Laboratory studies of sand problem prevention using Mechanical Methods and Gravelpack design performance analysis in Field X

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Abstract. Sand problem is one problem that can disrupt oil well production. With the sand problem, the productivity of the well decreases so that there will be a decrease in oil production. Sand problems that occur result in increased production loss and cost lost. The purpose of this research is to find the right solution in overcoming sand problem, by studying the characteristics of the rock. Laboratory experiments were carried out using a mechanical method approach which was then used to determine the appropriate gravelpack design. The steps taken include testing the strength of the core of the three zones, the decrease of strength can conclude that the core of the three zones has begun to weaken. The results of the analysis of the grain size of the D50 then used to determine the appropriate gravelpack design in each zone. Zone A, using gravelpack 60/80, zone B using gravelpack 16/20, and zone C using gravelpack 30/50. From the gravelpack design obtained then a sand retention test is performed to determine the gravelpack's performance. With the results of the sand retention test showing good gravelpack performance for each zone, where the permeability value is good and the solid produced is not too much.

1. Introduction
The problem of sand production is often found in oil fields. Sand problem is very important to be resolved immediately because it will result in an increase in maintenance costs of the well until the extreme stage will result in the well being unable to produce again. This matter of sand problem is very closely related to the characteristics of a reservoir rock, produced fluid, and pressure or stress [1].

Sand production begins to occur if the stress experienced by formations exceeds the strength of rock formations, the strength of this rock formation which is the natural strength of rock cementation material in maintaining the compactness of sandstone granules in formation besides the cohesion of "Immobile Formation Water / Fenida". Stress experienced by sandstone granules can be tectonic style, over burden pressure, pressure from stress changes due to drilling, and the thrust force of production fluid.

The presence of sand problems has led to increased production loss, which also results in more frequent repairs and maintenance of wells, and a decrease in oil production triggered by the formation damage and low water flood sweeping efficiency.

The most important thing that underlies the selection of methods to overcome this problem is the understanding of current borehole geometry conditions and mechanisms. In this study an analysis was carried out using rock mechanics data and stress / pressure data around perforation holes to make an onset of sanding model [2]. This model can be used as a reference for production in new wells in order to prevent the occurrence of sand problem. Laboratory tests carried out were rock strength tests in the...
form of UCS and TWC. UCS and TWC tests were carried out to determine the strength of the rock both in the reservoir layer which was far from the perforation / rock hole which had no perforation hole (UCS) and which reflected the perforation hole condition (TWC). The one of the methods used to predict the potential of sand problem was through TWC testing. Palmer et al. stated that the value of TWC-collapse strength is a value where significant sand production occurs [3].

Mechanical method is the use of sand control (gravelpack). To use this method, particle size testing was done before using the Particle Size Distribution (PSD) tool in dry conditions. In figure 1 it is indicated by the size of D10 which represents the size where 0% of the particles are larger. D50 represents a size where 50% of the grains are larger and D90 shows a size where 90% of the particles are larger.

Schwartz stated that to determine the size of the gravelpack to be used, it must first determine the value of the Gravel to Sand (G-S) ratio [4]. The recommended Gravel to Sand (G-S) ratio is around the value of 6 to 8 times the grain size of the sample at D50, where the gravelpack design will be optimum if it is worth 6 times the D50. Then the sand control (gravelpack) size can be determined to be used according to the results of the item analysis.

2. Methodology
In this study an analysis was carried out using rock mechanics data and stress / pressure data around perforation holes to make an onset of sanding model. Rock strength can be known through the UCS test and TWC test.

2.1. UCS (Uniaxial Compressive Strength) test
The purpose of the Uniaxial Compressive Strength (UCS) test was to determine the strength of the original rock without the influence of the pressure of confining (σ3). This test was carried out in zones B and C using two conditions or treatments before carrying out the test. The first treatment (I) is the sample is only conditioned dry at a temperature of 60 ° C. For another treatment (II) is a sample that has previously been used for testing using injection water and then dried at a temperature of 60° C. The two treatments (I and II) were carried out to obtain information on the presence or absence of changes (decreases) in rock strength.

The results of the UCS test are generally in the form of data pressure and strain. Data pressure indicates that the pressure applied to the sample, while the strain is a change in length (shortening) relative to the initial length that occurs in the sample during the sample under pressure.

Furthermore, from stress and strain data other rock mechanics parameters can be derived, namely young modulus, shear modulus, bulk modulus, and Poisson ratio. Whereas to conduct QC the results of the UCS test can be done by observing the formed fracture. A perfect UCS test will produce a fracture that cuts the sample diagonally and is shearing. Whereas the un-perfect test on UCS will produce a fracture that cuts the sample perpendicularly and is tensile.

2.2. TWC (Thick-Wall Cylinder) test
TWC is a cylindrical and hollow shaped core required by increasing the voltage limit automatically [5,6]. Unlike the UCS, the force treatment in this test is carried out hydrostatically, where the axial directional pressure value is the same as the lateral / tangential direction pressure. When the tangential voltage exceeds the effective strength of the rock, the inner hole begins to disintegrate. The TWC test results on testing using water and oil fluids. Tests carried out at room temperature conditions, the fluid in the cavity is static with a pressure of 20 psi, the ratio of Inside Diameter: Outside Diameter sample is 1:3.

Another factor is the value of TWC strength, this value is obtained from laboratory experiments where the value is strongly influenced by the ratio of inside diameter (ID) and outside diameter (OD), type of fluid, velocity of fluid, and type of rock. Several studies on TWC strength have been carried out as has been done by Cook, Tronvol, et al., Ewi., et al., and Wu and Tan [7-10]. The results of the four
studies show that the deformation pattern around the perforation hole is not elastic but there is a phenomenon of plastic deformation [11].

