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Flow Rate Control In Multilayer Injection Using Bridge Eccentric Injection Mandrel

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FLOW RATE CONTROL IN MULTILAYER INJECTION USING BRIDGE ECCENTRIC INJECTION MANDREL

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Abstract

Multilayer injection will increase oil recovery greater than single-layer injection in Water Flood Project. To inject water into many layer are able performed with a single layer completion but it requires a lot of injection well. In the other side, multilayer injection without flow separation has been proven ineffective because of permeability and reservoir pressure. Now, completion system to separate layer can be applied by using multi stage packer, it must be supported flow rate control system as base concept of injection program.

Bridge Eccentric Injection Mandrel has a configuration that provides controller of flow rate at each injection layers. There is Side Pocket Mandrel for placing nozzle that very useful to install Hydraulic Packer and to adjust flowrate accordance with injection target. This technology provides a method to prove the packer has been set and sealed by using Double Memory Pressure Gauge placed in Side Pocket Mandrel. Inside body of Bridge Eccentric Injection Mandrel has a special groove for guide Running & Pulling Tool when perform nozzle adjustment job.

Bridge Eccentric Injection Mandrel gives high accuracy reservoir data for each layer due to proven each packer has been set and seal flow connection between the layers. This technology have a system of separation and flow rate control. It have simple installation system for well completion. Replacement nozzle to regulate flow rate can be conducted using a slick line unit and rig less thereby reducing operational cost.

Implementation this flow rate control technology is able for multilayer injection in every oil field. Monitoring and surveillance for data update can be obtained any time with low operational cost.

Keywords: Multilayer, Water Flood, Packer, Nozzle

1. Introduction

Water Flood is a reliable strategy of increasing oil production which injection fluid sweep oil from injection wells toward production wells while maintain reservoir pressure to get optimum production performance. For economic reason and operating excellent, multilayer injection is applied due to obtain greater oil recovery.

Water Flood is formed as an injection pattern that adapts the productive reservoir and available well in a field. The particular pattern shape and availability of the well encourage efforts to develop an optimum system of well completion at each injection well. In multilayer, injection flow distribution for each layer just depends on permeability and reservoir pressure. This injection system has debility in term of flow rate control and separated injection. It always provide inaccuracy for injection performance determination and reservoir simulation inject.

That factors may be overcame by completion systems that effective and economical using

Bridge Eccentric Injection mandrel. This technology was invented and developed at Daqing Oil Field Limited Company. In one injection well, separated injection and flow rate control can be implemented in multilayer injection and provide high accuracy reservoir data. The other advantage is easy surveillance and operating rig less for saving operational costs. Illustrations of the difference in commingle injection and the separation of the multilayer injection flow rate is shown in Figure 1.

