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Research paper

Casing collapse risk assessment and depth prediction with a neural network system approach

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ABSTRACT

A large carbonate oil field in Iran is suffering from severe casing collapses. 48 casing collapses have been occurred due to reservoir compaction, poro-elastic effects and corrosion. The application of neural networks for predicting casing collapses using complex multi-dimensional field data has been undertaken. This paper shows how a neural network (ANN) system can be trained based on the parameters affecting casing collapse to estimate the potential of collapse of wells to be drilled as well as the current wells producing in the field. The potential use of this type of analysis is large in that it can be linked as a critical risking parameter in future field development analysis. Being able to quantify the potential for collapse of a well in the future can give management the foundation for a better financial decision making on what wells and where to drill them with the potential for the larger net return on the investment. The estimated collapse and corresponding depth could also benefit in the type of casing design and completion method to be selected as well as workover designs. Interpretation of the neural network results, together with engineering judgment, allowed us to conclude that using this method is technically feasible for predicting casing collapses in this field.

1. Introduction

The field analyzed has been produced since the early 1950s, but the first casing collapse was not observed until after 1974. Since then the collapses have increased in numbers until today. Fig. 1 gives an overview of the collapse grouped over the active failure periods. In this field 48 of totally 267 wells drilled have collapsed or more than 18%. This is seen as a serious problem and a predictive tool for estimating this occurrence is sought. A cross section of the field along the short axis seen from NE is shown in Fig. 2. Based on cross section map it shows that a fault is present which intersect the G formation members from 2 to 4. This means that there is a major plane of weakness with a low dip angle present across the entire field. The fault goes nearly to the surface at South East side where there are seen quite deformed and crushed rocks. From the casing collapse data analysis it is seen that the casing collapse occur mainly in G formation member 2 to 4. Table 1 summarizes the date of casing completion and casing collapse. From previous studies there is no single mechanism for casing collapse in this field but rather combinations of mechanism contributing to the casing collapses. Of these the most prominent one is reservoir compaction. A field that is depleted may also undergo reservoir compaction, even if the reservoir rock is relatively stiff. The reservoir compaction results in increased horizontal stresses in the crestal area of the field, while in the flank there will be horizontal unloading. This will result in slip along weak bedding planes as the formation tries to adjust to the reservoir compaction taking place. Another mechanism contributing to casing collapse is internal and external corrosions of the casing. The possible cause of corrosion in this field could be contact with saline water in the G formations due to poor cement jobs, bringing oxygen to the casing creating a corrosive environment outside the casing.

The main objective of this work was to be able to predict the potential for collapse occurrences. Data from 20 wells in the field was collected and analyzed using the neural network method approach. The results from the analysis were potential for collapse and corresponding collapse depth at different locations around the field on future wells.

2. Field description

This field produces from the Asmari reservoir formation, and the structure is oblong, 63 km long in the NE–SW direction and 7 km wide. The reservoir thickness is on average 1300 ft of Asmari formation in the crestal area, but due to the dipping strata the vertical thickness of the

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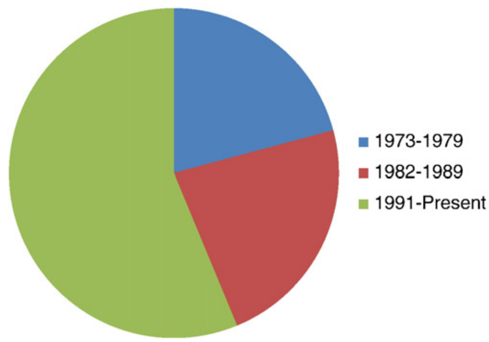

Fig. 1. History of casing collapses in m field.

reservoir is approximately 2600–2700 ft, depending on the cut off value used for the reservoir rocks. The initial oil in place of the Asmari was 43 MMMSTB, with an initial pore pressure of 5887 psi at datum depth of 10991 ft SS. In the initial years the reservoir was drilled with a MW of 72 PCF (pound per cubic feet), while around 2002 the reservoir could be drilled with a MW of 53 PCF. That is a depletion of approximately 1300 psi over a period of 50 years, referenced to the 10,991 ff SS datum depth. Current depletion of the reservoir is estimated to 1500–1800 psi. The average porosity is 12% in the mainly carbonaceous Asmari formation (NISOC, 2005).

