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PERFORATION PARAMETERS CONSIDERATION FOR STABLE PETROLEUM WELLBORE

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ABSTRACT

The paper describes a series of laboratory experiment to observe the effects of perforation parameters and fracture zone on the wellbore stability. The wellbore stability is the most important thing that should be considered during drilling and production activities. The paper will be presented only the on effect of wellbore stability due the structure design at production zone i.e perforated cased wellbore. Sandstone has been designed as wellbore where different perforation parameter has been imposed to see the effect on the stability i.e. shot density and perforation pattern. Then the effect of wellbore instability on sand production also analysed carefully. Generally all models fails and sand particles were produced and found that stable perforated wellbore produce less sand particles.

KEYWORDS :
Wellbore Stability, Sand Production, Shot Density, Perforation Patterns, Borehole

INTRODUCTION

When oil is produced the oil have to go through the wellbore before collected at the surface. Therefore maintaining or designing the wellbore would be the most important factor that should be considered in field development period. Fail to do so, the wellbore may fail and this will increase the rig time and lot of cost involve. Moreover the formation collapse will lead to sand production and total casing collapse. Thus, serious consideration need to be looked into the matter. It is known that a reservoir rock is in equilibrium between overburden and pore pressure and in triaxially stressed state. Hence, when perforation are created in the production zone, the stress will be redistributed to surrounding rock. Therefore the wellbore becomes more stressed any easy to collapse due to factor such as pore pressure, flow rate, shot density, perforation pattern. Since only the static has been conducted, only the shot density and perforation has been varied in this research paper.

LABORATORY WORKS

As early experiment, laboratory work has been done in order to determine the basic mechanical properties such as porosity, permeability, compressive and tensile strength of sandstone sample which will be used for design the wellbore model later.

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The basic mechanical properties were determined correspondence to the American Standard Testing Method (ASTM- Suggested Method by Brown).

Sandstone sample were cored for 2 inches diameter and cut for 5" length for compressive strength. Whereas for the tensile strength test 2" diameter cores were cut for 1" length. Then the specimen were tested for porosity and permeability before the compression test under a Servo Controller machine and for the tensile the Brazillian testing method were used.

Wellbore Model

Wellbore model designed from sandstone rock mass obtained from field. The sandstone were cored in dimension of 6" and then trimmed to 6" length. Later 2" borehole cored at the centre of the core. To represent casing, 1" OD steel pipe was then cut to correct length. The core then has been put in the oven to remove the moisture. The weight then recorded before the cores were saturated with glycerol to represent as oil formation. As the cores has been fully saturated again the weight been recorded.

In order to place the casing (steel pipe) in the centre of the borehole, G Class Cement as been squeezed in the annulus as bonding agent between casing and formation. The system then left over for 24 hours to allow the cement to set. Then sandstone model then perforated with various shot density (6 SPF, 8 SPF and 16 SPF) in accordance to the perforation pattern i.e.spiral, inplane and inline hand drill right through the cement into the sandstone wellbore model.

Stability Test

The stability test then been conducted for the wellbore model using Servo Controller Compression Machine. Load has been applied at a constant rate (0.7 $MN/m^2/s$) until the wellbore model fails. A plot of axial load against deformation was produced to indicate the onset of the failure of the wellbore model. Then the sand particle produced collected carefully for sieve analysis.

Sieve Analysis Procedure

The particles which produced by the wellbore model were weighted before being sieved. This weight will be recorded as recovered weight. Then the laboratory disc was carefully emptied on the nested sieves. To avoid contamination by dust and sand particle loss the sieve column was closed off with cover. Electric sieve shaker then used to shake the nested sieve for 10 minutes (Vicker (1978), Craigh (1978) and Wills (1979)). Then the contents of each sieve was carefully brushed off and weighted

RESULTS AND DISCUSSION

The results show that the porosity value is the range of 0.08% to 0.17%. Found that the permeability range from 0.1mD to 0.8 mD. The average value for the compressive strength, Co is 32 MN/m2 and average value for tensile strength, To is 1.85 MN/m2.

In general, the results show that the perforated wellbore may fail and sand particles were produced. The stability and sand particle are fully depends on the perforation parameter i.e. shot density and perforation pattern.