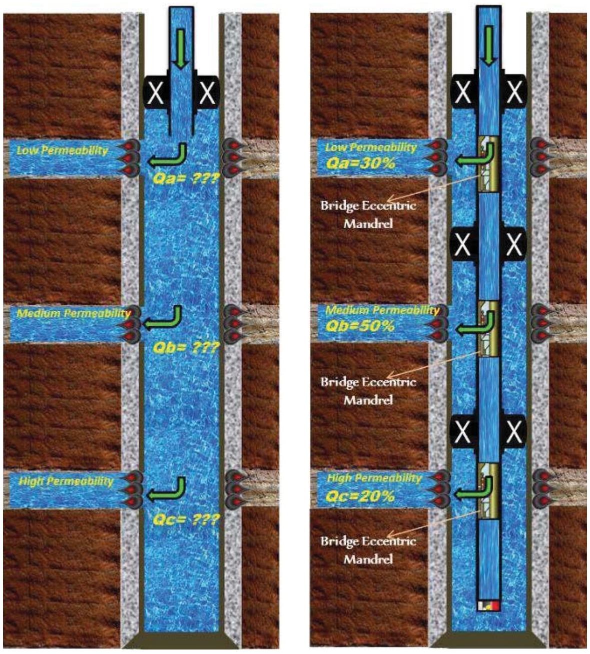

Figure 1 Multilayer Injection Comparison

2. Reservoir Data

Pilot project of separated injection using Bridge Eccentric Injection Mandrel is applied to three wells on Kenali Asam Field. Injection layer targets are layers B, F and P. Reservoir characteristics are sand stone lithology and have different permeability and pressure. Reservoir study show that B and P layers have a permeability of 100-110 mD with an average reservoir pressure of 700 psi and 880 psi. The F layer has a smaller permeability of about 80-90 mD with an average reservoir pressure of 925 psi. F layer is indicated as a strict zone based the results of injectivity test. Injection targets are 500 BWIPD for layer B and layer F, and 300 BWIPD for layer P. This injection flows are able to be splitted using Bridge Eccentric Injection Mandrel.

3. Completion System

Completion system of separated multilayer injection has two main part system. Packer has hydraulic system and Bridge Eccentric Injection Mandrel which simplify on packer installation, verify packers sealing, as flow rate controlling and provide high accuracy surveillance data.

4. Tools

Bridge Eccentric Injection Mandrel may installed in multistage system. Each injection mandrel corresponds to a specific layer and has water nozzles in Blanking Plug that can be adjusted to control injection flow rate. Mandrel has 1,811 inch main hole as injection streamline. There are five Eccentric Bridge Channel paths act as fluid path to lower layer while surveillance equipment exist in main hole and aims to prevent changes in flow contribution of each layer.

Bridge Eccentric Injection Mandrel has a special groove to facilitate nozzle replacement procedure. This special plot acts as a guide for Running & Pulling Tool to be able to jar in and jar out Blanking Plug easily. Bridge Eccentric Mandrel configuration is shown in Figure 2.

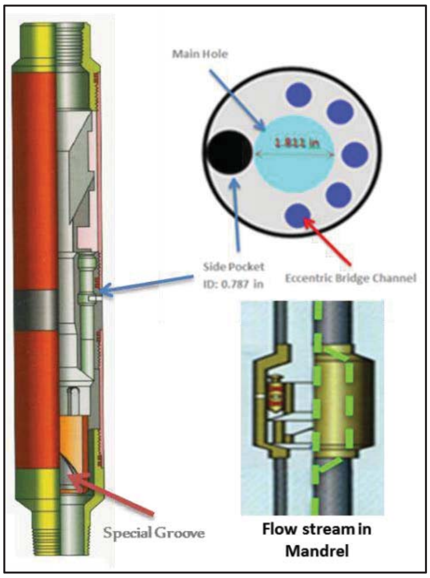

Figure 2. Bridge Eccentric Injection Mandrel

4.1 Blanking Plug

Blanking Plug has Fishing Bolt and a Pressing Hat on the top that is connected directly to Jar Head of Running & Pulling Tool circuit. These serve to seat in and seat out Blanking Plug. Fishing bolt is useful for locking the tool when it is inside of side pocket mandrel. In seating out procedure, Pressing Hat is lifted and Fishing Bolt is open to release Blanking Plug from side pocket mandrel.

4.2 Ceramic Nozzle

Blanking Plug placed by ceramic water nozzle that can be pulled out from side pocket of Bridge Eccentric Mandrel and run in to, through Running and Pulling Tool. Water nozzle is as valve to control water injection. This object has a specific diameter (2 mm - 12 mm) that can be replaced in accordance with the desired flow rate. With ceramic material, the nozzle will be resistant to abrasion and corrosion because of injection fluid. Both unit of Blanking Plug and Nozzle is shown in Figure 3.

Figure 3. Blanking Plug and Nozzle (Valve)

4.3 Double Memory Pressure Gauge

This device has the same structure and installation procedure as Blanking Plug. However, there is a memory recorder to record data from two sides (double recording). When this tool are in Side Pocket Mandrel, top side point will record annulus pressure and bottom side will record tubing pressure. This data separation can be occured because there is a rubber to prevent tubing flow into Side Pocket Mandrel. The memory recorder serves to confirm setting and sealing of packer.

