

Prospects of arresting excess water from wells producing from KS-II and KS-III sands: a case study from Nandasan field of Mehsana, India

Saroj Chaudhary, P.K.Saxena and Om Prakash

Institute of Oil & Gas Production Technology
Oil & Natural Gas Corporation Ltd, Panvel, Navi Mumbai, India-410221
Email: s_chaudhary@rediffmail.com
Mb: 9969228785, 022-27486169(O)

Introduction: In mature or old reservoirs, most of fluid production is water. Water affects every stage of oil field life from exploration---the oil water contact is a crucial factor for determining oil in place---through development, production and finally to abandonment. As oil is produced from a reservoir, water from an underlying aquifer or from injectors eventually will be mixed and produced along with the oil. A continuous increase in water production is a normal behavior in the life time of a field. Cause of excess water can be anticipated with following reasons.

Completion problems

- Tubing/casing/packer leaks
- Channels behind casing

Reservoir problems

- Layered reservoirs with vertical flow barriers.
- Moving oil water contact
- Individual fractures between injectors and producers.
- “2-D coning” through fractures.
- Channeling through naturally fractured reservoirs.
- 3-D coning or cusping.
- Layered reservoirs without vertical flow barriers
- Wormhole development (heavy oil in consolidated sands).

Field description: The hydrocarbon play in Nandasan field is mainly in two sequences. One in the shallow level of Wavel, Kansari, Sertha and Chattral sands in the depth range of 1200-1520mt and the other in deeper coal-sand-shale sequences of Mehsana member of Kadi formation. Pay sand KS-II and KS-III of Kalol formation are

producing under active water drive and sand KS-XIII A2 is producing in depletion/
mixed drive where as Mehsana sands are producing in depletion drive.

Table-1

Average Reservoir and fluid parameters

Sl no	Parameter	Kalol pays	
1	Reservoir lithology	Sand Stone	
2	Pay zones	KS-II	KS-III
3	Thickness mt	2-8	2-10
4	Average depth (mt)MSL	1190	1200
5	Porosity (%)	21-25	28-30
6	Permeability(md)	300-350	300-350
7	Oil specific gravity	0.91	0.91
8	API gravity	24	24
9	Average oil saturations	65-70	75

Objective :To find out the likely cause of high water production from the wells producing from KS-II and KS-III sands. The finding of real problem of high water cut in KS-II & KS-III wells of Nandasani field will help in understanding the other wells of this field for the said problem. Implementation of water control measures will result in reduction in produced water handling requirement or oil gain.

Selection of candidate wells was done with data having

1. Reservoir lithology and stratification,
2. Information on existence of natural fractures, presence of clay lenses and their extensions, directional permeability trends.
3. Pay zone average thickness,
4. Number and size of perforated intervals.
5. Average permeability and anisotropy
6. Well completion details
7. Well production history,
8. Well logs
9. Core analysis reports
10. Analysis of produced fluids

11. Production mode and constraints, field facilities,
12. Analysis of injection water

Once all information was collected, the choice of a candidate well is based on the following criteria:

- **Heterogeneity:** A certain degree of heterogeneity in terms of permeability and oil saturations near well bore is required. Those wells which have to be treated should be perforated in either two or more independent pay zone or else in a single reservoir exhibiting several inter-bedding of sizable lateral extensions.
- **Sweeping efficiency:** Water injection within the reservoir should not have been initiated too long ago (about 10 years is a reasonable figure). A favorable criterion is a recent perforation of a reservoir layer, either in a producer or in an injector.
- **Production:** the water cut should be in the range of 70-90%. Moreover, in order to obtain a reasonable pay-out, the fluid rate should exceed 50 m³ per day (or 300 bbl/d)

Water production mechanism

The commonly observed water production mechanisms and expected water production rates are described below in the plot of Water production History curves by Mary Hardy and Thomas Lockhart. Water production mechanisms could be suspected with following curves depicted in Fig-1