3. Collapse failure mechanisms

Reservoir compaction results in 4 different collapse mechanism; buckling, bending, traction and shear. In the context of this field it is believed that only buckling and shear may be relevant.

The creep phenomenon may be important in the relation to the salt layers in the G formation. Shear due to compaction will occur due to differential loading across lithology interfaces, especially if it is an interface between hard and soft formations. The reservoir depletion will directly affect the horizontal stresses due to poro-elastic response of the reservoir rock. This phenomenon will result in a reduction of the horizontal stresses in the reservoir rock and these stresses must be taken by the surrounding rocks above and below the reservoir. Rock mechanical properties were used from reference Hareland and Salehi (2007).

4. Corrosion

4.1. External corrosion

External corrosion can be caused by several factors, such as:

– Exposure to water zones (salt water in G formation).
– Formation differences (e.g. salt, carbonates, sand etc).
– The casing acting as an offer anode for surface equipment or other wells. Corrosion due to exposure to water and different formations can be effectively prevented by a proper cement job, which will protect the casing towards the exposure and thereby exclude any external corrosion. In the G formation there is high pressure saltwater which may be creating an electropotential external corrosion, especially if there is a poor cement job. This type of corrosion would be evenly distributed across the field as we expect that the cementing practices are equally distributed across the field. Corrosion should therefore be a problem which is found in most wells across the field, also wells in the crestal area. But according to the analysis corrosive failures are only found at the flanks of the field not in the crestal area which indicates that there is not just corrosion alone that is fatal but in conjunction with other parameters more dominant at the flanks like possibly stresses.

The third effect can normally be avoided in on future well by cathodic protection schemes.

4.2. Internal and annulus corrosion

When a well is completed there will normally be a mixture of fluids in the annulus between the casing and tubing. Typically, there will be a mixture of mud, brine and sometimes produced oil or gas in the annulus, and the corrosion will be a function of the composition of this fluid. To prevent such internal corrosion it is normal to use packer fluids that are specially designed to avoid corrosion. One example to avoid this could be to use oil based mud drilling the last section before the completion is put in place.

In case the completion is set without a packer the annulus will be filled with produced fluid up the fluid level and above there will be wet gas. If the H_2S is present in the gas this will cause corrosion.

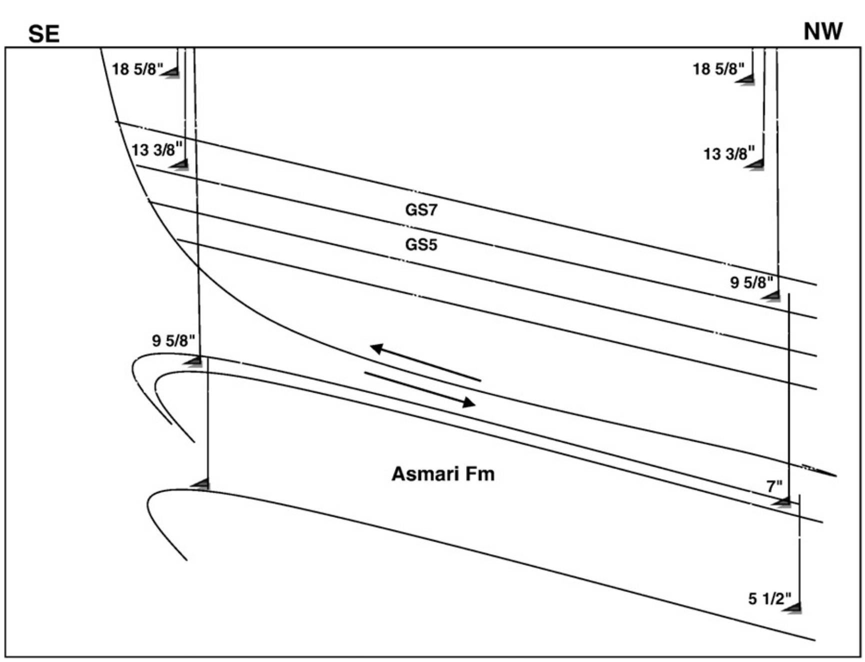

Fig. 2. Simplified cross section M field seen from NE, with typical casing designs.