The complete summary of the effects can be seen in Table 1. It is found that the sand particles are basically related to the gross deformation and stability of the perforated wellbore. Basically the stable wellbore produced less sand particles.

Table 1 - Summary of the results

Aspect			
Factor Increase	**Perforated Wellbore Stability**	**Sand Particles Produced**	**Size Distribution (> 500 microns)**
Shot Density	Decrease	Increase	Increase
Spiral Pattern	Strongest	Lowest	Lowest
Inplane Pattern	Intermeadiate	Intermeadiate	Intermeadiate
Inline Pattern	Weakest	Highest	Highest

Effects of Shot density

In general increasing shot density will decrease the stability of the wellbore model. Figure 1 shows that the 6 SPF shot density exhibit the most stable wellbore followed by 8 SPF and 16 SPF.

As a result, increasing the shot density can be defined as reducing the amount of the rock mass. Thus more stress have to be redistributed along the perforation system. In other hand the redistributed load/stress must be carried by the surrounding rocks. Therefore the rock mass strength reduced tremendously as shot density increases. Moreover, greater stress concentration in the rock between perforation tunnel can be experienced as the number of shot density increases.

Hence, 16 SPF shot density will be exposed to more stress concentration compared to 8 SPF and 6 SPF. Thus the 16 SPF wellbore model fails at lower axial stress since the wellbore model couldn't stand much stress and the yield point has been achieved earlier compare to 8 SPF and 6 SPF models.

Effect of Perforation Patterns

Known that all the model were perforated with different perforation pattern i.e. Spiral, Inplane and Inline. This patterns have a great influence on the wellbore stabilities failure orientation and stress at the failure. Fig. 2 gives the effect of the perforation patterns on wellbore stability for the models.

Overall view tells us that the spiral is the most stable perforation pattern for all the shot densities. This is followed by the inplane pattern and the weakest model would be the inline pattern.

This phenomenon is due to inline pattern, the perforation tunnels are in one vertical line, parallel to the applied load, which resulted in a rock mass strength to the applied vertical stress which is lower than for an inplane pattern where the perforation tunnels are

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In one horizontal line perpendicular to applied vertical/axial load. Therefore the rock mass strength to the applied vertical stress is higher in inplane pattern than inline pattern.

In Spiral pattern, the perforation tunnels are in a plane inclined to the applied vertical stress, resulting in higher rock mass strength to the applied vertical stress than for the other two previous patterns. The spiral pattern produces the greatest distance between each successive perforation and therefore a stronger perforated structure.

Sand Particles Produced

Figure 3 shows the total sand particles produced after the wellbore model fails under uniaxial compression. The Figure explains that the most sand produced for the wellbore model which perforated with 16 SPF and inline pattern. Whereby the 6 SPF shot density and spiral pattern exhibit the least sand particle produced. In other words it can be said that the more stable the wellbore the lesser will be the sand particle produced.

Size distribution for sand particles.

Figure 4, 5 and 6 show the distribution of sand particle sizes for spiral inplane and inline respectively. Found from Figure 4 (Spiral pattern) that as the shot density increases the oversized 500 micron of sand produced at failure also increases. The increment is 10.63% % to 33.58%. The Inplane pattern also exhibit the same phenomenon where the 500 microns size sand particles increased from 6.43 % to 15.9 % as the shot density increases. As for the inline pattern the oversized fragments increases from 5.57 % to 31.73 % as the shot density increases from 6 SPF and 16 SPF.

Generally, less 500 microns sand fragments were produced by decrease in the shot density and by changing the perforation pattern from inline to inplane and spiral.

Thus, can be concluded that the spiral perforation pattern with 6 SPF shot density produced the least large sand particles

CONCLUSIONS

From overall observation, it was found that all the perforated wellbore models may fail and sand fragments were produced based on to the shot density and perforation pattern. As the shot density increases and perforation pattern changes from spiral, inplane, inline, the wellbore stability decreases and the amount of sand fragments produced increases. In other word, the more sand fragments produced by the unstable perforated wellbore.

