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Overcoming the Sand Problem using the Gravel Pack Method in Well X in the Field of Kalrez Petroleum (Seram) Ltd

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ABSTRACT

In the oil and gas industry, there are often various problems that can interfere with the production process. One of the problems that often occurs is sand problems. The impact of sand problems is to cause damage to downhole and surface equipment. To solve the problem of sand in boreholes, gravel fill can be used. This study was conducted Kalrez Petroleum (Seram) Ltd Field Well X. The purpose of this study was to determine the size of gravel Bagging overcomes sandy issues and determines front and rear production performance Installing a gravel pack and determining the cost comparison of the gravel pack method and sand screening method in terms of cost benefit analysis. Based on the smallest average size of sand grains is 0.024 inch, this size is in accordance with the size of gravel pack in general, namely 16/30 M. Calculation of PI after the use of gravel pack has increased production from 4.4 bbl/psi to 7.8 bbl/psi. Based on the IPR curve before the use of gravel pack, the maximum flow rate (Q max) was 527.4372 bpd, experiencing an increase in the maximum flow rate (Q max) of 907.108 bpd. Based on calculations using cost benefit analysis (Coast Benefit Analysis) between the gravel pack and screen liner methods. The screen liner method can be an alternative to overcome the sand problems, this is because it is seen from the value of the B/C ratio> 1 or 2,3. This means that for every one dollar invested in the method, a savings ratio of 2.3 will be obtained. So the screen liner method is more useful and also efficient.
Keywords: Sand problem, downhole and surface equipment, gravel pack, sieve analysis, cost benefit analysis

I. INTRODUCTION

The problem of sand production is one of the problems encountered by the oil and gas industry, especially the upstream of the oil and gas industry (Roslan, et, 2010). Oil and gas companies spend millions of dollars each year to prevent and solve sand problems Problems in unconsolidated formations result in lost production and damage to well equipment (Hisham, 2015).

According to data obtained from Kalrez Petroleum (Seram) Ltd, the oil field is an old oil field that has been operating since 1939, so there are many problems in the oil wells in this field, and the most common problem is the problem of passivity. In the X well of the Kalrez Petroleum (Seram) Ltd field, the potential for the occurrence of sand is very high, causing the production of crude oil from year to year to decline. Sand production usually comes from younger tertiary reservoirs, such as Miocene and Pliocene aged sands. These sands are usually unconsolidated sand layers that are highly susceptible to changes in reservoir pressure as well as water coning, which can cause sandiness problems (Bergkvam, 2015). Sand production is highly undesirable during production activities because it can cause many problems both in the surface facility and downhole equipment.

The mechanism that causes the siltation problem starts with the production rate exceeding the critical flow rate, leading to water breakthrough (Ahmed, 2006). In the reservoir production zone, with low rock compaction and poor rock bonding and cementation, it is susceptible to contact with formation water, which causes the clay content to swell and weaken. Thus, the bonds between the rock grains are released along with the reservoir fluid during well production (Isehunwa & Farotade, 2010). In addition, decreasing reservoir pressure can also lead to the occurrence of passivation problems where, when reservoir pressure decreases, it will affect the increase in overburden pressure which causes weakening of rock cementation (Mayokun A. O., 2011). One way to overcome the problem of passivity is by using mechanical methods, namely gravel packs.

Overcoming the problem of sandiness with the gravel pack method is by installing gravel that is inserted into the borehole so that it can prevent the entry of sand grains into the production hole or production well. The selection of gravel size must be adjusted to the condition of the rock grains. Therefore, in determining the size of gravel, the right design is needed. In this study, the data source comes from the Kalrez Petroleum (Seram) Ltd field located in Bula, in addition to using economic analysis to choose a method of overcoming sandiness.

The formulation of the problem in this research thesis is to understand the problem of passivity, determine the size of gravel pack used to overcome the problem of passivity, production performance before and after gravel pack installation, cost benefit analysis that occurs in the X well field of Kalrez Petroleum (Seram) Ltd. This research was conducted to be able to understand the problem of passivity, determine the size of gravel pack used to overcome the problem of passivity, production performance, and cost benefit analysis at the X well of the Kalrez Petroleum (Seram) Ltd. field.

In the concluding section of the introduction, the research's objectives or aims should be articulated. These objectives should be highlighted in the literature review to underscore the novelty of the scientific article.

