Research Paper

Formation of Sand Production Control in an Oil Field, Libya.

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Abstract: Based on the characteristics of Amal oilfield, Libya, a detailed analysis of production problems, as well as the latest literature findings and the applied procedures, an algorithm for the selection of gravels and filters have been defined. It was found that the key problem at Amal oilfield in the production process is sand fill production. The problem, individually, has caused lowering oil production in some wells. In addition, based on the formation sand sample taken from the oilfield, its granulation is determined using granulometric analysis and, consequently, granulometric S-curve is obtained. That way, the coefficient of uniformity of the formation sand is obtained. since the gravel selected in such way completely prevents formation sand penetration into the wellbore while achieving its maximum permeability. The most modern Halliburton's three-layer filter was elected, with a complex structure, which completely prevents the penetration of formation sand with adequately embedded gravel.

Keywords: control, formation sand, granulometric analysis, gravel pack, filter.

1. Introduction

1.1. Oil Field Description

Amal oilfield or block *NC12* is located *50 km* north of Augila oasis in the eastern part of the Sirte Basin. Latitude and longitude are *29 ° 25 '0 N* and *21 ° 10' 0 E.* Oilfield consists of eight different reservoirs, which are located at a depth of about *3600 meters* and it covers an area of more than 100,000 hectares.Amal oil field was the leading oil producing field in Libya with extensive production capacity. It was discovered in *1959*, with average daily production about *200 M bbl/d*. Up to date, *226* wells have been drilled of which *122* wells were in production, while *58* wells occasionally do not work due to compressor downtime or for workover. Around *104* wells, which are not in function for a longer period of time because of low oil production, are shut off. At present, the average oil production is *19000 bbl/d*, consequently, this has also had a negative impact on the country's economy, since the product forms the organization of the country's export value **[1] – [3].**There has been an intensive development of oilfield over the past decades when a large number of new wells were drilled. New collecting stations 8, 9, and *10* have also been constructed. Production of oil is carried out mainly by means of Gas Lift.

Oil production in the Amal oil field has been declining over the past *40* years. Experts have argued that various surface as well as subsurface problems that can be attributed to this decline. Action must be taken to mitigate or to completely stamp out these problems to avoid the risk of the decrease in the production of oil from Amal oil field. Wireline jobs, as well as literatures, daily production reports and well test, all, show the oil production decline in the field. Subsurface operations are not well treated as surface operations, did not find enough care and most of the work over programs were about *ESP* wells and formations collapse are not satisfied. The development program over the past four decades have seen numerous wells drilled, but the field has not been improved in oil production. The life of the field after redevelopment *(2007)* was expected to be around *10-11* years with complete abandonment by *2017* **[4],[5].**

Production tests are run to obtain an indication of well productivity about thirty-nine oil wells in the Amal oil field declined by forty percent to eighty percent. Oil produced by Amal Wells has an *API* of between *36°* and *39°*and contains high wax, sulfur composition, salt and there are some wells producing with sour gas **[6].**Amal oilfield is owned by a Harouge Oil Operations company, previously (Veba Oil Operations), which is the joint venture of the National Oil Company of Libya and the Canadian company "Petro-Canada", each with a share of *50%*. According to the contract in *2007*, "Petro-Canada" should have implemented a comprehensive program of geological exploration, together with drilling new wells and expanding production facilities, all with the aim of increasing the production of oil from this oilfield. Since August *2009*, the share of "Petro-Canada" has been taken over by "Suncor Energy" **[7],[8].**

1.2. Exploitation methods

At Amal oilfield, oil production is carried out predominantly by using mechanical methods of exploitation:

- Gas lift (continuous) and
- Electric Centrifugal pumps.
- Natural flow

Gas Lift Exploitation Method was applied at *88* wells, while Electric Centrifugalpumps are used for production at *27* wells .Figure - 1 shows the representation of exploitation methods at Amal oilfield.
In spite of the extensive reported work in the area of understanding and control of sand production, theoretical approaches and guidelines for predicting the sanding phenomena and techniques for sand control still need further research and development as demonstrated by **[9].**The majority of the available gravel sizing criteria, based on the gravel to sand grain size ratio do not actually