Understanding the effect of the perforation parameters i.e. shot density and perforation pattern to the wellbore stability and sand production, thus, optimisation of production and minimising the sand production problem can be done. Consideration the wellbore stability effects in designing phase of petroleum field development can accomplish mention optimisations. As a result, this knowledge also can improve the well stimulation project or requirement such as acidizing, hydraulic fracturing and etc.

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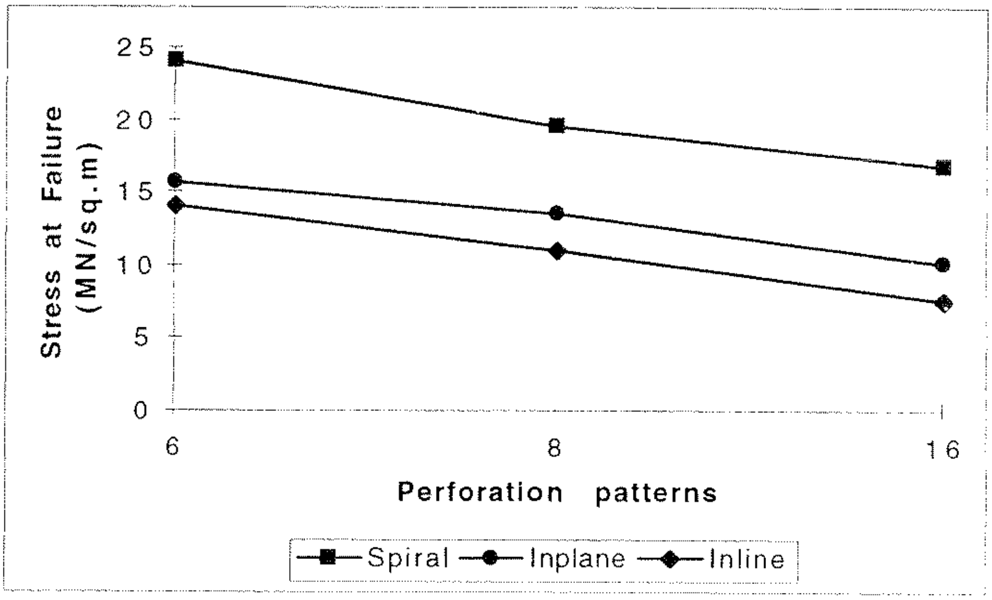