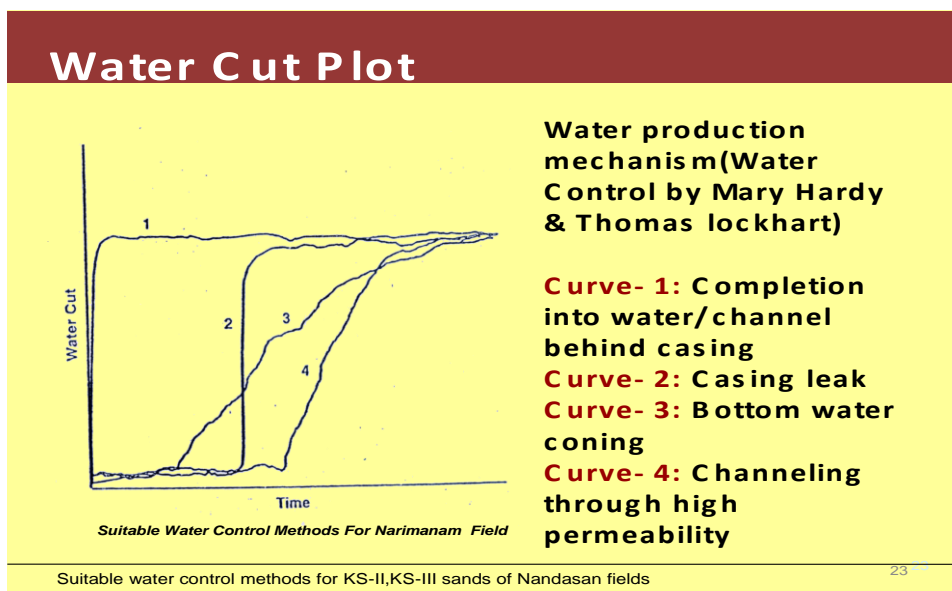
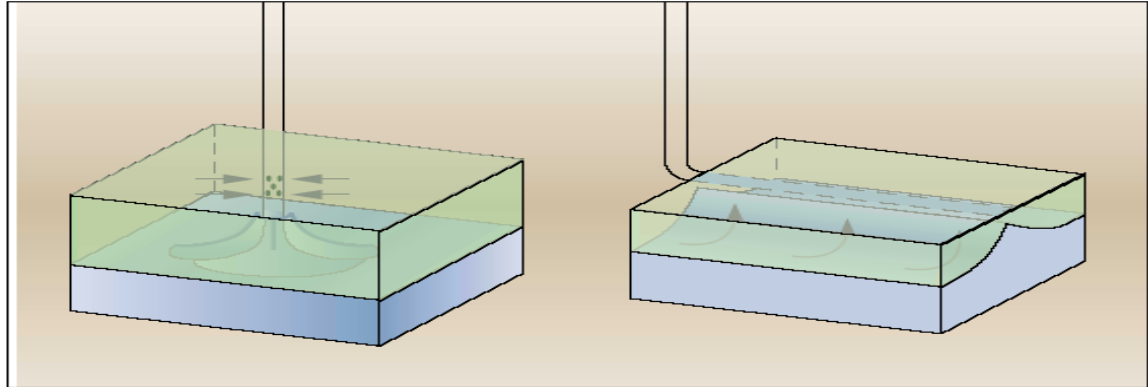


Fig-1

Well diagnostics for selected six wells (A-F) was done in three ways as the key to water control is diagnostics- to identify the specific water problem at hand. Reliable production

history can help to diagnose water problems. Analytical techniques using information, such as water oil ratios, production data and logging measurements have been developed to distinguish between the different sources of unacceptable water by plotting



^ Coning or cusping.

Fig-2

Results and discussion:

From well diagnostic studies it was concluded that 'Water coning & Channeling' were two main causes of water production in the reservoir of Nandasan considered in the present study. In a water drive reservoir, the draw down at the well bore will tend to pull water in to the well bore. When extreme draw downs exist in a vertical well, the resulting shape of the near well bore water oil contact is conical. In a horizontal well, the shape is more like a crest of a wave. Coning is a case of vertical water movement where the water phase moves upward through a hydrocarbon phase in the direction of a negative pressure gradient around well bore towards the open set of perforations

Water coning problem can remediate in following ways:

