IATMI22-046

Sand erosion detection by In-service Ultrasonic Testing to prevent hydrocarbon leak at wellhead choke valve in Handil Field – Pertamina Hulu Mahakam

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Abstract. Handil field is a mature oil field located in the Mahakam delta that has been in production since 1975. Following its natural decline, sand production management is a challenge that cannot be avoided to sustain the Handil field oil and gas production.

About 65% of Handil field production comes from a high-risk sand production well category. As part of the sand production monitoring strategy, the choke valve verification program is carried out regularly to identify the erosion due to sand which may lead to hydrocarbon leaks. However, this approach has a few limitations and requires a well shut down.

This paper discusses a new method to detect sand erosion at the choke valve by using an In-service Ultrasonic test (UT) implemented in the Handil field. In-service choke inspection by Ultrasonic Testing (so-called iCIUT) is an innovation implemented to avoid hydrocarbon leaks due to sand erosion by early detection of the erosion sign and potential escalation at the internal part of the wellhead choke without production losses impact.

A new methodology to improve the existing manual choke verification is introduced in 2019. This method promotes the utilization of ultrasonic testing to resolve the limitations to identifying erosion of the inaccessible internal part of the choke valve. The ability to conduct in-service inspection provides a valuable benefit to avoid the need to shut down the well and production losses during the operation.

This innovation has successfully identified a defect at the wellhead choke valve in more than 40 wells in the Handil field since 2019. It's been proven capable of detecting erosion at the wellhead choke valve in advance, so hydrocarbon leaks can be prevented. The iCIUT method demonstrates advantages as follows:

- Provides simple operation without the requirement for unit dismantling and a lifting equipment.
- No production losses during the operation.
- Estimate choke valve service life and replacement time.

This iCIUT method opens an opportunity and low-cost operation to optimize production from shallow zone when a limited option is available for sand control installation or high-cost sand-resistant materials. On the other hand, it improves well operational efficiency and HSE wise.

Keyword(s):
Sand Production, Production Optimization; Shortfall; Sand Management; In-service inspection; Ultrasonic Test

1 Introduction

HANDIL oil field is located in the MAHAKAM delta (swamp area). Its size is approximately 10 km x 4 km. The reservoirs are deltaic multilayer sand reservoirs. There are more than 330 reservoirs – 250 blocks. Hydrocarbon layers are located within 230 m to 3,500 m depth.

Having produced for more than 40 years, presently, about 20% of total well strings completed are still in operation, which consists of 104 live oil producer wells (mainly gas lifted), seven water producer wells (dedicated to producing water for water injection) and 14 water injector wells.

Despite the natural decline and ageing production facilities, the potential of Handil Field is maintained through strategy, innovations and operational excellence to tackle field depletion.

2. Sand Production Challenges

The Handil field has been in production since 1975. Following its natural decline, sand production management is a challenge that cannot be avoided to sustain the Handil field oil and gas production. Hence, the policy of "living with sand" has been established with sand production permitted at an acceptable sand rate with minimum impact to the surface equipment, the so-called Maximum Allowable Sand Rate (MASR). At present, about 65% of Handil field production comes from a high-risk sand production well category.

Sand production is a significant challenge for sustaining oil field production safely and with minimum impact to the reservoir, well downhole equipment and surface facilities impairment. The possible result of sand production may lead to sand control damage, excessive erosion and thinning of the production lines, and solid depositions, which could lead to uncontrolled hydrocarbon releases with severe consequences.

2.1 Handil Sand Management

Sand management implementation in Handil Field is carried out to maintain oil and gas production safely. An adequate surface facility is one of the key factors for sand management implementations. Material selection, design, safety equipment and monitoring means the mitigation action as well as sand management guidelines to be put in place prior to the decision to manage sand production.

There are a few main activities and mitigation in place as company sand management policy such as: downhole sand control, sand free rate policy, periodic acoustic sand monitoring, sand verification by hydro-cyclone, downhole sand consolidation, sand probe erosion monitoring, erosion monitoring by choke verification.