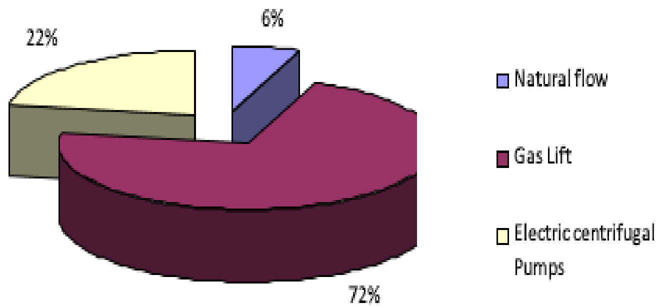

Figure – 1: Representation of exploitation methods at Amal oilfield

Agree with each other **[10].** Others developed gravel sizing criteria based on the gravel to mean size of the formation sand for similar percentile points of sieve analysis curves, solely from the geometrical point of view. Therefore, Bouhroum and **[9]** state: A major problem with gravel-pack design criteria is the significant focus given by researchers to the geometrical retention criteria while neglecting the other aspects of the filtration process, such as clogging and hydrodynamics **[11],12].** The important simplifying assumptions of this model are: *(a)* the sand particles are generated in the near-wellbore formation and deposited in the gravel pack, and *(b)* the clay swelling effects are not considered. Production of formation sand at Amal oilfield has caused many problems. The problems have intensified over time, which caused defects and partial or complete interruption of oil production at certain wells. Figure - 2 shows the sand fill sample from oilfield Amal **[13].**

Amal oilfield, there were attempts to control the phenomenon of formation sand at a certain number of wells by controlling the removal of sand but they were ineffective. From the scientists' experiences, it was shown that the method of removing formation sand is an exception rather than the rule. The consequences of formation of sand production are shown in Figure - 3.

1.3. Effects and causes of Sand Production

1. Erosion – down-hole and surface

*Figure – 2: Formation sand sample, Source **[13***

2. Plugging
- Sump and flow-lines
- Perforations
- Pore space - fines!
3. Near wellbore compaction
- Slumping of casing
- Subsidence
- Loss of productivity (increased apparent skin) Filling of separators – poor efficiency Removal difficulties
4. Disposal of contaminated sand

Figure – 3: The consequences of formation sand production, Source: Sanjay K. Dhiraj Dy. SRE, G&R Deptt.

Sandstone strength linked to the degree of cementation. Cementation increases over time, older sediments are more consolidated.

- Sand production more common in younger and shallower sediments. Effects of production (pressure reduction and fluid movement) contribute to formation breakdown due to inertial and viscous forces.
- Pressure depletion increases grain to grain forces, potential to exceed compressive strength and failure.

In the wellbore and surface, equipment is the erosion of drilling and surface equipment and this sand causes collapse of formation at the good zone. In addition to the costs of direct removal of formation sand deposition or replacing damaged equipment due to erosion, deposits of sand have furthermore caused an interruption of production which must also be taken into account. The classical filter was applied to solve the problem of sand deposits into the wellbore. This application did not give a proper result, because after a period of time the deposits of sand into the wellbores were recorded again **[13].**

1.4 Screens -Principles

- Sand control using installed screens is designed to exclude all but the finest formation particles from being produced into the wellbore.
- Effective design of screens requires the acquisition of core samples for particle size analysis. Seeking to induce particle bridging and dynamic filtration as shown in Figure - 4.

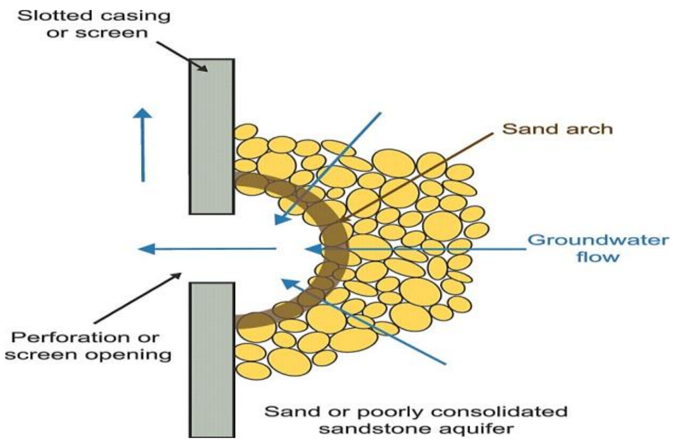

Figure – 4: poorly consolidated sandstone aquifer, Source: A. N. Charalambous, M. Packman and B. R. Burnet

1.5 Sand depositionin the wellbore and surface equipment

When the velocity of fluids which are produced is not high enough to bring the formation sand to the surface, the sand tends to accumulate at the bottom of the wellbore. During the further process of the formation of sand entering the wellbore, it begins to cover the perforations which cause a reduction in productivity that would eventually end the production completely. Formation sand is removed from the well by using wire-line tools or through coiled tubing tools with a constant circulation of fluids. The process of removal requires closing the well or interruption of production.

At the velocity of the fluid, which are sufficiently great to carry the formation sand to the surface, causes the sand to appear in the surface equipment. Greater quantities of formation sand in any part of the equipment cause problems such as lowering the capacity or damaging individual pieces of the equipment. Reduction of the separator capacity was a characteristic problem. It is necessary to mechanically remove formation sand from the equipment, which requires interruption of production.

