Deep Penetration Acid (DPA*) Combined With MGA* Solve The Challenges Of Acidizing In The High Clay Content Sandstone Formation

Case Study: The high clay content sandstone success acidizing is always one of the most challenge problem that oilfield facing. The combination of the deep penetration acid (DPA) and MGA* technology provide an innovation acidizing solution and enhance the production in Chun6 block in Shenli Oilfield - China.*

The sandstone formation reservoir damages can be typically removed by pumping mud acid (a mixtures of hydrochloric acid HCl and hydrofluoric acid HF). However when the clay content increased, the normal matrix acidizing by using mud acid fluid system could not remove the damage effectively due to the second or third reaction between the mud acid and clay. In addition to the acidizing fluid problems, the nature of the formation permeability contrast add more challenges to matrix acidizing. The acidizing fluid pumped into formation tend to entering into the relative high permeability formation zone and leave relative lower zone untouched. This will lead to quite lot of pay zones were un-stimulated and the ultimate hydrocarbon recovery were reduced. This case history will demonstrate how the Deep Penetration Acid (DPA*) combined with MGA* fluid to solve the above fluid challenges and the multi-zone permeability contrast challenges, and eventually enhance the productions in the Chun6 block of Shengli Oilfield in China.

Introduction

The damage of Chun6 block is typically removed by pumping mud acid and HCl fluid in the past. However the results of jobs were not satisfied. The fluid compatibility with formation is believed the main reason why the well post acidizing performance was not met the expection.

The Chun6 block reservoir temperature is around 95 degC and reservoir pressure is around 20.7Mpa. The following table-1 is showed the formation parameters of the zone C2~C5. The table showed the average clay content is 28.4% and maximum clay content is 47.8%. The high BH temperature together with high clay content in the formation make the mud acid fluid spent very fast at the near well bore area. Which also caused the 2nd and 3rd reaction precipitation in near wellbore while the fluid penetrate deeper into formation rock. The damage caused by the acidizing fluid was left there.

Zone	Interval (m)			Thickness (m)	Perm (md)	Porosity (%)	Clay Content (%)	Formation
C2	2281.0	-	2281.8	0.8	32.9	24.7	47.8	Sandstone
C2	2283.0	-	2283.9	0.9	8.1	22.0	38.2	Sandstone
C2	2284.9	-	2285.8	0.9	10.6	20.2	14.8	Sandstone
C2	2286.3	-	2286.9	0.6	11.2	18.2	21.7	Sandstone
C3	2302.8	-	2303.8	1.0	10.8	19.7	12.5	Sandstone
C3	2304.9	-	2305.8	0.9	13.1	23.4	24.8	Sandstone
C4	2311.0	-	2312.4	1.4	30.5	21.7	35.6	Sandstone
C4	2319.9	-	2321.0	1.1	85.6	24.2	32.4	Sandstone
C4	2324.0	-	2324.8	0.8	6.3	22.0	29.2	Sandstone
C5	2330.3	-	2331.0	0.7	25.5	19.2	26.0	Sandstone
C5	2334.6	-	2335.9	1.3	10.3	15.5	29.5	Sandstone

Table-1 Chun6 block C2~C5 formation parameters

In addition to the fluid problems, the formation permeability contrast (from 6.3md to 85.6md) made the acidizing fluid placement difficult in evenly distribution. The effective diversion fluid should be used to divert the acidizing fluid from high permeable zone to lower permeable zone so that all the pay zones could be stimulated properly.

Challenges

The chun6 block sandstone formation matrix acidizing will face the following challenges:

- High BH temperature may cause high acid spending rate. It may lead to shallower acid penetration depth.
- High clay content may cause the precipitation from the 2nd and 3rd reaction between mud acid and formation rock.
- High permeability contrast sandstone formation may cause the acid to be unevenly placed across the pay zone.

Solution

Use the DPA* fluid to slow down the acid reaction rate and eliminate the precipitation caused by the 2nd and 3rd reaction between mud acid and formation rock.

Use the MGA* to divert the main acid fluid from the high permeable zone to the relative lower permeable zone.

DPA* fluid property

- F^{-1} will be released slowly at the high temperature from DPA* fluid which cause the acid reaction rate slowing down. The DPA* fluid can penetrate deeper into formation and reduce the skin further.
- The Chelant complexes make Al and SiF6 remains in solution instead of forming $Al(OH)_3$, AlF_3 or $Si(OH)_4$ precipitation. The process can be showed in the following figure-1
- The DPA* fluid also can prevent the migration of un-dissolved fines after acidizing treatment.

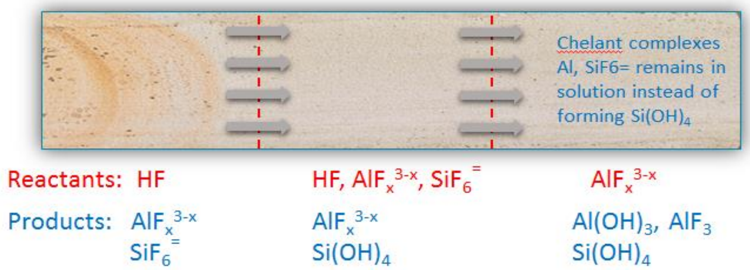

Figure-1 DPA* fluid reaction process with sandstone

MGA* fluid property

- The MGA* fluid is surfactant based diversion fluid. There is no damage to the formation. The figure 2 demonstrate how the MGA* fluid divert in a dual core flow test.
- The MGA* can divert the fluid from permeability of 5mD to 2 D
- The MGA* fluid is compatible with HCl, HF, Clay Acid, Organic acid.