II. METHODS

In this research, there are several stages used by the author in this research methodology:

1. Study Literature
   Is the initial stage carried out by searching for information both from supporting books, journals, theses and papers related to the research being conducted.

2. Data Collection
   Is taking the data needed in the research preparation process. Data collection is done by requesting data and discussing with field supervisors regarding matters related to research.

3. Data Processing
   a. Determine Sand Grain Size
      Determined from sieve analysis obtained from formation sand samples. Sieve analysis begins with
      - Preparing formation sand samples that have been dried and free from oil
      - Prepare a sieve analysis whose bottom has been cleaned, the sieve is arranged above the shaker and above the bowl at its base
      - Set the sieve starting from the finest at the top of the bowl and the coarsest at the top.
      - Pour the formation sand sample into the top sieve, attach the cover securely and shake for 30 minutes.
      - Pour the formation sample in the topmost sieve into a container and weigh it and continue to the next sieve layer.
      - Weigh the cumulative weight of the formation sample using a digital balance.
      - Make a semilog graph between opening diameter and cumulative %

   b. Gravel Pack Size
      Determining the size of the gravel pack is done after obtaining the sieve analysis data which then plots the sample data results on the opening diameter and also the cumulative % so as to get the sorting coefficient so that it can determine the size of the gravel pack. The graph between opening diameter and cumulative % is done with the equation

      $$\text{Uniformity Coefficient} = \frac{(\text{Diameter at } 40\%)}{(\text{Diameter at } 90\%)}$$

   c. Calculating PI and IPR
      In this step the author analyzes the production performance before and after the installation of gravel packs using PI and IPR calculations.

   d. Cost Benefit Analysis
      At this stage, the author can compare the costs that have been invested in the development of the benefits or profits obtained by Kalrez Petroleum (Seram) Ltd.

III. RESULTS AND DISCUSSION

3.1. Sand Problems in Well X of Kalrez Petroleum (Seram) Ltd Field

During production activities, the problem that often occurs is the production of sand to the surface, which can affect the productivity of the well. Sand formations generally contain clay or cement rock as well as clay. Clays have a characteristic called water wet, so when water flows through rock layers containing clays, there is a tendency for sand particles to migrate towards the wellbore when produced water is produced.

The production of sand to the surface along with the fluid is one of the problems that often occurs in the Kalrez Petroleum (Seram) Ltd field such as in the X well. This well uses an artificial lift method using a sucker rod pump. Where this pump is less than optimum for handling sand problems. With the condition of the well like this so that to handle the problem of sandy needs special handling, namely by using the gravel pack method so that the sandy problem can be handled.

3.2. Size of Gravel Pack Used

To determine the size of sand grains in the X well of Kalrez Petroleum (Seram) Ltd, a core analysis using sieve analysis is carried out, where sieve analysis is an analysis carried out on the size of sand grains to select the size of sand grains and also gravel packs or determine the weight presentation of grains that pass a set of sieves.

Table 1. Sand Grain Size Distribution

Grain Size		% Weight	% cumulative
Mesh	Inchi		
20	0,0331	0,471	0,471
30	0,0232	0,548	1,019
35	0,0197	0,430	1,450
50	0,0117	2,771	4,221
60	0,0098	11,466	15,687
80	0,0070	23,400	39,087
100	0,0059	44,548	83,635
200	0,0029	15,741	99,376
>200	0	0,624	100

Before determining the size of gravel pack to be used, first know the distribution of sand grain size in the well. By analyzing the size of sand grains, it can determine the selection or sortation (C).

The results of core analysis using sieve analysis of sand from well X, in the sample above illustrates the particle size distribution of sand expressed in terms of weight percentage of each particle size. The sample data is then plotted into a semilog graph shown in the figure below.

