PREDICTING SAND PRODUCTION

Introduction

As a follow up to the Causes and Effects of Sand Production article in the last DiaLog update, the next area of interest would be predicting formation failure prior to drilling a well to enable sand control options to be evaluated and considered economically. Being able to predict whether a well will produce fluids without producing sand or predicting that some type of sand control will be required has been the goal of many completion engineers and research projects. In spite of the fact that there have been a number of analytical techniques and guidelines developed to assist in determining if sand control is necessary, no technique has yet proven to be universally acceptable or completely accurate. In some geographic regions, guidelines and rules-of-thumb apply but these have little validity in other areas of the world. At the current time, predicting whether a formation will or will not produce sand is not an exact science and more refinement is still needed. Until better prediction techniques are available, the best way of determining the need for sand control in a particular well is to perform an extended production test with a conventional completion and observe if sand production occurs. Offset wells producing in the same formation, in the same field and under similar conditions are also a good indicator of the need for sand control.

Operational and Economic Influences

The difficulty of determining whether or not sand control is required in a given well is compounded when the well is drilled in an area where there is little or no producing experience and where the various reservoir factors are slightly different from previously exploited regions. Even if the reservoir and formation properties are almost identical to other developments, the operating conditions and risks may be such that different strategies apply. One example is a subsea project as opposed to a platform development. Here, the consequences and risks associated with sand production are significantly different due to differing cost and risks associated with remedial well operations. Hence, the decision to use a sand control technique is both an economic and operational decision that often must be made with limited data. The decision is complicated by the fact that sand control techniques, such as gravel packing, are expensive and can restrict well productivity if not done properly. Therefore, gravel packing cannot be applied indiscriminately when the possibility for sand production from a well is unknown. Making the decision to gravel pack is not too difficult or risky if the formation material is either very hard or very weak. The difficulty arises when the strength of the formation material is neither strong nor weak, but is in the range between those two extremes. At that point the decision normally ceases to be primarily a technical issue but more of an economic and risk management exercise.

Formation Strength

The general procedure followed by most operators considering whether or not sand control is required is to determine the hardness of the formation rock (i.e. the rock's compressive strength). Since the rock's compressive strength has the same units as the pressure drawdown in the reservoir, the two parameters can be compared on a one to one basis and drawdown limits for specific wells can be determined. Research performed at Exxon (1) in the early 1970s shows that there is a relationship between the compressive strength and the incidence of rock failure. These studies show that the rock failed and began to produce sand when the drawdown pressure is 1.7 times the compressive strength. As an example, a formation sand with a compressive strength of 1,000 psi would not fail or begin to produce sand until the drawdown was about 1,700 psi. The testing described was performed with the equipment illustrated in Figure 1 and an example of rock sample failure is shown in Figure 2. The correlation of the data

from the research is shown in Figure 3. Sometimes the Brinnell hardness of the rock is used as an indicator of whether to apply sand control. Although the Brinnell hardness of the rock is related to the compressive strength it is not as convenient to use since the units of hardness are dimensionless and cannot be related to drawdown as easily as compressive strength.

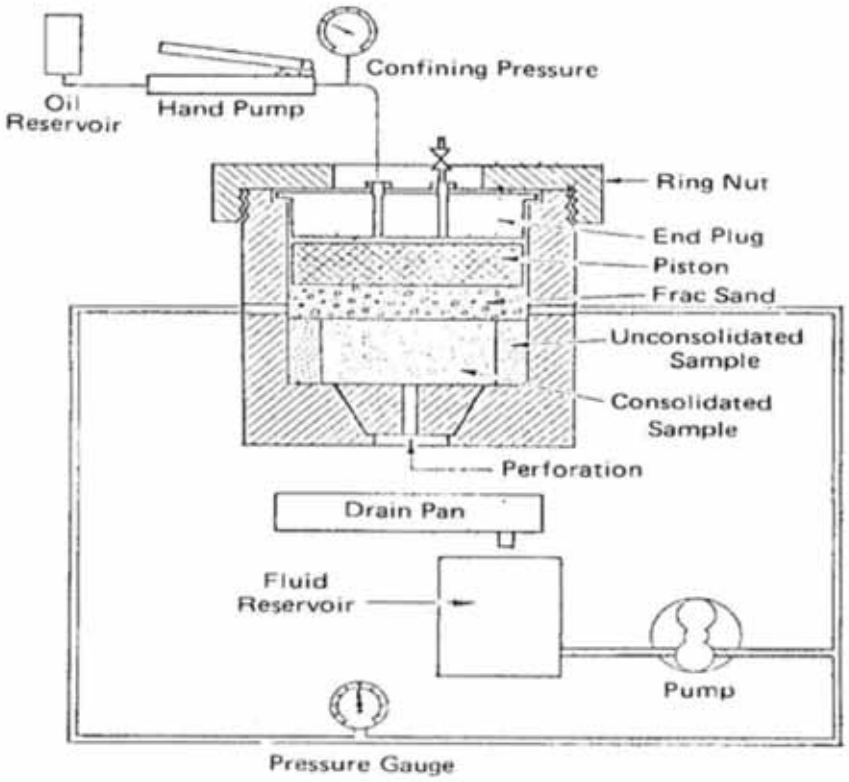

Figure 3.1
Apparatus for Testing Failure of Rock with Pressure Drawdown[1]