2.2 Surface sand monitoring system

Following the implementation of Pertamina Hulu Mahakam Sand Management Policy, a surface monitoring system is carried out in the Handil field with the objective to detection and quantification of sand production, early detection of down-hole sand control failure and to the anticipation of erosion damage due to sand production. As this system is implemented, action can be taken to avoid the escalation impact of sand erosion leading to hydrocarbon leaks. This monitoring system consists of four main categories:

1. Sand rate monitoring and quantification by Acoustic Sand Detection (ASD)
   As the Handil field is located in a swamp area and wells location spread at 65 clusters, a portable ASD measurement was selected to cover sand rate monitoring periodically.
2. Thinning rate monitoring
   Manual Ultrasonic inspection at well flow lines with focusing on critical location with consideration to the flow dynamic effects (reducer, elbow, tee etc.).
3. Visual Choke inspection
   A choke inspection (so-called "check choke") is carried out to verify degradation of the wellhead choke valve condition as this part is suffering the highest velocity in the surface production system.
4. Manual sampling
   Quick verification of sand production evidence and the first level of grain size analysis without interruption to production and can be done anytime.

2.3 Sand erosion at choke valve

As part of the monitoring sand production, the choke valve verification program is carried out regularly to identify the erosion due to sand which may lead to hydrocarbon leaks. This method may confirm any indication of erosion and thinning area by direct observation. However, its required to shut down the well and dismantling part of the choke to allow access for inspection. Hence the frequency of choke verification will impact production losses.

Lesson learned from previous hydrocarbon leaks incident (Figure 1), it's concluded that leaks that occurred at the wellhead choke valve are caused by erosion due to the sand jetting effect at a location which cannot be accessed by manual choke verification and by visual check of the choke condition. On the other hand, the sand probe installed downstream choke at the flow line failed to detect previous sand production.

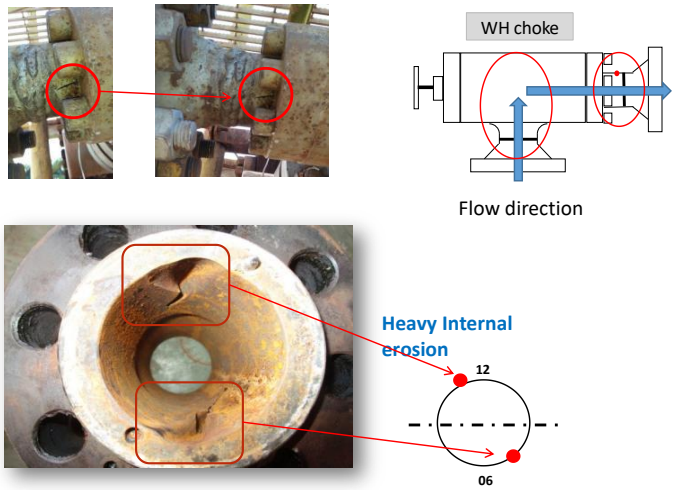

Figure 1 Wellhead choke leak due to sand erosion (jetting effect, 2018)

3. Utilization of UT inspection for sand erosion detection

Initially, UT inspection for choke valve is performed as a complimentary assessment of choke condition after dismantling following sand production event. A new methodology to improve the existing manual choke verification was introduced in Handil field in 2019. This method promotes the utilization of ultrasonic testing to resolve the limitations identifying erosion of the inaccessible internal part of the choke valve.

Basic Principles of Ultrasonic Testing (UT) uses high-frequency sound energy to conduct examinations and make measurements. When there is a discontinuity (such as a crack, corrosion or differences of material) in the wave path, part of the energy will be reflected back from the flawed surface. The principle of Ultrasonic Testing is illustrated in Figure 2. One of the main advantages of using ultrasonic in place of radiography is a decrease in the cost of and an increase in the speed of inspection (J.D Lavender, 2014).

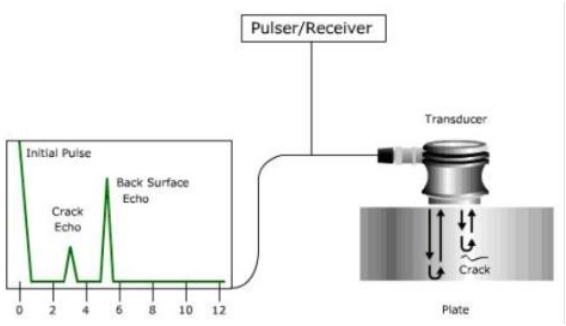

Figure 2 Principe of Ultrasonic Testing (S Esther Florence et al, 2018)

The ability to conduct in-service inspection provides a valuable benefit to avoiding the need to shut down the well and avoid production losses during the operation.

The In-service Choke Inspection by UT (so-called iCIUT) approach focuses on five working principles.