Figure 4. Double Memory Pressure Gauge

4.4 Hydraulic Packer

Type of Packer is hydraulic compression Packer, released by pulling straight of tubing string. It is applied in water injection well with different Inner Diameter casing pipe and used to protect casing pipe. This packer does not have a grip so pulling force is only to release the rubber kit from casing.

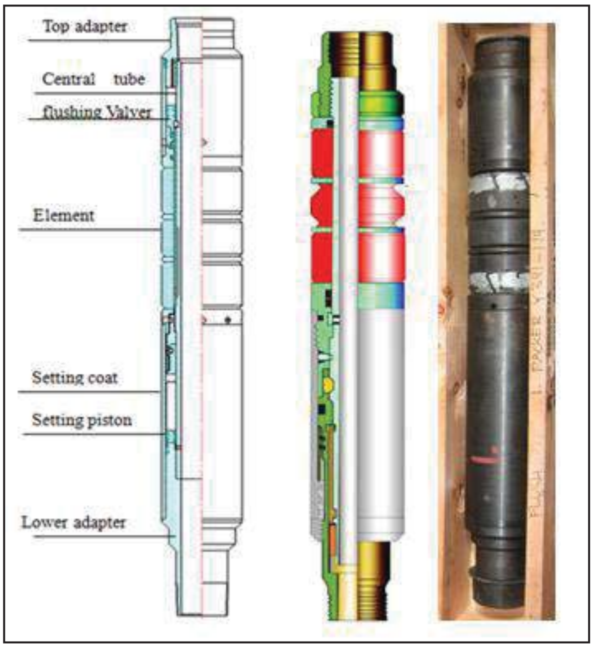

Figure 5. Hydraulic Packer

4.5 Running & Pulling Tool

Running & Pulling Tool serves to jar in and jar out Blanking Plug from Side Pocket Mandrel. It has two Flexi hand and is open when Running and Pulling Tool is pulled from bottom pass the mandrel. Top Flexy Hand is connected to Jar Head that has two different shapes for Jar In and Jar out Blanking Plug. Delivery Head is used to hold and hang Blanking Plug when jar in. Fishing Head of Jar Head counter serves to jar out on the Pressing Hat so that Fishing Bolt can open and release Blanking Plug from Side

Pocket Mandrel. At the bottom of the Running & Pulling Tool, there is other flexi hand. Wheel Guide is used as a guide Jar Head go into the Pocket Mandrel Side following special groove inside body of Bridge Eccentric Injection Mandrel. Illustrations of Running and Pulling Tool assembly is shown in Figure 6.