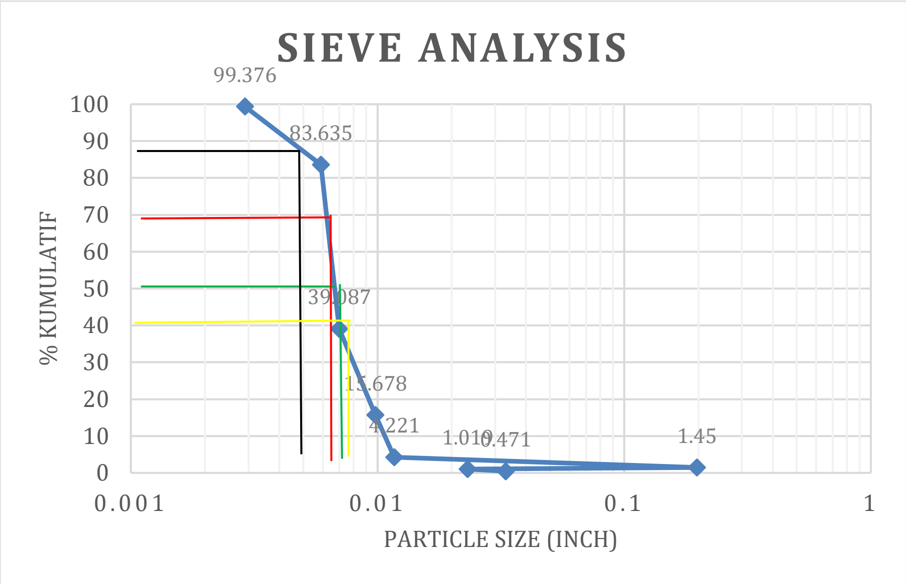

Figure 1. Cumulative vs Particle Size

From the curve, the percentage of sand grain size can be determined. To determine the percentage value, the most dominant distribution can be selected, as shown in the table below:

Table 2. Most Dominant Sand Grain Size Distribution

Persent, D	Ukuran, Inch
D40	0,0088
D50	0,0086
D70	0,007
D90	0,004

After determining the size of the sand distribution as in the table above, the next stage is to determine the uniformity of the sand grains.

3.3. Determining Sand Grain Uniformity

The Coefficient of Uniformity is calculated by comparing the sand grain size at the 40% percentile (D40) with the sand grain size at the 90% percentile (D90). The equation is as follows:

From the Percent Result, determine the uniformity of sand grains.
If known:

D40 = 0,0088
D90 = 0,004
Answer:

$$\text{Uniformity Coefficient} = \frac{\text{Diameter at } 40\%}{\text{Diameter at } 90\%} = \frac{0{,}0088}{0{,}0024} = 2{,}2$$

Based on the sand grain size consistency calculations that have been carried out, it can be observed that the Coefficient of Uniformity (C) value is lower than 3 (C < 3). Therefore, it can be concluded that the sand grain size is classified as good or uniform.

Table 3. Selection of Good, Medium, Poor, Sand Grain Size According to Schwartz

C = d40/d90	Sorting
C < 3	Well sorted
C < 5	Moderately sorted
C > 5	Poorly sorted

3.4. Determining Gravel Pack Size

To determine the gravel pack size to solve the sand problem in well X, the authors used the Schwartz approach. This approach involves the selection of gravel pack size based on sand particle size. This method involves the use of a formula where the gravel pack size is determined by multiplying 6 times the diameter of the sand particles at the 40% percentile (6 x D40) and 90% percentile (6 x D90). Details of the results are provided in the table below:

Table 4. Schwartz Method 6× Formation Sand Size

Percent	Size, inch	6×
40%	0,0088	0,0528
50%	0,0086	0,0516
70%	0,007	0,042
90%	0,004	0,024

Table 5. Gravel Pack Size

Size Range, Inch	Gravel Size, U.S. Mesh
0,066-0,094	8/12
0,033-0.066	12/20
0,023-0,047	16/30
0,017-0,033	20/40
0,010-0,017	40/60

From the table above, the smallest gravel pack size is 0,024, thus, this size corresponds to the size generally used for gravel packs, which is 16/30 US Mesh.

3.5. Production Performance Before and After Gravel Pack Installation

To determine the production performance before and after the installation of gravel packs, the production data in the table below is used.

Table 6. Production Data Before and After Gravel Pack Installation

Production Data	Before Gravel Pack Installation	After Gravel Pack Installation	Unit
Qt	130	150	BFPD
Q0	14	16	BOPD

Table 7. Pressure Data

Parameters	Before	After	Unit
Ps	198	198	Psi
Pwf	169	179	Psi

3.5.1. Evaluation of PI (Productivity Index) Before and after Gravel Pack installation

PI (Productivity Index) is a value that expresses the ability of a well to produce. To calculate PI before and after gravel pack installation, the following equation can be used:

PI Before $= \frac{Qt}{Ps-Pwf}$

$= \frac{130}{198-169}$

$= 4{,}4$ bbl/psi

PI After $= \frac{Qt}{Ps-Pwf}$

$= \frac{150}{198-179}$

$= 7{,}8$ bbl/psi

3.5.2. Evaluation of IPR (Inflow Performance Relationship) Curve Before and After Gravel Pack Installation

The IPR curve is a curve that describes the ability of a formation to produce, by relating well pressure (Pwf) to production rate (Q).

