen any tool and cable stuck, and also packer failed downhole until now.

PTTEP Operation Geology team has fully utlized to apply realtime derivative pressure to wireline pressure test operations. This unconventional application is the best practice implemented to PTTEP which applied to four rigs in offshore for Arthit and Bongkot fields and two rigs in onshore for Sirikit field that saved about 0.7 to 1.0 MMUSD per month as well as 6 to 8 MMUSD per year. Furthermore, this application was shared to PTTEP international where we are operator such as Myanmar and CPOC.
For Thailand sustainable energy, realtime derivative pressure is one of innovative unconventional application to optimize wireline pressure test and sampling operations as well as overall cost saving.

Every step of this project development always comprises of key team mebers from corporate, offshore and onshore assets, drilling team and wireline services providers. According to our hard working, the excellent results are contributed to the company and the value of them could not specify in one page.