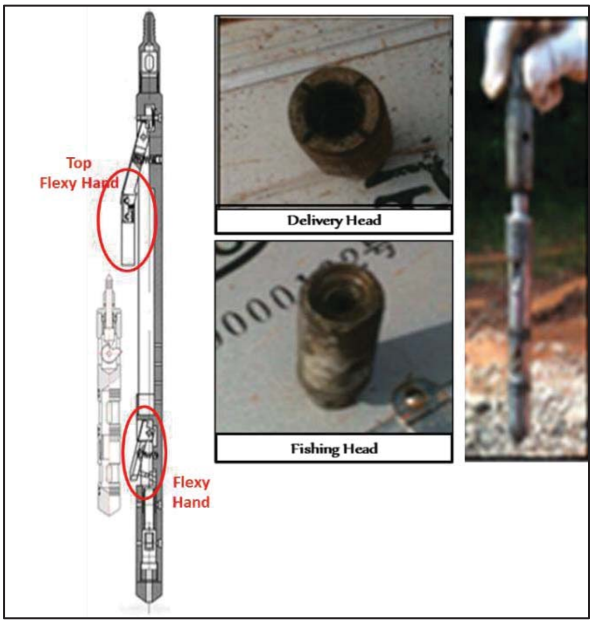

Figure 6. Running and Pulling Tool

4.6 Electromagnetic Flowmeter

Principle of this tool is the electromagnetic induction generated by the voltage difference due to the fluid flow rate of the injection. When the conductive liquid through the electromagnetic flow meter, as long as the measured induced voltage to be directly proportional to flow rate, and convert the flow. Electromagnetic Flowmeter take and store water injection flow rate date of each spot in downhole. Inspired by current instrument field, the special electrodes have been the signal after low noise amplifier plastic, voltage - frequency transform, handled by MPU into data stored in memory, after the measure, through a serial port playback measurement data to the computer, the specialized software processing and output statements.

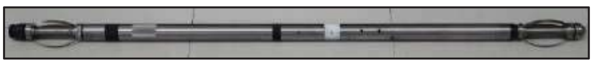

Figure 7. Electromagnetic Flowmeter

5. Completion Job and Surveillance Job

Number of Hydraulic Packer and Bridge Eccentric Injection Mandrel depend on productive layer in Water Flood Project. As multistage system, Bridge Eccentric Injection Mandrel used can be reach 7 mandrel. When packer installation, Blanking Plug filled with Blind Nozzle and bottom of string mounted ball seat so pressurized can be conducted. Well completion configuration is shown in Figure 8.

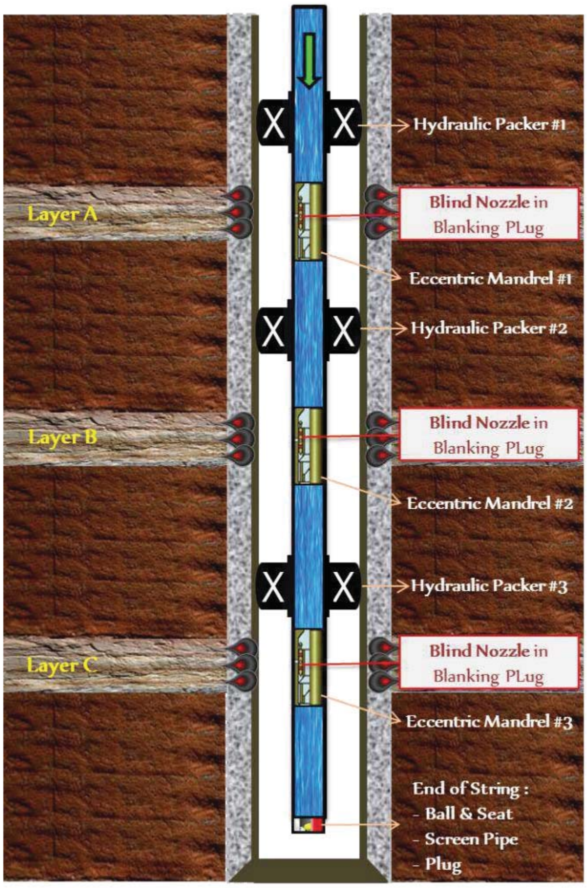

Figure 8. Well Completion Schematic

Running & Pulling Tool is assembled and lowered using Slickline Unit. Blind nozzles attached to each Side Pocket Mandrel should be replaced with a certain nozzle size. Replacement of Blanking Plug has a simple procedure (Illustration Running & Pulling Tool in Figure 9). Flexi hand from Jar Head and Wheel Guide will open when the tool is pulled upwards pass the mandrel. Then the tool is lowered to the mandrel. Jar Head automatically enters Side Pocket Mandrel by way of guidance of Wheel Guide. Type of Surveillance Job is Running and Pulling Job for nozzle replacement to regulate flow rate and Flowrate Test using Electromagnetic Flowmeter. Well maintenance can be performed rig less so it can save operating costs.