A. Before Gravel Pack Installation

1. Before Determining Qmax

$$Q\ max = \frac{Qt}{1-0.2\left(\frac{Pwf}{Ps}\right)-0.8\left(\frac{Pwf}{Ps}\right)^2} = \frac{130}{1-0.2\left(\frac{169}{198}\right)-0.8\left(\frac{169}{198}\right)^2} = 527{,}4372 \text{ bpd}$$

2. Assume the Pwf and Q values before installing the gravel pack to get an IPR image
   - Calculating the Q value before gravel pack installation at Pwf assumption =190

$$Q = q\ max\left\{1-0{,}2\left(\frac{Pwf}{Ps}\right)-0{,}8\left(\frac{Pwf}{Ps}\right)^2\right\} = 527{,}4372\left\{1-0{,}2\left(\frac{190}{198}\right)-0{,}8\left(\frac{190}{198}\right)^2\right\} = 37{,}67024 \text{ bpd}$$

Table 8. Assumed Value of Pwf and Q Before Gravel Pack Installation

Pwf, psi	Q, bpd
198	0
190	37,67024
160	166,6639
100	366,5315
50	473,8916
0	527,4372

B. After Gravel Pack Installation

1. After Determining Qmax

$$Qmax = \frac{Qt}{1-0.2\left(\frac{Pwf}{Ps}\right)-0.8\left(\frac{Pwf}{Ps}\right)^2} = \frac{150}{1-0.2\left(\frac{179}{198}\right)-0.8\left(\frac{179}{198}\right)^2} = 907{,}108 \text{ bpd}$$

2. Assumptions Pwf and Q values After installation of gravel pack to get IPR curve
   - Calculating the q value after gravel pack installation at Pwf assumption = 190

$$Q = q\ max\left\{1-0{,}2\left(\frac{Pwf}{Ps}\right)-0{,}8\left(\frac{Pwf}{Ps}\right)^2\right\} = 907{,}108\left\{1-0{,}2\left(\frac{190}{198}\right)-0{,}8\left(\frac{198}{190}\right)^2\right\} = 64{,}78682 \text{ bpd}$$

Table 9. Assumed values of Pwf and Q after Gravel Pack Installation

Pwf, psi	Q, bpd
198	0
190	64,7868
160	286,635
100	630,376
50	815,018
0	907,106

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To determine the gravity of the IPR curve, plot the Pwf and q data pairs before and after gravel pack installation, thus forming the IPR curve.

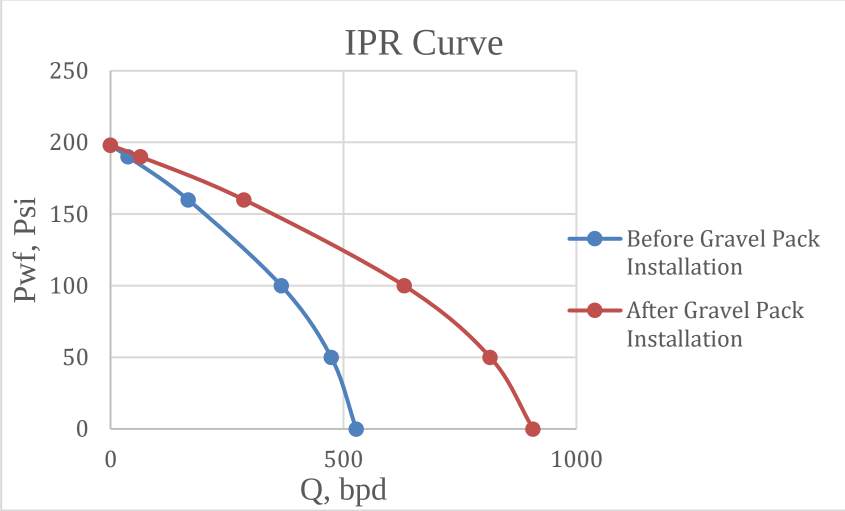

Figure 2. Before and After Gravel Pack Installation

From the results of the production performance analysis above, the production rate is obtained before and after the installation of gravel packs. Where after the installation of gravel pack the production rate has increased. So that this gravel pack installation activity is said to be successful.