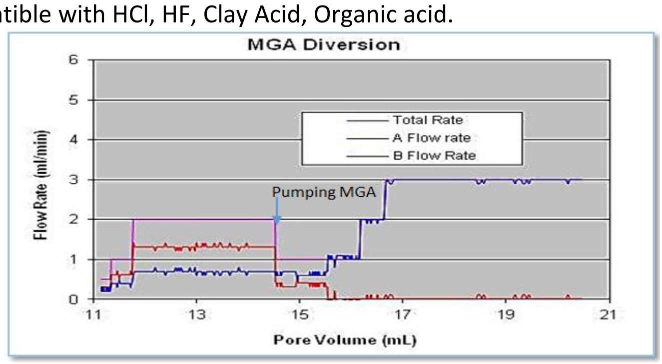

Figure-2 MGA fluid diversion test

Operation result

The 3 wells were selected as a campaign project to evaluate the DPA* and MGA fluid in Chun6 block. The 4 offset well were set as the comparison wells which acidized by the conventional way. The following table2 is the post job production result of those 7 wells. The result showed that the production of DPA* and MGA* treated wells is about 20% higher than the offset conventional acid treated wells. The result is showed in the figure3.

Well#	Fluid Production（t）	Oil Production（t）	WC（%）
C6X52	13.9	7.5	46
C6X84	18	3.7	79.3
C6X81	17.1	5.3	69.2
C6NX27	15.7	3.3	78.8
C6X82	25	5.3	78.7
C6X83	16.9	5.2	69
C6X85	16	7.3	54.5
Offset Well Average	16.2	5.0	68.3
OPT Treatment Average	19.3	5.9	67.4
OPT wells/offset wells	119%	120%	

Table2 the post acidizing production comparison

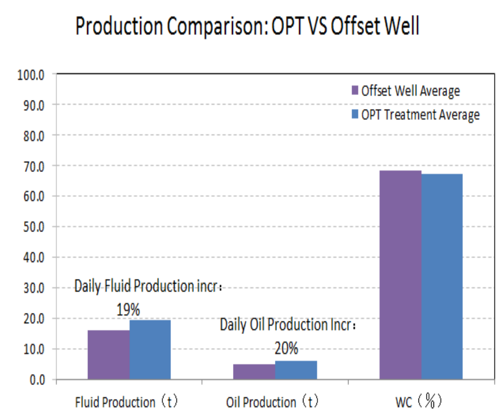

Figure3 the production comparison

During the pumping in well C6X82, the stage1 and stage 2 pumping pressure plot (figure4) showed that additional 1MPa pressure gained when MGA* fluid enter into formation, which demonstrate the MGA* diversion worked as per design. The treatment plot of well C6X83(figure5) showed additional 2MPa pressure was gained when MGA* fluid enter into formation.

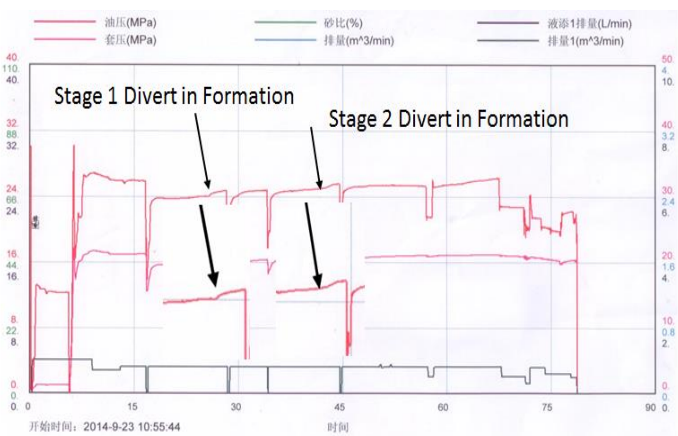

Figure4 C6X82 treatment plot

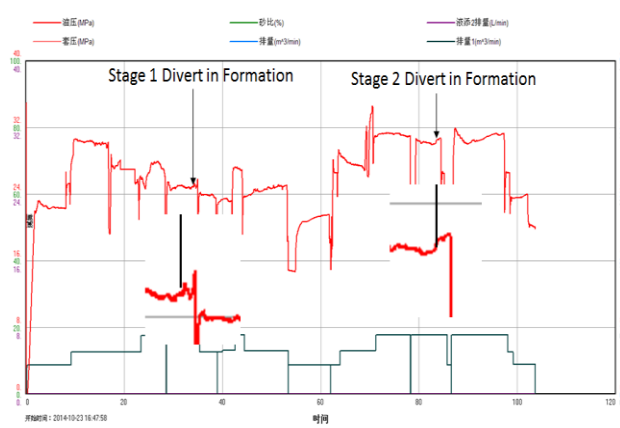

Figure5 C6X83 treatment plot

Conclusion

- The DPA*fluid is effective acidizing fluid for the high clay content and high temperature sandstone formation.
- The MGA* fluid can effectively divert the fluid in matrix acidizing from high permeability zone to low permeability zone.

DPA* fluid Applications

- ✓ HCl sensitive formations
- ✓ Clay content：> 20% Silt/Clay
- ✓ Major clays：chlorite and zeolite
- ✓ Fines: migration control
- ✓ Temperature range: up-to 250F（121C）

MGA* fluid Applications

- ✓ Temperature range: 100-320oF (35-160oC)
- ✓ Permeability range: 5mD to 2D
- ✓ Fluids work together: HCl/HF,
  Organic acids/HF,
  HCl/organic acids
- ✓ Mix-water: Fresh water, Brine

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