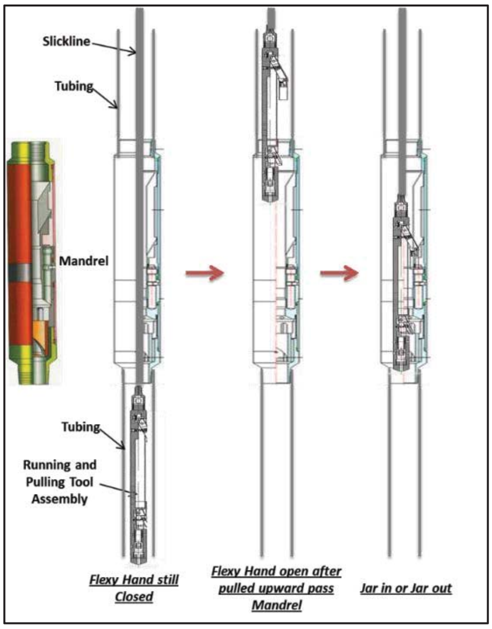

Figure 9. Procedure of Running and Pulling Tool

This test aims to determine leakage of installed packers. Side pockets of two adjacent Bridge Eccentric Injection Mandrel attached by Blanking Plug with open nozzle and Double Memory Pressure Gauge. Fluid flow will pass through Blanking Plug and suppress annulus packer. Double Memory Pressure Gauge records annulus pressure and tubing pressure in the Bridge Eccentric Injection Mandrel so that there are two graphical views of the test results. The packer leakage can be analyzed by the pressure graph, anulus pressure and tubing pressure. Packer is sealed and prevent inter-layer connection if annulus pressure is constant or tend to decrease toward static pressure. In leakage case, annulus pressure graph will indicate a change because the pressure intervention to packer. Illustration of fluid flow and pressure during Packer Sealing Test is shown in Figure 10.

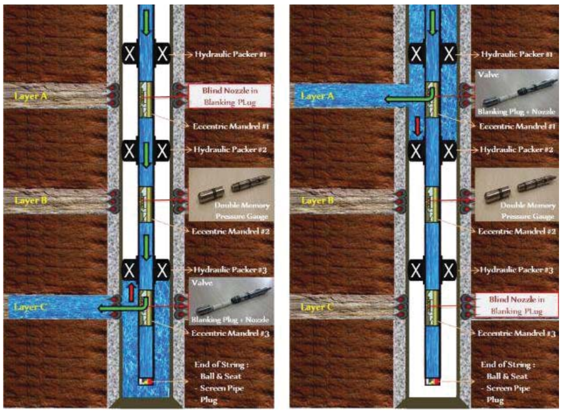

Figure 10. Sequence of Packer Sealing Test

Output data of ths test is total flow rate at each measurement point that is several meters above each Bridge Eccentric Injection Mandrel and will be analyzed and evaluated flow distribution for each layer. Injection monitoring is able to be performed any time and without rig. Nozzle replacement by Running and Pulling has do to set injection flow rate target. Electromagnetic Flowmater position during measurement can be seen in Figure 11.

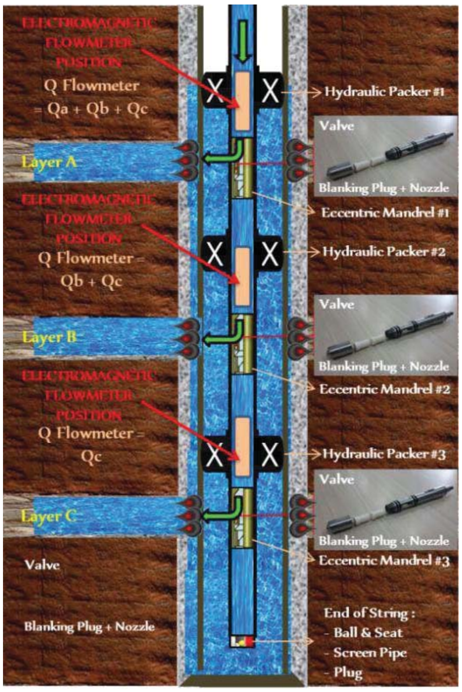

Figure 11. Flowrate Test Running Position

6. Data and Result

Application of Multilayer Packer using Bridge Eccentric Mandrel and Hydraulic Packer technology was performed on several wells in Kenali Asam Stucture at KAS-063, KAS-073 and KAS-039.