1. Application of Ultrasonic Testing (UT) technology. UT uses high-frequency sound waves to conduct examinations and make the measurement. The sound energy is introduced and propagated through the materials in the form of waves. When there is a discontinuity in the wave path, part of the energy will be reflected back from the flawed surface (Mix. P.E, 2005).
2. Measurement focused on the downstream part of the wellhead choke valve, which is the area impacted by the jetting effect.
3. The main objective is to identify thickness differences and/or changes due to jetting effect.
4. Evaluation of thinning rate and evolution
5. Main steps: Identification of sand risk well, thickness/flaw measurement, thinning rate evaluation, and choke valve serviceability or replacement recommendation

The iCIUT methodology described in the flow diagram shown in Figure 3 below:

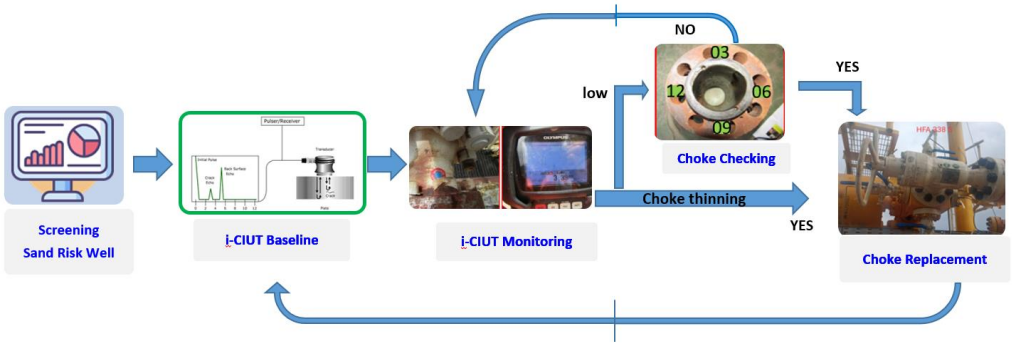

Figure 3 Simplified schematic of in-service choke inspection by UT

4. Result and Analysis

The in-service choke inspection method (iCIUT) has been successfully identifying a defect at the wellhead choke valve in more than 40 wells in the Handil field since 2019. It's been proven capable of detecting erosion at the wellhead choke valve in advance, so hydrocarbon leaks can be prevented. The ability to conduct in-service inspection provides a valuable benefit to avoiding the need to shut down the well and avoid production losses during the operation.

Following iCIUT implementation, it may reduce the number of visual choke inspection activities up to 35%, with estimated 4,425 bbls of oil production shortfall avoided annually. From 2019 to 2021, at least 5 sample cases of severe choke erosions were identified, and hydrocarbon leaks can be avoided. After iCIUT identified severe thinning, the choke valve was dismantled and replaced. Further investigation was conducted at the workshop by choke part teardown or *borescope* camera, confirming the consistent location of the eroded spot. Figure 4 shows one of sample case of severe choke erosion detected by iCIUT method: UT scan (left), marked thinning spot (middle), inspection after choke dismantled at the workshop (right). As the first approach, choke replacement will be considered when the thinning reaches 50% from the baseline. In some cases, choke replacement can be extended if the thinning rate relatively consistent and minimum choke adjustment.

Figure 4 Sample case of severe choke erosion detected by iCIUT (minimum thickness at 30% from baseline)

However, iCIUT method also has limitations for some choke designs i.e. limited access due to bolt position and difficulties in detecting anomalies at the slanted section of the choke.
Due to the limitation of UT tool availability compared to the number of well, this iCIUT method currently will only partially replace the visual choke inspection method in Handil Field. iCIUT prioritized for critical and high sand risk well categories with bi-weekly and monthly schedules, respectively.

5. Conclusion

In-service choke inspection (iCIUT) was successfully implemented in Handil field and has been proven capable to detect erosion at the wellhead choke valve in advance, so hydrocarbon leaks can be prevented. i-CIUT demonstrates advantages as follows:

- Provides simple operation without the requirement for unit dismantling and a lifting equipment
- No production losses during the operation.
- Estimate choke valve service life and/or replacement time

This iCIUT method opens an opportunity and low-cost operation to optimize production from shallow zone when limited option is available for sand control installation or high-cost sand-resistant materials. On the other hand, it improves well operational efficiency and HSE wise.

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Acknowledgments

The authors gratefully acknowledge permission from SKK MIGAS, and PERTAMINA HULU MAHAKAM to publish this paper. Our profound gratitude is also given to Production Operations Division, Operation and Surface Facilities, Production team Handil CPA site, Inspection team, for full support during the preparation of this paper.