Figure 1- Effects of Shot Density to Wellbore Stability

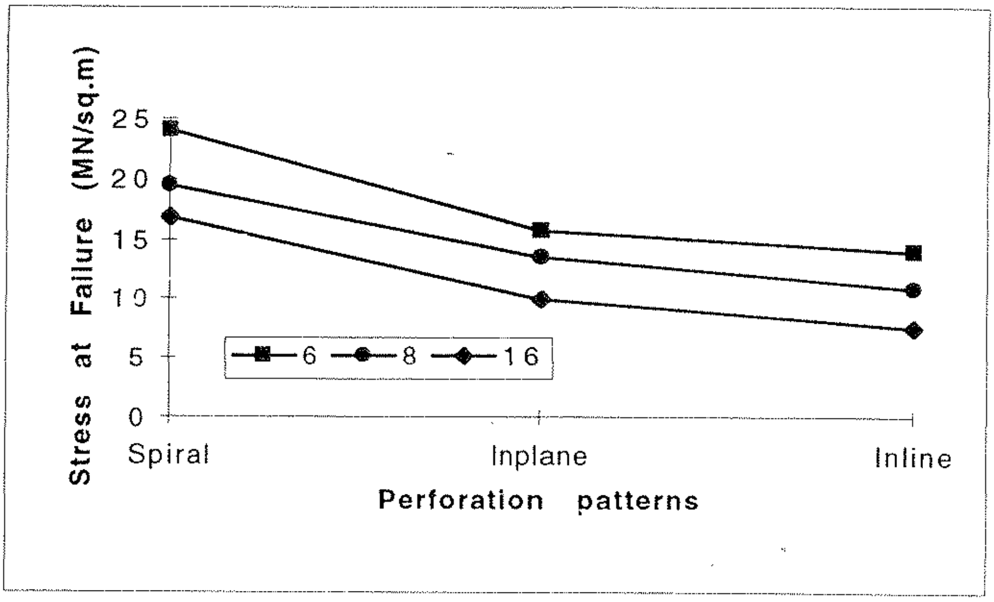

Figure 2- Effects of Pattern to Wellbore Stability

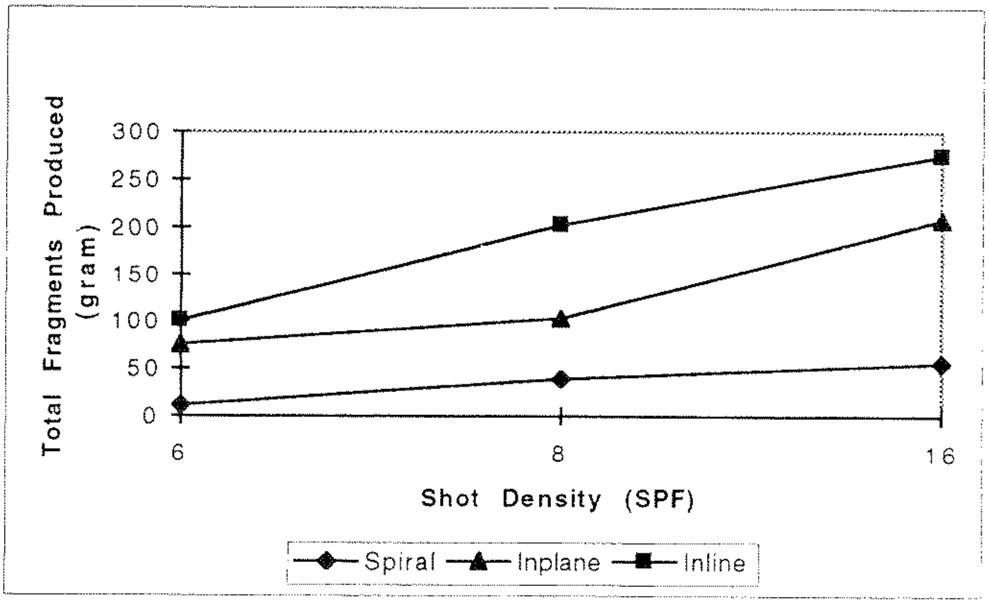

Figure 3- Effects of Shot Density to Sand Particles Produced

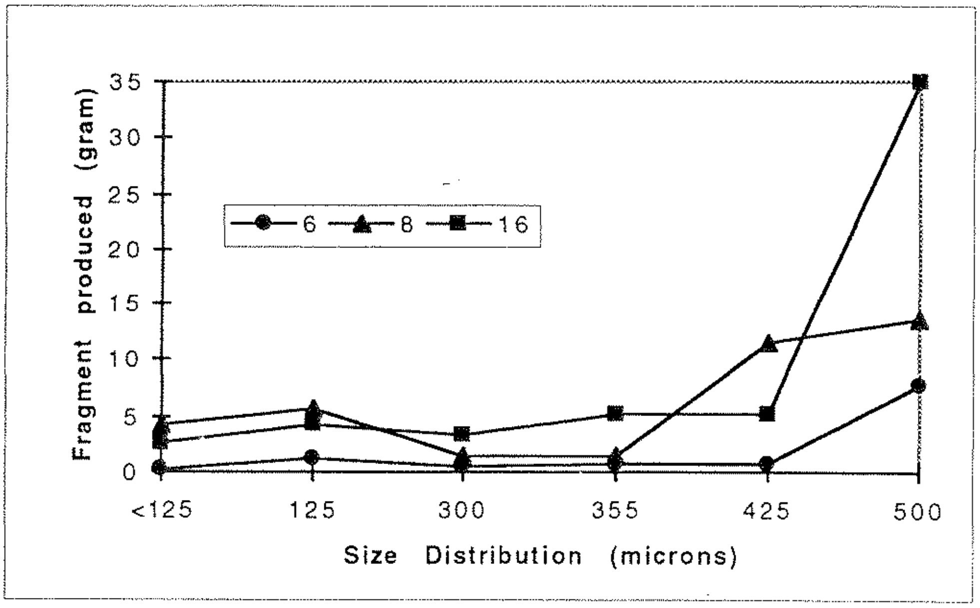