a. Well Completion

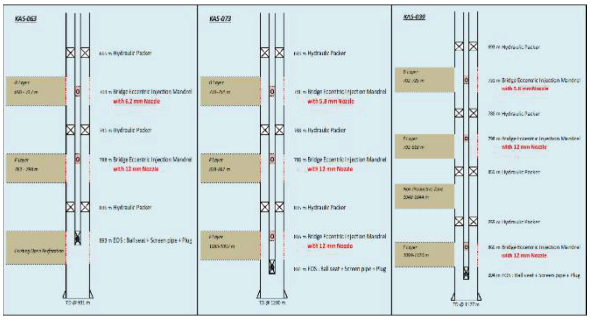

Figure 12. Well Schematic

b. Packer Sealing Test

The graph of Packer Sealing Test is generated by Double Memory Pressure Gauge. Graph analysis is based on annulus pressure (red) and pressure tubing (blue). In KAS-063, the first period graph is generated when the Double Memory Pressure Gauge is at the lower mandrel with an inlet flow through the upper mandrel. The annulus pressure is not affected by the tubing pressure so it can prove that mid packer and lower packer do not leak. In the second period, the Double Memory Pressure Gauge is on the upper mandrel with the inlet passing through the lower mandrel. The annulus pressure is not affected by the tubing pressure. If so it can prove that the mid packer and upper packer have not been perfectly sealed.

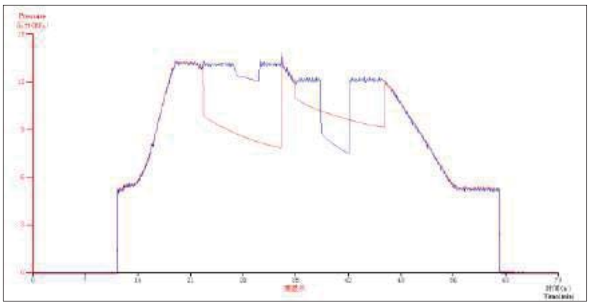

Figure 13. KAS-063 Packer Sealing Graph

For KAS-073, the measurement has constraints due to mechanical problems of injection pumping. Packer sealing analysis can be seen in the last three periods. The first and second periods, annulus pressure is not affected by the pressure changes in the tubing. Shows no leakage in the lower packer and mid packer. Peda third period, pressure measurement cannot be done because of mechanical constraint pumping. The upper packed proof has sealed is to observe the flow and pressure of the valve casing on the wellhead. With no annulus flow passing through the valve casing, it can be proven that the upper packer has sealed well.

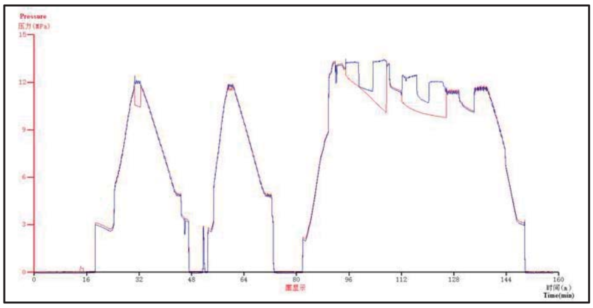

Figure 14. KAS-073 Packer Sealing Graph

Packer Sealing Test in KAS-039 is the same as in KAS-063. Pressure graph shows that each packer has been sealed perfectly. With the proven packer has been set and sealed, the confidence of injection data accuracy becomes higher.

