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Failure Mechanism and Parameters Impact on Sanding In the Early Miocene Reservoirs at Dai Hung field, Vietnam

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Abstract: Sanding is one of the most serious problems in completion and production for petroleum wells in unconsolidated and weakly consolidated rocks. Sand production can cause wellbore instability, reduced production, damaged equipment, eroded casing and surface facilities, and in extreme cases, loss of wells may also occur. The determination and identification of sand failure mechanism and parameters influencing on sanding is actually necessary and important to predict accurately sanding and rates. This study aims to determine sand failure mechanism and evaluate key parameters impact on sanding at Dai Hung field, Vietnam. Until now, the predicting models of sand production at Dai Hung field still have not been established and evaluated. Therefore, it is very hard to monitor and control the sand production during the exploitation of petroleum wells at Dai Hung field.

Field observation technique was used to study sanding at Dai Hung field. Studied data are taken from the completion and production history of petroleum wells that have been produced in the Early Miocene reservoirs. Results obtained from petroleum wells in the Early Miocene reservoirs at Dai Hung field showed that the impairment of cohesive stress is the major sand failure mechanism. Furthermore, the sand production of petroleum wells in the Early Miocene reservoirs is also depended mainly on parameters such as water cut, gas oil ratio, bean size, etc. These parameters affect sanding at Dai Hung field either separately or simultaneously .By their monitoring and controlling, the production conditions of petroleum wells may predict and prevent more accurately sanding, as well as mitigate and control more effectively the sanding problems at the Early Miocene reservoirs in Dai Hung field, Vietnam.

Keywords: *Sanding, failure mechanism, cohesive stress, production, Dai Hung*

Introduction:

Sand production can be presented in unconsolidated and consolidated rocks. To determine whether or not sanding, we must research two stages of sanding process. Firstly, tensile failure and compressive failure are causes change stress rocks. In case of induced stresses exceed formation in-situ strength, the formation will be demolished and sand will be detached from failure rocks. Second stage is the penetration of production flow into wellbore and transportation free grains up to surface [6].

Sand production may lead to wellbore instability, reduced production, damaged equipment, eroded casing and surface facilities. So expenditures of work-over increase, long term shut-in for maintain and loss of wells also may occur [1]. Sand production can be classified to three assortments: transient sand production, continuous sanding during oil and gas production, and catastrophic sanding due to cannot control reservoir fluids [7]. For the last sanding assortment, the permanent well closing obviously is required for safety production. The other assortments sanding can be controlled by work-over methods. Expenditures to hire the submersible rig for sub-sea wells and slickline for surface well are so expensive, especially during the time which price oil has been strongly declined. Hence, the assessment of influence parameters on sanding will be the experimental approach to control sand produced, which is especially suitable with production wells without sand control equipment[6].

Dai Hung field has produced over 20 years without sand produced. However, currently it is facing sanding problem in production sub-sea wells. Now reservoir pressures of almost wells at Dai Hung field are lower than the saturated pressure. Until now, this field still has not had the predicting model of sanding to evaluate sand produced. The detection sand produced in produced fluids is carried out by laboratory measurements and field test results. In addition, the expenditures of work-over for subsea wells are so costly. Subsea wells at Dai Hung field also do not have high oil recovery factor due to their long production lifetime. Therefore, the study of failure mechanism and the assessment of parameters impact on sand production are really important. They may allow to optimum the oil amount produced without sanding and guarantee safety production. Field observation technique was used to study sanding at Dai Hung field. Studied data are taken from the completion and production history of subsea wells that have been produced in the Early Miocene reservoirs. Adjusting production parameters to monitor sanding is the corresponding method for subsea wells at Dai Hung field.