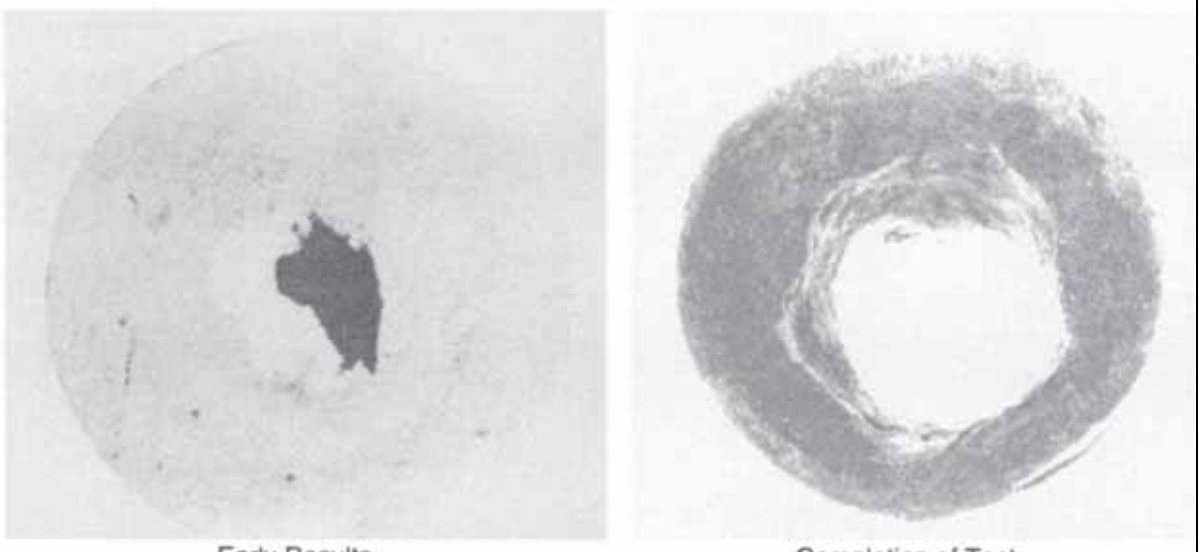

Figure 3.2
Cavity Formation in Rock Sample During Drawdown Failure Testing[1]

