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Contribution of Collapse Perforation to the Production of Loose Sand in the Wellbore

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ABSTRACT

This paper present the results of a laboratory study of the loose sand produced from the collapse perfora-tion. Sections of a perforated wellbore were ...erated and expose to various rock mechanical stresses and conclusions were drawn with respect to the produced loose sand during loading process, up to failure of the perforated structure. The results show that the perforation may fail during the creation process and the oversized 500 microns loose sand were produced or subsequent production life, depending on the perforation length, shot density, phasing angle and pattern, and rock proper-ties. In general, stable perforated wellbore can minimize the loose sand production in the wellbore, therefore minimizing the sand production problems.

INTRODUCTION

It is known that a reservoir rock is in equili brium between overburden and pore fluid pressure. When borehole and perforations are created in the productive zone, the reservoir rock stresses are redistributed around the borehole and perforation. According to several investigators, (1-4) the borehole wall appears to be the weakest area. Therefore, when there is a perforation tunnel within the rock mass, rearrangement of the stress takes place and the surrounding rock must carry the redistributed load. This produces a stress concentration around the perforation tunnel, with maximum on the perforation wall, which corresponds to Jaeger's conclusion on a hollow cylinder. (5-6) This may exceed the peak strength of the rock, causing failure within the rock. This process may produce crushed material on the perforation face or the perforation may totally collapse, causing a reduction in perforated well productivity or sand production.

The sand production mechanism is exceedingly complex and it is influenced by every completion operation from first bit penetration to production period of the well. Sand production has become a major problem in many regions of the world. A high percentage of current exploration and development effort is being expended in these areas. Sand control is not only time-consuming and expensive, but also generally causes severe productivity restriction.

Loose sand has a tendecy to move toward a wellbore as fluids move in the reservoir unless some action is taken to prevent the movement. Sand migration into a wellbore can have devastating effects, such as production loss; failures of casing, slotted liners and other equipment; material handling and disposal problem. Successful sand control application requires that each step of the well completion and production be designed and executed properly. Such steps including drilling and hole opening, primary casing cementing, perforating and perfora-tion clean-up and use of completion and workover fluids, as well as the sand control installation and production operation.

Little attention has been paid in the literature to the stability of the perforation and it contribu-tion to the production of the loose sand in the wellbore.

THE EXPERIMENTAL WORK

The laboratory work used two types of models; i.e. blocks and hollow cylinders. For both models an extensive rock properties testing program was run to determine strength, modulus of elasticity, Poisson's ratio, angle of internal friction and apparent cohesion. There are six different types of rock which have been used: yellow well cemented sandstone (YH), red well cemented sandstone (RH), white well cemented sandstone (WH), white well cemented with carbonaceous layers sandstone (WHWR), red sandstone with well cemented grain and carbonace-ous layers (RHWR) and yellow loosely cemented sandstone (YS).

Block Models

The block models dimensions were 457 mm by 305 mm by 305 mm, with a 127 mm diameter hole cored in them to represent a wellbore. They were then split along the axis of the hole to provide two half boreholes. To represent the casing, a steel pipe of 102 mm inside diameter and 114 mm outside diameter was cut to the correct length. The section of steel pipe was then cut into two halves through the centre and trimmed to the exact dimensions to fit exactly to the block. Once the steel pipes were of the correct dimension, the 12 mm diameter holes were then drilled through the wall in accord-ance with the particular shot density, phasing angle, spacing and pattern of the block to be

Loose Sand Size Distribution

The perforation length also influnced the size distribution of the produced loose sand, that is, more oversized 500 microns loose sand are produced as the length increases, as shown by Fig (4). This figure also shows that increasing the 6 shots per foot, inline perforation length from 120 mm to 130 mm will increase the amount of oversized 500 microns loose sand from 50.95% to 68.92%.