Erosion of surface production equipment and facilities, as well as drilling equipment, is observed in high producing wells, which require intensive maintenance and replacement of damaged equipment. Long-term erosion of formation sand on some wells caused serious damage. The failure caused disruption in productivity due to equipment failure in the well and it was necessary to engage a workover rig. When the oil is produced from relatively weak reservoir rocks, small particles and sand grains are dislodged and carried along with the flow. This sand production can create erosion in flow-lines and other equipment, Figure 5. Shows transporting an enormous quantity of formation sand with the produced oil at some wells caused a failure of the formation near the wellbore area and causes erosion in tubing and casing strings.

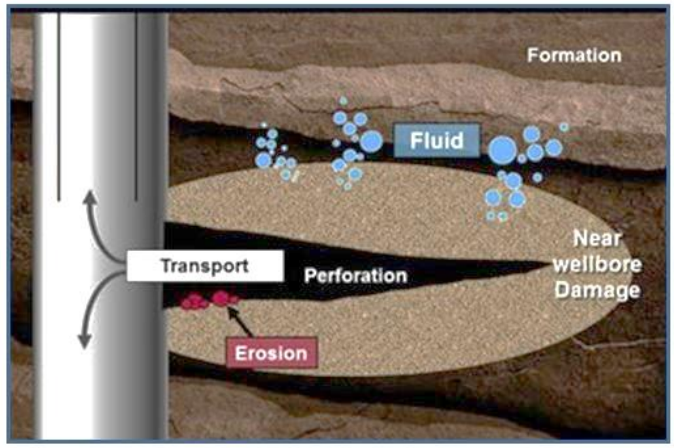

Figure – 5: Erosion in Tubing and Casing strings. Source: IPTC Photo Metadata, Matricardi.

2. The Method

Sand can present major obstacles to well production through reduced production rates, sand bridging, erosion of equipment, and sand disposal and removal.

The problem of formation sand production at the Amal oilfield is present and so far, methods for its solution have not been applied. "Gravel Pack" method is suggested. It is based on the installation of filter equipment in the wellbore and additional filling of the extra space between the filter and wellbore with artificial materials - gravel **[14].** This method has been successfully applied in the world for solving the problem of formation and production in the wellbore [**15 - 18**]. Also, at the "NIS" wellbores, where this problem is present, "Gravel Pack" method proved to be very successful because the installation of gravel prevents contact between formation sand and filter equipment and its damage due to this. Since the problem of formation sand has not been solved yet, it's necessary to undertake a range of actions such:

- Sampling of formation sand.
- Grain-size analysis of formation sand
- Determining the uniformity of the formation of sand
- Determining the optimal granulation of gravel
- Determining the optimal clearance of filters.

Based on the study of the corresponding literature **[19 - 23],** and the applied procedures, an algorithm for the selection of gravels and filters have been defined as shown in the figure 6

To effectively solve the problem of formation sand, it is very important to obtain a representative sample. A sample of the formation sand may be obtained by coring and taking it from the depth of the wellbore or from the surface of the wellbore. By coring, an adequate sample is obtained if coring can be carried out. Since this case is rare, the sample is usually taken from the wellbore itself using slick-line. The sample may also be taken from the surface of the wellbore, but it is of lower quality as it contains smaller particles. Based on the formation sand sample taken, its granulation is determined using granulometric analysis and, consequently, granulometric S-curve is obtained. That way, the coefficient of uniformity of the formation sand is obtained.