Dai Hung field:
Dai Hung field is located at Block 05.1a at North-West of Nam Con Son basin within South-East continental shelf, Viet Nam, 250km far from the coastline of Vung Tau, and situated in the average water depth of 110m. Dai Hung field has operated by PVEP since 2003. The field production facilities include: Floating production unit Dai Hung 01(FPU-DH01), mid depth buoys, calm buoys, flowlines of subsea wells, Wellhead access platform Dai Hung 02 (WHP-DH02), and two 6 inches export flowlines which transport crude oil from FPU-DH01 to FSO (Floating storage offloading). (Figure 1)

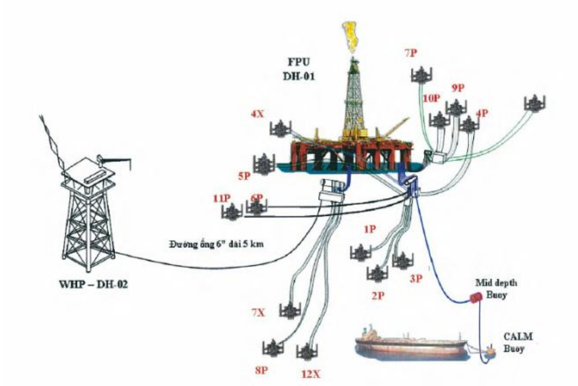

Figure 1: Distribution of facilities at Dai Hung field

Dai Hung field is also divided four production regions with different geological and hydrodynamic characters: Early production system (EPS), Center system, Southern system, and Eastern carbonate system (Figure 2) [8]. Commercial crude oils only present in Miocene. Results of DST show that commercial crude oils do not exist in basement rock formations [9].

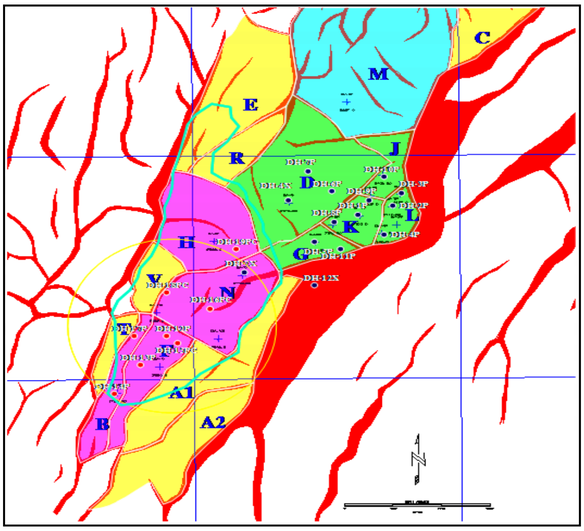

Figure 2: Production regions of Dai Hung field

Dai Hung field commenced first oil in 1994 by BHP with facilities comprising FPU-DH01 and subsea wells located far from the FPU-DH01. In 2007, Dai Hung field also had ten production subsea wells and one injection subsea well when PVEP commenced operation. Production history of Dai Hung field had not appeared sand production until PVEP operated. For this reason, PVEP did not set up sand control equipment for production wells in the Dai Hung field extended project. Eight dry wells were completed in 2011 and four dry wells were completed in 2013 which was single completion, did not have sand control equipment.

Dai Hung field has produced over 20 years, therefore the different production technology were used. Old wells including 1P, 2P, 3P, 4X, 5P wells located in EPS apply subsea production well with vertical Christmas trees. New wells include 6P, 7X, 8P, 9P, 10PST, 12X wells with horizontal Christmas trees. Twelve dry wells in the Southern system with Christmas trees located in the wellhead access platform WHP-DH02 [9]. All wells in the Dai Hung field have used natural energy. Dry wells can be changed to gas lift production in case of pressure reservoir decline lower than saturated pressure. This research only concerns with wells that produce in the clastic of Early Miocene, Dai Hung field.

Analysis of failure mechanism and causes on sanding at Dai Hung field

Production wells in Dai Hung field had not presented sand until sanding appeared in subsea well 3P and dry wells 14P, 18P. General feature of all wells in the Dai Hung field is single completion with the different pressure reservoirs [9]. Cross-flow phenomena have occurred between produced reservoirs. Therefore, it is very hard to control when anomalies appear in the production well. Production history of 3P well showed that this well was drowned early. Results of PLT indicated that water from carbonate reservoir penetrated into sandstone reservoir [8]. For this reason, water cut of 3P well increased to 30 % after two producing years. This phenomenon also happened for 14P and 18P wells after a half year first oil. So, this cross-flow phenomenon is responsible for formation instability originating of sanding.