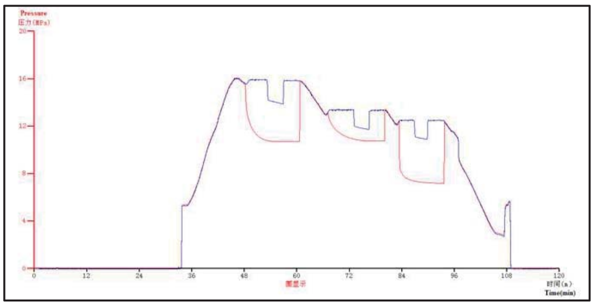

Figure 15. KAS-039 Packer Sealing Graph

c. Flowrate Test

Table 1. Flowrate Test Result of KAS-063

Well	Sand	Target bwpd	1st Monitoring P inj @ Surface = 700 psi		2nd Monitoring (next 6 month) P inj @ Surface = 650 psi	
			Nozzle Size (mm)	Qi (bwpd)	Nozzle Size (mm)	Qi (bwpd)
KAS-063	B	500	6.2	496	6.2	248
	F	500	12	418	12	371

Table 2. Flowrate Test Result of KAS-073

Well	Sand	Target bwpd	1st Monitoring P inj @ Surface = 700 psi		2nd Monitoring (next 6 month) P inj @ Surface = 750 psi	
			Nozzle Size (mm)	Qi (bwpd)	Nozzle Size (mm)	Qi (bwpd)
KAS-073	B	500	5.8	526	5.8	629
	F	500	12	0	12	195
	P	300	12	430	12	226

Table 3. Flowrate Test Result of KAS-039

Well	Sand	Target bwpd	1st Monitoring P inj @ Surface = 700 psi		2nd Monitoring (next 6 month) P inj @ Surface = 650 psi	
			Nozzle Size (mm)	Qi (bwpd)	Nozzle Size (mm)	Qi (bwpd)
KAS-039	B	500	12	526	12	452
	F	500	12	0	12	152
	P	300	8	430	8	215

KAS-063 flowrate table shows injection target can be achieved on 1st monitoring in layer B using a nozzle size of 6.2 mm. In F layer, the injection target is not achieved optimally due to the limitation of the nozzle size and injection pressure of wellhead. With a 700 psi injection pressure, 12 mm nozzle produces a flow rate of 418 bwpd. From approaching formulas determination, 500 bwpd injection target can be achieved using 13.2 mm nozzle size. Another option is using 12 mm nozzle with 750 psi injection pressure of wellhead. At 2nd monitoring, there is a decrease in injection pressure at wellhead which effect to decreasing of flowrate in each layer. Flow rate decline can also be occured by increasing of reservoir pressure due to injection. So, it takes more injection pressure to keep the flow rate according to the target injection. Reservoir characteristics in KAS-039 and KAS-073 are different than KAS-063 where F zone is tight layer so difficult to water penetrate using the nozzle layer even with the largest size. Injection begins to penetrate to layer after initial injection which can be seen in table 2nd monitoring. This can happen because at the same pressure, P layer reaches saturation pressure and F layer reaches the fracture pressure. The data indicate that the injection pressure required to achieve injection target must be greater than the existing injection pressure in Kenali Asam Field.

7. Conclusion

Bridge Eccentric Injection Mandrel is flow separation technology of multilayer injection required to control the injection flow rate at each layer.

Flow rate control is conducted only by adjustment nozzle size placed inside Blanking Plug. Surveillance and equipment maintenance is performed using slickline unit and rig less so that operational cost becomes more efficient.

Completion system of this technology is quite simple in installation. Pressure is built up inside tubing to set hydraulic packer where blind nozzle placed on each Bridge of Eccentric Injection Mandrel.

Packer sealing can be proven by using Double Memory Pressure Gauge which is placed on Bridge Eccentric Injection Mandrel. Thus, confidence injection data becomes higher in determining reservoir performance of multilayer injection.