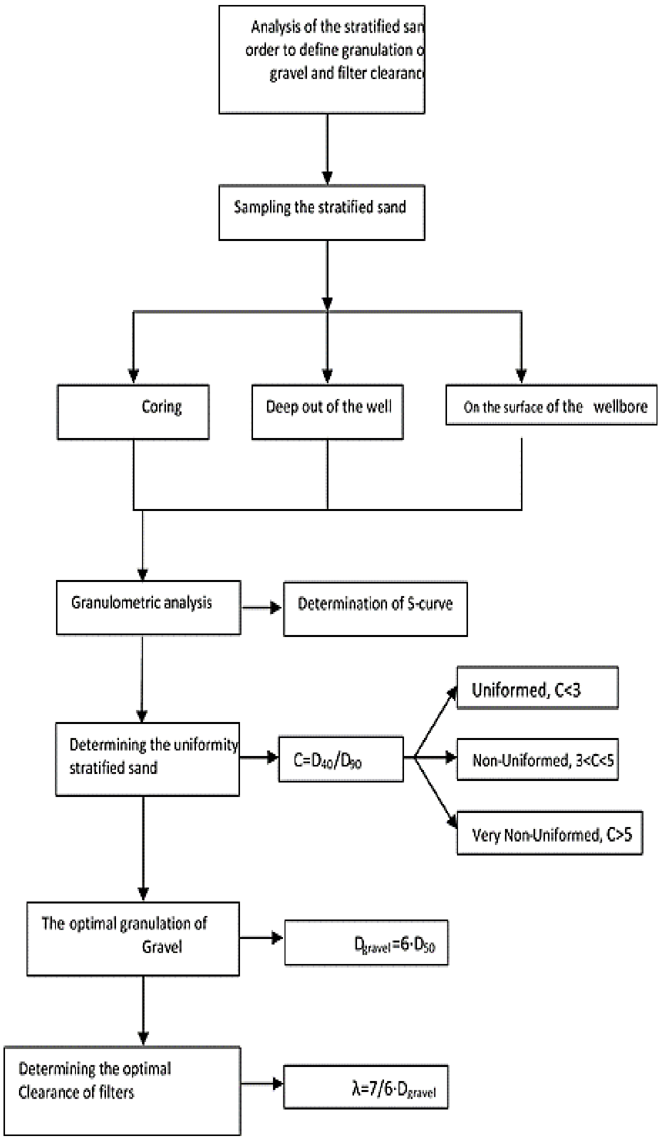

Figure -6: Analysis of the formation sand in order to define optimal granulation of the gravel and filter clearance

Nowadays, the granulation of the gravel is usually determined on the basis of the Saucier's method **[24 - 26],** since the gravel selected in such way completely prevents formation sand penetration into the wellbore while achieving its maximum permeability. The optimum clearance on the filter is determined based on the selected size of the gravel by applying expression*: λ = 7/6 • Dgravel* **[27 - 29].** Based on the performed granulometric analysis, the appropriate gravel has been chosen and shown in Figure – 6, **[30 - 32].** Granulometric S-curve and other detailed results of the analysis of the formation sand are not shown due to confidentiality.

Figure – 7: Selected gravel

Figure - 7 and Figure – 8 Show the selected filter and cross section of the selected filter respectively **[30].** It is a new type of filter with complex structure. Part of the filter construction is shown in figure 8. The filter consists of three levels, the base of the filter consists of the perforated pipe equal to tubing diameter. It has a first level of filter that is made of round wire winding with diameter of *0.5 mm*. The third level of the filter is made of wire of trapezoid shape with the longer side of the trapezium facing the outside of the wellbore. With such position of the trapezoidal wire, the minimal opening of a filter towards the formation sand is achieved and thereby it prevents a possible breakthrough in the construction of the filter. The second layer of the filter represents the filling between the first and third layer of the filter. The filling represents safety layer which should also prevent any penetration of the formation sand through the third layer of the filter.

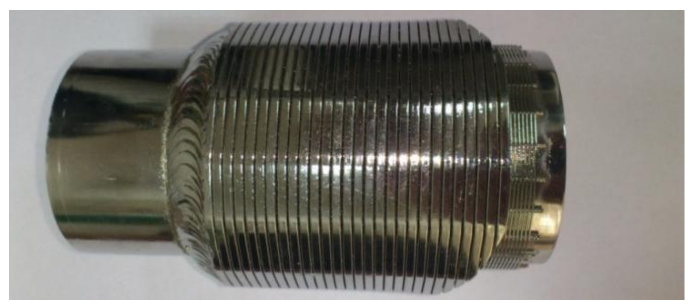

Figure – 8: Selected filter

Figure – 9: Cross-section of the selected filter

3. Results and Discussion

Based on the characteristics of Amal oilfield, a detailed analysis of production problems, as well as the latest literature findings It was found that the key problem at Amal oilfield in the production process is sand production. The problem, individually, has caused lowering oil production in some wells. It was, therefore, necessary to take additional measures and actions to solve production problems so that they would not worsen and cause an even greater drop in oil production.

Selected gravel which backfills the filter installed in the wellbore prevents direct contact between formation sand and filter. This is very important because otherwise, the oscillation of the formation sand in direct contact with the filter would cause the damage to the filter and gradual penetration through the layers and its entry into the wellbore. This is the reason why the application of the filter in the wellbore is not successful without the gravel pack.The gravel selected in such way completely prevents formation sand penetration into the wellbore while achieving its maximum permeability. The most modern Halliburton's three-layer filter was elected, with a complex structure, which completely prevents the penetration of formation sand with adequately embedded gravel.

4. Conclusion

Gravel pack method is proposed for solving layer sand penetration into the production system. The complete procedure is defined, starting from sampling formation sand, granulometric analysis of formation sand in order to determine the uniformity of formation sand, optimal gravel granulation, as well as determining the optimum gap of filters. The scientific contribution of this work is reflected in the original model for solving production problem at Amal oilfield. In addition to the importance of this oilfield, the paper has a wider significance as well, since the proposed model is applicable at other oilfields for solving a similar problem.

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