Increasing water cut in the reservoir leads to instability of formation, reduces the capillary force and bonds between grains. Moreover, penetrating water also dissolves cement materials to decrease the formation strength, especially for the sedimentary formations. Due to water flooding during 20 producing years, the formation around perforation hole of 3P well becomes weak. Consequently the cohesion strength declined and free grains were detached from rocks. Finally, the beginning of sand production appears in the 3P well. Therefore, the formation with non or weak cohesion is also responsible for sand production.

The 3P well is located in the block L together with the 2P injection well. During first years carrying out injection, the gross flow of 3P well was stable at the high rate, proved that the 3P well was easy to flood.

After the phenomenon of water tongue appeared in the 3P well, the capacity of 3P well quickly declined. In addition, the sea water injection systems in Dai Hung field have not frequently operated for many recent years. So, produced reservoirs also have not provided the supplementary energy. Instability of 3P well formation was originated from lack of supplying injection energy. This is also responsible for sanding with the high rate.

Nowadays, many scientists proposed some failure mechanisms to interpret sand produced cause in the petroleum industry. Surface failure, tensile failure, shear failure, etc…are elucidated like the cause of sand production [2]. To determine failure mechanism it is required to need a large account of information about logging documents. However, for subsea wells in Dai Hung field recent results from PLT measurements are rather limited. Therefore, the research shows failure mechanism from evaluating surface factors.

Consolidated or unconsolidated formations also have strength to build stable arches and resist the drag force of flowing fluid. Water breakthrough into a well changes the water saturation of rocks near the well, reduces the capillary force and the strength of sand reservoirs. When the total stress exceeds the strength of rocks near wellbore and water breakthrough release sand in cavities, sanding will occur. The common point of sand produced in wells is high water cut before the sanding onset. From the effect of water breakthrough to the rock formation, especially for sand reservoirs, the research shows that the depletion of rock cohesive is mainly cause to sand production.

Parameters impact on sanding at Dai Hung field:

PVT values of subsea wells in the Dai Hung field are monitored from parameters at the surface of platform. Due to high expenditures and difficulties to carry out PLT (production logging tools) for subsea wells, the downhole pressure monitoring as well as the evaluation of the depleted reservoir pressure may be not periodic. Commonly, production wells need to carry out PLT measurements with a period of six months to assess exactly the state of production well. However, the last PLT results for subsea wells at Dai Hung field were carried out since 1997. The downhole pressure transmitters for subsea wells also were broken. Expenditures of the work-over for subsea wells are costly due to hiring submersible rigs. Therefore, to monitor and assess the state of subsea wells at Dai Hung field the surface parameters, including flow under choke pressure (FUCP), annulus pressure, shut-in pressure were used. These parameters also depend on separator working pressure and bean size. When there have any changes of separator working pressure and bean size, FUCP and annulus pressure will be variable. If working pressure of separator increases, FUCP and annulus pressure will be increased. On the contrary, if bean size decreases then these two parameters will be also increased. For this reason, Dai Hung field controlled sand production by the adjustment of separator working pressure and bean size. The results from the chart (figure 3) showed that when bean size is less than 20.0 mm and separator working pressure is 1,100 KPa then sanding was absolutely controlled in the 3P well at Dai Hung field.

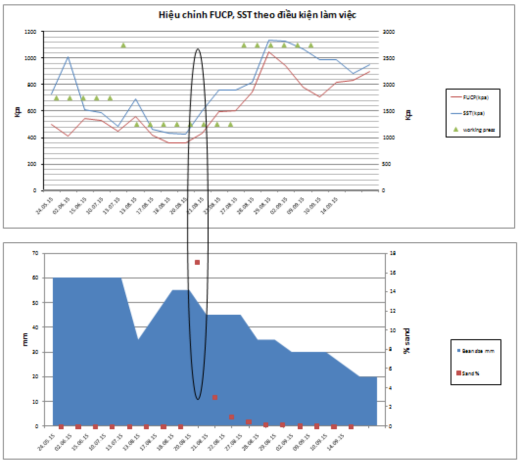

Figure 3: Effect of bean size and working pressure in the 3P well, Dai Hung field.