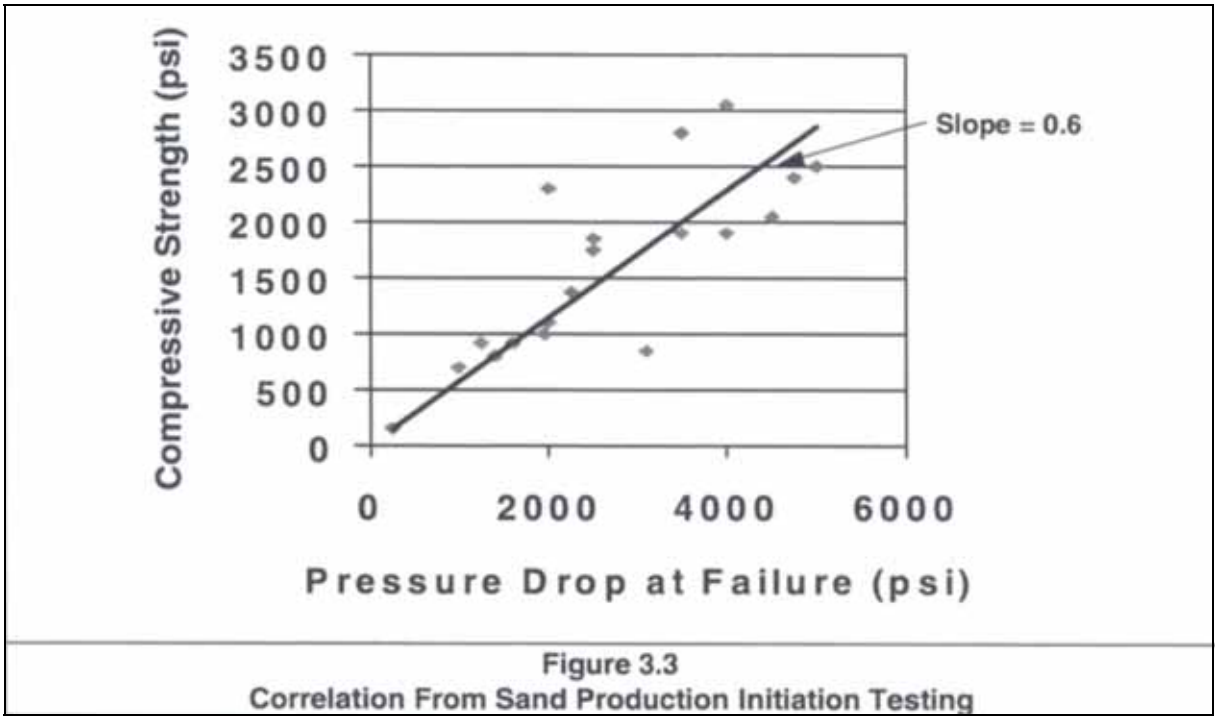

Figure 3.3
Correlation From Sand Production Initiation Testing

The Sonic Log

The sonic log can be used as a way of determining the sand production potential of wells. A common technique used for determining if sand control is required in a given geological area is to correlate incidences of sand production with the sonic log responses. This establishes a quick and basic approach to the need for sand control, but the technique can be unreliable and is not strictly applicable in geological areas other than the one in which it was developed.

Formation Properties Log

A formation properties log (2) is offered by several wireline companies that performs a calculation using the results of the sonic, density, and neutron logs to determine the likelihood of whether a formation will or will not produce formation material at certain levels of pressure drawdown. This calculation identifies which intervals are stronger and which are weaker and therefore more prone to produce formation material. While the formation properties log has been used by some companies for over 15 years, the consensus is that this type of log is usually conservative in its predictions of the need for sand control.

Porosity

The porosity of a formation can be used as a guideline for the need for sand control. If the formation porosity is higher than 30 percent, the probability of a requirement for sand control is higher. Conversely, if the porosity is less than 20 percent, the need for sand control will probably be less. The porosity range between 20 to 30 percent is where uncertainty usually exists. Intuitively, porosity is related to the degree of cementation present in a formation; thus, the basis for this technique is understandable.

Finite Element Analysis

Probably the most sophisticated approach to predicting sand production is the use of geomechanical numerical models developed to analyse fluid flow through the reservoir in relation to the formation strength. The effects of formation stress associated with fluid flow in

the immediate region around the wellbore are simultaneously computed with finite element analysis. While this approach is by far the most rigorous, it requires an accurate knowledge of the formation's strength both in the elastic and plastic regions where the formation begins to fail. Both of these input data are difficult to determine with a high degree of accuracy under actual downhole conditions and that is the major difficulty with this approach. The finite element analysis method is good from the viewpoint of comparing one interval with another but the absolute values calculated may not represent the actual formation behaviour.

Time Dependence

Whether time has an effect on the production of formation sand or not is sometimes considered to be an issue however there is no data that suggests that time alone is a factor. There have been undocumented claims that produced fluids could possibly dissolve the formation's natural cementing materials, but no data is available to substantiate these claims.

Summary

In some respects the inaccuracies in predicting the sanding potential of formations may be an academic exercise. Present technology can produce a calculation or other methodology to accurately determine whether sand control will be required in a particular well or reservoir. The irony of this situation is that at the point where the calculation or methodology has been developed and proven, the operator already knows whether sand control is necessary or not due to the producing experience gained while obtaining the necessary data for the calculations.

Experience has generally indicated that the best approach to completing wells, particularly in high productivity and high cost developments, is to avoid sand control in situations where the need for sand control is not clearly defined and where economics and risk analysis suggest that conventional (no sand control) alternatives are economically more attractive. Production experience from early wells should indicate whether this approach is correct. If sand control is in fact required, a few wells will have to be worked over; however, the sand control issue will be resolved once and for all and the remaining field development can proceed with a high degree of confidence in knowing the sand production tendencies of the formation.

To summarise, the best technique for predicting sand control is the performance of the well in an extended production test. If such a test is not available then existing technology, as discussed above, should be used to assess the sand producing tendencies of the formation. In the unfortunate event that applicable sand prediction techniques are inconclusive or borderline, the risk and economic analysis of not installing sand control can be evaluated to determine the type of well completion best suited for the formation and operating environment.

References

1. Penberthy, W.L. and Shaughnessy, C.M., Sand Control, SPE Series on Special Topics, Volume 1, 1992.
2. Tixier, M.P., Loveless, G.W., Anderson, R.A., "Estimation of Formation Strength from the Mechanical-Properties Log", Journal of Petroleum Technology (March 1975), 283-293.

This article was produced from material contained within the Baker Hughes Sand Control manual used for training clients and field service engineers and itself being an amalgamation of prior training resources.