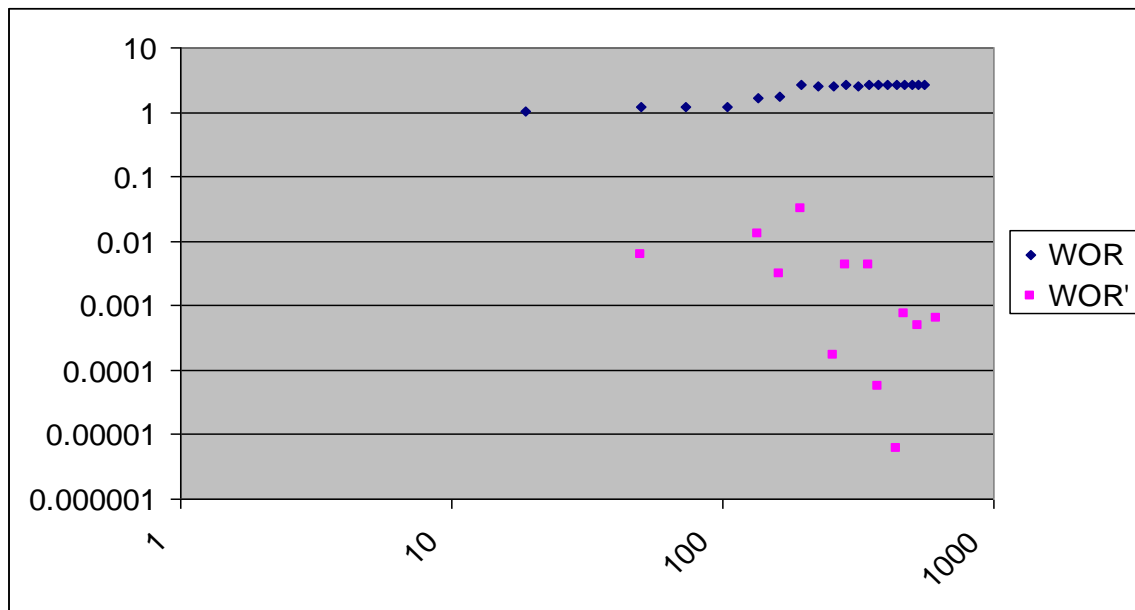
- Reduction in relative permeability to water;
- Placing a blocking agent between the perforations and the oil/water contact;
- Using a combination of reduction in relative permeability to water and a permeability block. For water control in KS-II, KS-III sands of Nandasan, option of placing blocking agent between the perforations and OWC has been considered. The salient features for this option are:
 - Placement of the blocking agent near the bottom of the perforation
 - Larger disc is desirable.

Disc sizes of 50 ft, 100 ft, 200 ft radius can be considered.

Table -2 summarises cause of problem and intervals to treat with polymer gel disc in all six wells under study.

Chart for well -wise treatment intervals (Table-2)

Well no	Diagnostic plot	Water cut	Treatment	OWC
A	Bottom water	channeling	1294.5-1296.5	1297
B	Channeling	coning	1299-1301	1301
C	Bottom water	channeling	1308-1310	1310.5
D	BWC with late	BWC	1299-1301	1301
E	BWC	BWC	1324.5-1326.5	1327.0
F	BWC	BWC	1328.5-1330.5	1330.5



Diagnostic plot for coning problem

Conclusions:

- Due to active aquifer below KS-III pay zone, problem of coning and channeling have been observed. Problem of excess water in the given wells for study are well specific not reservoir specific as per information shared by Mehsana asset during project presentation

- To mitigate the problem of coning and channeling in these wells; it has been suggested to put permeability blocking gel system above oil water contact and below KS- III pay zone.
- The design of Formulation (Polymer gel) includes 5% polyacrylamide of medium molecular weight, Hydroquinone.05%, HMTA (Hexa methyl tetra amine).05% established during lab studies.
- Pre-flush is important to remove oily saturations, if any; in the area of treatment zone.
- Guidelines for field implementation with due stress on” Post job” before activation has also been detailed in job plan in order to ensure wettability change as well as water saturation reduction.

Problem of water production is well specific not reservoir specific. Feed back given by Asset reaffirmed that wells drilled in KS-II &KS-III sands recently do not show oil water contact movement. Hence it is confirmed that active water aquifer below the KS-III sand perforation is resulting in to coning because of draw down .KS-II sand is facing problem of excess water due to micro channels left in poor cement bonding with the formation.

Recommendations: Remediation by putting blocking permeability type of polymer gel below the KS-III perforation and above oil water contact is recommended. For each well depth for placement of gel at particular depth has been decided after deliberating with logging and reservoir team. Larger volume of treatment is recommended to improve longevity of the water control treatment job.

For water control in KS-II &KS-III sands of Nandasan field, following is recommended:

- Minimum 100 m³ sealant type of gel treatment job as per well specific job design.
- Pre flush of 5% EGMBE, 10% IPA and 1% surfactant (nonionic) in 84% water to remove oily saturations for gelation
- To soak KS-III and KS-II zones with 79% light oil of having 10% IPA (Iso Propyl Alcohol), 10% EGMBE and 1% surfactant nonionic for 24 hours to remove water saturation after treatment
- Optimize bean size so as to restrict production to critical rate

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