Another parameter to monitor and assess the situation of subsea production wells is the shut-in pressure. The determination of shut-in pressure is carried out by closing choke size, opening subsea and downhole safety valves and keeping a close watch on the FUCP increase steadily until a stable value. In case of the flow in tubing is static, the downhole pressure will be the total of shut-in pressure and hydrostatic column pressure. If the subsea well has a lower shut-in pressure, the drawdown pressure will also get high values. Increasing drawdown pressure around perforations causes formation instability. Figure 4 indicated that decreasing of shut-in pressure followed by many years. Shut-in pressure had got the lowest before sand production appeared. When sand production was controlled in the 3P well, shut-in pressure value slightly increased.

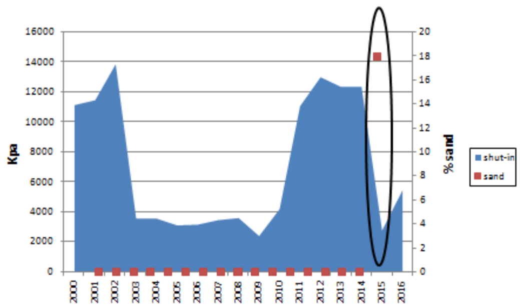

Figure 4: Effect of shut-in pressure on sanding

Gas oil ratio (GOR) is also an important parameter to assess whether or not sanding in the fluid flows. Current reservoir pressures of subsea wells at Dai Hung field are lower than the bubble point pressure, so a large amount of secondary gas exists in reservoirs. High gas rates may cause the tensile stress in reservoirs, leading to sand production. The figure 5 showed that sand produced in the 3P well did not present when reducing produced gas rate. Oil rate also relates with transportation of sand to surface. Quantity of produced sand strongly decreases to zero when gas rate declines. Thus, decreasing gas rate may bring about declining GOR, cut down sand produced to approximately zero.

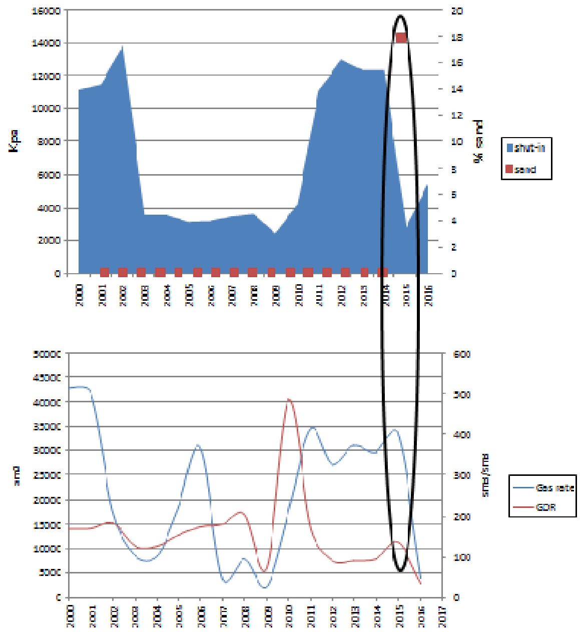

Figure 5: Effect of gas rate and GOR

Several production wells at Dai Hung field were early flooded due to cross-flow phenomenon between different gradient pressures. In case of any reservoir flooded, water cut will not control in the well. Most of wells in the EPS of Dai Hung field have high water cut around 40-70%. Exploitation with high water cut during the long period caused to dissolve cement materials, erode rock formations, bringing about sanding. Nevertheless, the influence of water cut to sand production is not clear. It did not directly impact to amount of sand production. When sanding commenced in the reservoir, the water-cut varied around 70%. However, when the sand produced was controlled, water cut only altered around 60%. So, although the relation between water cut and sanding is not rather clear for production wells at Dai Hung field, the water cut controlling for production wells has been still important because high values of water cut will reduce the strength of formation rocks.

In summary, main parameters impact on sanding for subsea wells in the Early Miocene reservoirs at Dai Hung field are bean size, separator working pressure, gas rate and gas oil ratio GOR, and shut-in pressure. The other surface parameters consisting of flow under choke pressure (FUCP), annulus pressure only depend on well working factors such as bean size, separator working pressure. They do not nearly impact on whether or not sand production in the fluid flows. The high values of water cut also do not nearly affect to the volume of sand produced but high water cut may cause the formation instability.