3.6. Comparison of Gravel Pack and Screen Liner Methods in Terms of Cost Benefit Analysis

Cost benefit analysis (benefit cost analysis) is an analysis that is very commonly used to evaluate government and private projects. This analysis is a practical way to assess the benefits of a project, this requires a long and extensive review. In other words, analysis and evaluation is needed from various points of view that are relevant to the costs and benefits contributed.

The cost benefit analysis method applied in this study is an analysis that aims to compare the costs that have been invested in the development of the sales system with the benefits or profits obtained by Kalrez Petroleum (Seram) Ltd.

Table 10. Estimation of Cost Benefit Analysis of Gravel Pack and Screen Liner Methods

Methods	Benefit Annual Equivalent US$	Cost Annual Equivalent US$	Ratio
Gravel Pack	1.486.309,077	716.824,8933	2,073461861
Screen Liner	1.300.520,443	545.301,1153	2,38495834

From the table above, the formula for determining equivalent benefits and equivalent costs is

- Benefit Equivalent

  AEB = Σ (Bt/ (1+r)^t)

  AEB : Benefit Equivalent

  Bt : Benefit at Year-t

  r : Discount rate or interest rate

  t : Year

- Equivalent Cost

  AEC = Σ (Ct/ (1+r)^t)

  AEC : Annual Cost Equivalen

  Ct : Cost in year-t
  r : iscount rate or interest rate
  t : Year

From **Table 10**, the first thing to do is to compare the screen liner method with the 0 or "Do Nothing" method. The increase in benefit from method 0 to the screen liner method is 1,300,520.443 and the increase in cost is 545,301.1153. Thus the B/C ratio of the increase is

$$B/C_{\text{S-0}} = \frac{\text{Screen Liner Benefit Equivalent}}{\text{Screen Liner Cost Equivalent}}$$

$$B/C_{\text{S-0}} = \frac{1.300.520,443}{545.301,1153} = 2{,}38495834 \text{ US\$}$$

B/C S-0 > 1, then the screen liner method is chosen, then the screen liner method is compared with the gravel pack method, so that the B/C ratio increases as follows:

$$B/C_{\text{G-S}} = \frac{\text{Benefit equivalen Gravel Pack} - \text{Benefit equivalen Screen liner}}{\text{Cost Equivalen Gravel Pack} - \text{Cost Equivalen Screen Liner}}$$

$$B/C_{\text{G-S}} = \frac{1486309{,}077 - 1300520{,}443}{716824{,}8933 - 545301{,}1153} = 1{,}083165472 \text{ US\$}$$

From the results of the above calculations it can be concluded that the screen liner method is better than the gravel pack method, so the US & method is more useful and efficient. In summary, the selection of the above methods can be shown in the table below.

Table 11. Method Selection

Method	Δ Annual Benefits US $	Δ Annual Cost US $	Δ Ratio	Decision
S-0	1300520,443	545301,1153	2,38495834	Screen Liner
G-S	185788,634	171523,778	1,083165472	Screen Liner

IV. CONCLUSION

Based on the results of the above research, the conclusions that can be drawn are as follows:

1. The production of sand to the surface together with fluid is one of the problems that often occurs in the Kalrez Petroleum (Seram) Ltd field such as in the X well. This well uses an artificial lift method using a sucker rod pump. Where this pump is less than optimum for handling sand problems. With the condition of the well like this so that to handle the problem of sandy needs special handling, namely by using the gravel pack method so that the sandy problem can be handled.
2. Based on the smallest sand grain size of 0,024 inch, the size of the gravel pack used in the X well of the Kalrez Petroleum (Seram) Ltd field is 16/30 U.S MESH.
3. Based on the production performance before the installation of gravel pack, the fluid flow rate (Qt) was 130 bfpd, the oil flow rate was 14 bopd, and Q max was 527,4372 bpd. While the results of after the installation of gravel pack the fluid flow rate (Qt) was 150 bfpd, the oil flow rate was 16 bopd, and Qmax was 907,108 bpd. So that the gravel pack installation activity is said to be successful because the flow rate before and after the installation of gravel pack has increased.
4. Based on calculations using cost benefit analysis between the gravel pack and screen liner methods. the screen liner method can be an alternative to overcome the problem of sandiness, this is because it is seen from the value of the B/C ratio > 1 or 2,3. This means that for every one dollar invested in the method, a savings ratio of 2,3 will be obtained. So the screen liner method is more useful and also efficient.

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