Figure 4- Effects of Shot Density and Spiral Pattern on Size Distribution

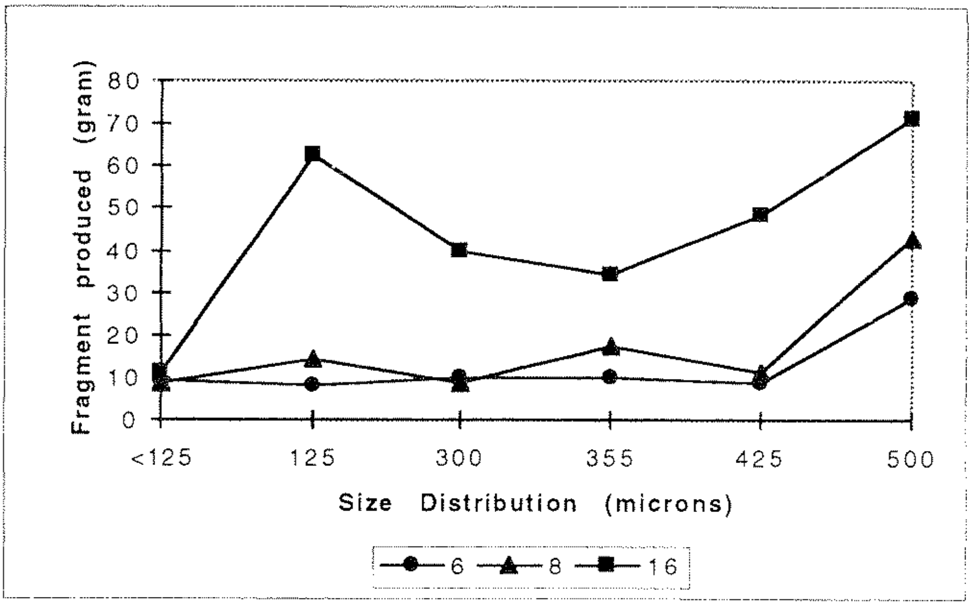

Figure 5- Effects of Shot Density and Inplane Pattern on Size Distribution

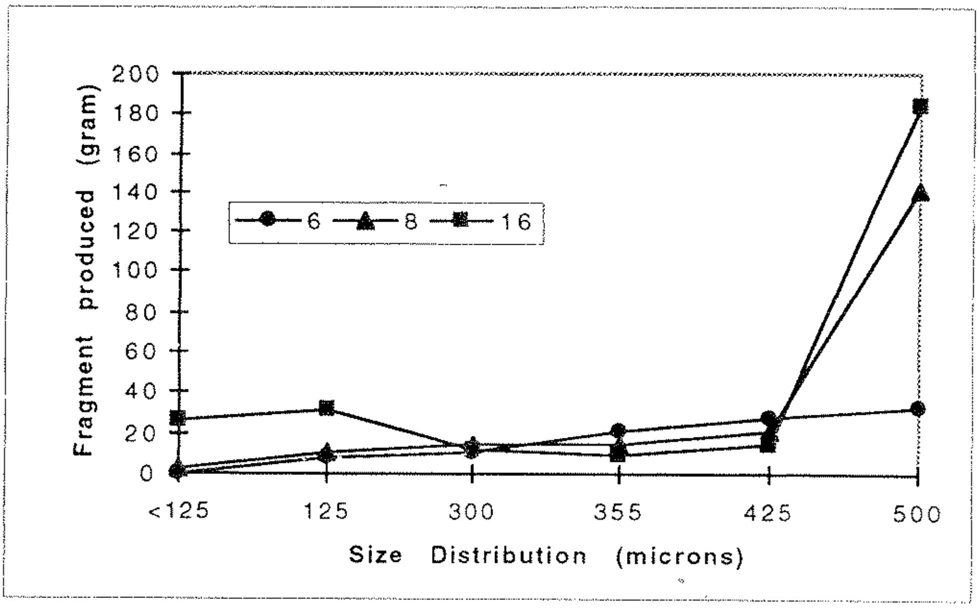

Figure 6- Effects of Shot Density and Inline Pattern on Size Distribution