Besides the subsea production technology, Dai Hung field utilized another petroleum production technology with 12 dry Christmas trees on the wellhead platform WHP-DH02. The monitoring PVT parameters and the work-over for production wells with dry Christmas trees can be performed easily and their expenditures are cheaper than wells with subsea Christmas trees. Using slick-line technology to fix internal equipment of well and carrying out PLT measurements are cheaper than hiring submersible rigs. Regarding to production wells with dry Christmas trees, only production wells of 14P and 18P appeared sand produced. The 14P well has characters similar to the 3P subsea well. It also was produced in the Early Miocene reservoirs with the single completion technology and one production tubing. Although the 18P well was similar to the wells of 3P and 14P with their products from the Early Miocene reservoirs and single completion technology, it also has got another produced fluid from carbonate reservoirs.

Figures 6 and 7 showed that downhole pressure of the 14P well strongly declined at the onset of sanding. This demonstrated that anomalous changes of stresses around the bottom hole and perforation areas occurred. Furthermore, gas rate measured at the onset of sanding also increased highly. This proved that the amount of unusual gas has presented in the reservoir. High gas rate causes increasing the tensile stress around the perforation areas, leading to sand produced.

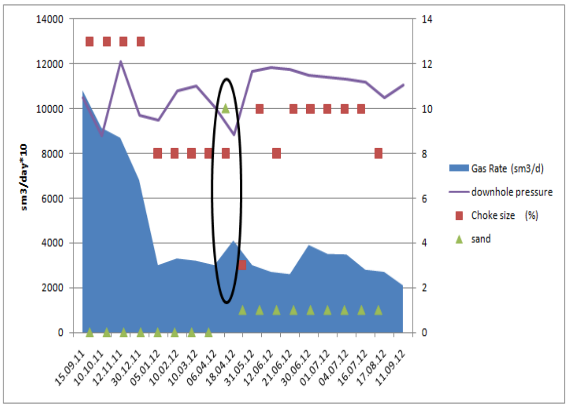

Figure 6: Effect of down-hole pressure and gas rate in the 14P well

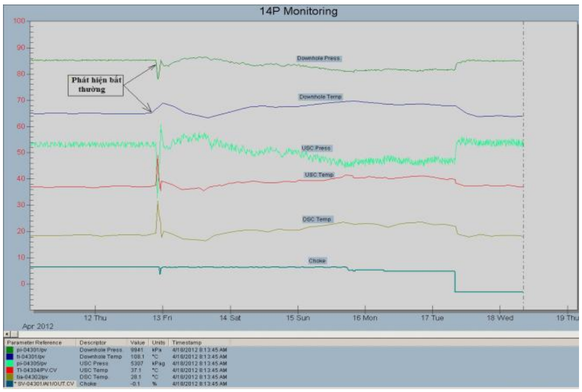

Figure 7: Monitoring parameters at the sanding onset in the 14P well

Most of wells in the wellhead platform WHP-DH02 also have been produced at the conditions with suitable separator working pressure and bean size from the beginning time of production. Therefore, separator working pressure did not obviously affect to extraordinary sand production. The water cut values of the 14P well varied from 3% to 14 % after one year commenced production. This proved that water cut also did not impact to amount of sand production.

Conclusion:

The results obtaining from analysis of production and completion history for production wells in the Early Miocene sedimentary reservoirs have proposed failure mechanism and major influencing parameters on sanding at Dai Hung field, offshore Vietnam.

Single completion with one production tubing for different produced reservoirs may bring about cross-flow phenomenon. The increasing water cut value may lead to dissolve cement materials, decline capillary pressure. Flow rates of injected water were unstable during the exploitation, so the reservoir energy was not supplied timely. All factors are origin of declining the rock cohesion, which is main failure mechanism.

Bean size, separator working pressure, gas and oil rate, and downhole pressure are main parameters impact on sand production at Dai Hung field. Water cut values do not influence to sand produced but may lead to decrease the cohesion of formation rocks.

The production zones at Dai Hung field do not relate about hydrodynamic aspects but they have the similarity in geology features. Therefore, the sanding prediction for production wells, which have not still existed sand produced, can be based on data obtained from production wells that appeared sanding. Especially, the main parameters affecting to sand produced should be paid attention to adjust corresponding production regulations.

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