3. Result and discussion

3.1. Grain size analysis
Grain size analysis was carried out using Dry-PSD (Particle Size Distribution). The Dry-PSD method is performed on core samples. Based on the results of the Dry-PSD test, the grain size in the D50 condition is 35,589 μm (core zone A), 152,848 μm (core zone B), 71,859 μm (core zone C). The data also shows that zone A generally has a smaller grain size compared to the other two zones. Populations with the largest grain size are in zone B.

![Figure 1. Cumulative particle size graphic.](image1)

The Dry-PSD test results show D50 values from each zone A, B, and C are 35.61 μm, 152.99 μm, and 71.91 μm. Furthermore, Schwartz suggested to multiply the numbers 6 and 7 to the D50 value in each zone to obtain the optimum gravel pack configuration [4].

Testing using GPS 60/80 configuration (Figure 2) results in satisfactory apparent permeability and produced solids, where the apparent permeability is in the interval of 19 - 58 mD and the solid is produced in the range of 0.01 gram.

![Figure 2. Sand retention result zone A using GPS 60/80.](image2)
The test uses the GPS 16/20 configuration, which results from the calculation of several previous studies. This configuration shows results that are beyond expectations, where the apparent permeability values in the interval 43 - 110 mD and produced solids are around 0.001 - 0.015 grams (Figure 3). The apparent permeability obtained in this configuration shows a value that is far greater than the relative value of permeability (Kw) which is worth 16.11 mD.

![Graph showing apparent permeability vs. injection volume for GPS 16/20 configuration.](image)

**Figure 3.** Sand retention result zone B using GPS 16/20.

The graph of apparent permeability at Figure 4 shows a pattern of increasing apparent permeability along with increasing flowrate. The apparent permeability in Figure 4 shows significant results compared to the previous three configurations. Configurations designed based on formulas / rules obtained from previous studies show more optimum results when viewed from the permeability parameters, compared to configurations using API-based gravelpack. For the formula used is D50 multiplied by 6 for the upper limit and multiplied by 7 for the lower limit.

![Graph showing apparent permeability vs. injection volume for GPS 30/50 configuration.](image)

**Figure 4.** Sand retention result zone B using GPS 30/50.

If comparing the results of the sand retention test in the three zones, it shows that zone B tends to be easier to get a good configuration, then followed by zone C. Zone A is the most difficult zone to get the appropriate gravelpack configuration. This phenomenon is related to the grain size of the three zones, where grain size in zone A is dominated by very fine grain size, while zone B and C relatively have grain size that is coarser than zone A.
4. Conclusion
From the discussion, had some of conclusions, decrease in rock strength occurs if water begins to be produced and there is incompatibility with mineralogy so that it has the potential to be the cause of the occurrence of sand problem. The optimum gravel pack configuration for tackling the irrigation of old wells in this field can be obtained from the D50 formula multiplied by 6 and 7 as the upper and lower limit. Sand retention testing can be used as a method to test the performance of the sand control that will be used, in this case it is gravel pack. The optimum gravel pack for use in this field based on sand retention testing is: zone A (60/80), zone B (16/20) and zone C (30/50). The apparent permeability of zone A with gravel pack 60/80 ranges from 19-58 mD, zone B with gravel pack 16/20 ranges from 43 to 110 mD and zone C using gravel pack 30/50 ranges from 9 to 38 mD.

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References
[1] Ballard, Tracey, S Beare and N Wigg 2016 Sand Retention Testing: Reservoir Sand or Simulated Sand – Does it Matter? (Louisiana, USA) SPE-178966-MS.
[2] A R Jennings Jr 1997 Laboratory Studies of Fines Movements in Gravelpacks SPE Drilling & Completion.
[3] I Palmer, H Vaziri, S Wilson, Z Moschovidis, J Cameron and I Aspas 2003 Predicting and Managing Sand Production: A New Strategy SPE 84499 (Denver-COLORADO: USA).
[4] D H Schwartz 1969 Successful Sand Control Successful Sand Control Design for High Rate Oil and Water Wells SPE-AIME.
[5] D Antheunis, P B Vriezen, B A Schipper and A C Van der Vlis 1976 Perforation collapse: failure of perforated friable sandstones In SPE European Spring Meeting. Society of Petroleum Engineers.
[6] C A M Veeken, D R Davies, C J Kenter and A P Kooijman 1991 Sand production prediction review: developing an integrated approach In SPE annual technical conference and exhibition. Society of Petroleum Engineers.
[7] N C Cook and S Samman 1996 Flavonoids—chemistry, metabolism, cardioprotective effects, and dietary sources The Journal of nutritional biochemistry 7(2) 66-76.
[8] J Tronvoll, E Papamichos, A Skjaerstein and F Sanfilippo 1997 Sand production in ultra-weak sandstones: is sand control absolutely necessary? In Latin American and Caribbean Petroleum Engineering Conference. Society of Petroleum Engineers.
[9] E W I Schweiger 1999 The interaction of habitat fragmentation, plant, and small mammal succession in an old field: Patterns and mechanisms.
[10] G Alfthan, G L Xu, W H Tan, A Aro, J Wu, Y X Yang, W L Xue 2000 Selenium supplementation of children in a selenium-deficient area in China Biological Trace Element Research 73(2) 113-125.
[11] C A M Veeken, D R Davies, C J Kenter and A P Kooijman 1991 Sand Production Prediction Review: Developing an Integrated Approach SPE 22792.