As the shot density increases from 4 to 6 shots per foot with length ranges from 78 mm to 89 mm, the oversized 500 microns loose sand produced will increase from 56.25% to 88.19%, as shown by Fig (5). The effect becomes smaller as the length increases, as shown by Fig (6). These figures show that for a perforation length of 125 mm to 130 mm, increasing the shot density from 4 to 6 shots per foot, will increase the oversized 500 microns loose sand produced from 45.73% to 68.92%, which is less than for perforation length range of 78 mm to 89 mm. These results show that increasing the shot density will increase the amount of larger loose sand produced, depending on the perforation length.

Fig (7) shows that changing the phasing angle of 6 shots per foot from 0 degree to 60 degree will reduce the amount of oversized 500 microns loose sand produced from 88.19% to 35.68% and 30.54% for inline, inplane and spiral pattern, respectively. These results also show that 60 degree phasing with spiral pattern produces lesser larger loose sand from another two basic patterns since the spiral pattern is the most stable perforated structure.

Fig (8) shows that the grain size distribution of loose sand produced by the collapse perforation also depend on the rock type. The effect of rock type on grain size distribution depends on perforation length, shot density, phasing and pattern of the perforation system. It shows that oversized 500 microns loose sand produced from spiral perforation in yellow well cemented sandstone will increase as the shot density increases. On the other hand, oversized 500 microns loose sand produced from 6 shots per foot collapse perforations in red well cemented sandstone will increase as the pattern changes from inplane to spiral.

CONCLUSIONS

The study has shown that the perforation may collapse during the creation process or subsequent production life and there are also loose sand produced from the collapse perforation tunnel. Most of the loose sand produced are oversized 500 microns. The amount and size distribution produced depend on the perforation length, shot density, rock type, phasing angle and pattern. The amount of loose sand produced by collapse perforation increases as the perforation length and/or shot density increase. On the other hand, the amount of loose sand produced decreases as the phasing angle increases and the pattern changes from inline to inplane or spiral. The effect becomes greater as the shot density or the perforation length decreases.

In general, the amount and size distribution of loose sand produced by collapse perforation depend on the stability of the perforation system. More stable perforation system produce less loose sand. Loose sand has a tendecy to move toward a wellbore as fluids move in the reservoir, so collapse perforation will contribute to any production of loose sand in the wellbore. Stable perforated wellbore can minimize the loose sand produced in the wellbore, therefore minimize the sand production problem.

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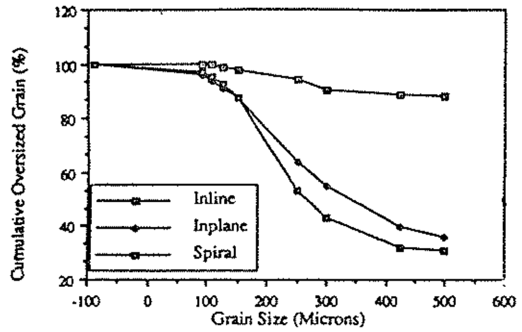

Fig. 7. Effect of Phasing Angle and Pattern on Loose Sand Size Distribution Produced by Collapse Perforation

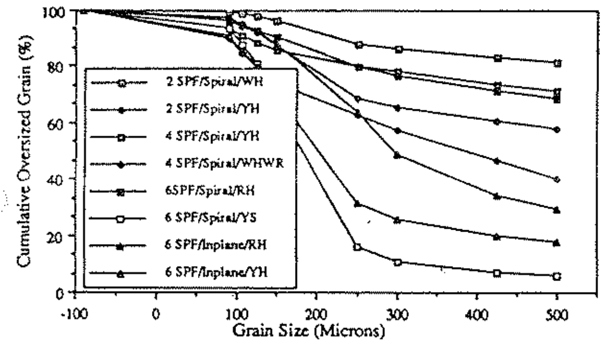

Fig. 8. Effect of Rock Type on Loose Sand Size Distribution Produced by Collapse Perforation