8. Recommendation

Application of Bridge Eccentric Injection Mandrel technology in Kenali Asam Field shows correspond results for purpose of multilayer separated injection. Well completion can be done perfectly and every packer proven to close inter-layer connection. Injection target of each layer achieved by optimizing injection pressure and nozzle size.

9. Acknowledgement

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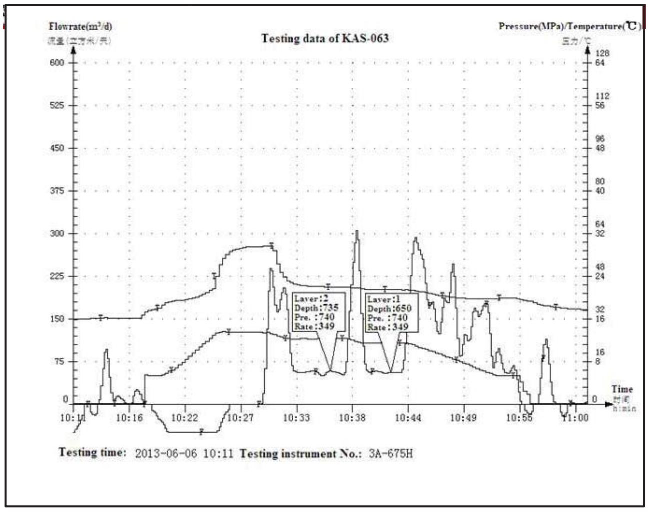

Figure 16. Downloaded Flowmeter graph of KAS-063

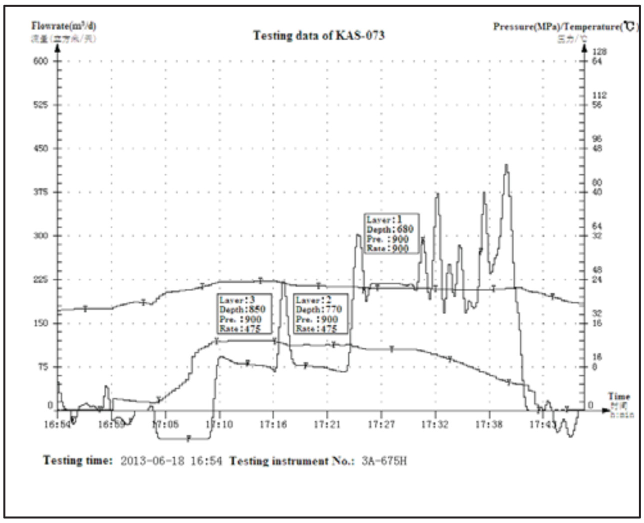

Figure 17. Downloaded Flowmeter graph of KAS-073

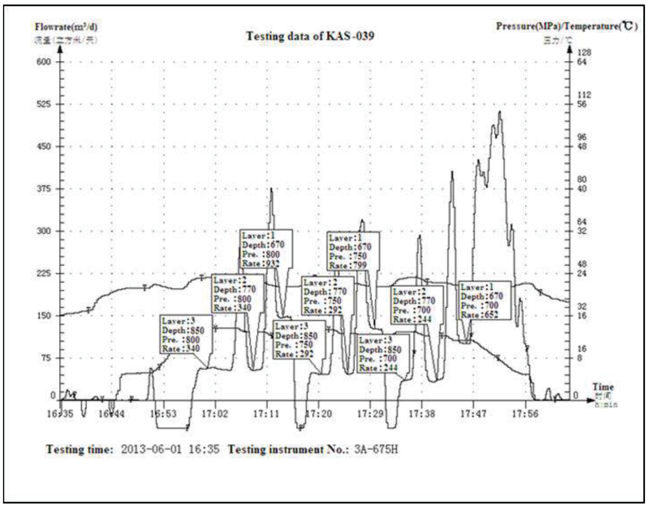

Figure 18. Downloaded Flowmeter graph of KAS-039