

INCREASING WELL PRODUCTIVITY BY USING CARBAMIDE NITRATE

Dr.Gholamreza Giahpour, prof. Victor Svitlitsky, Dr. Olga Ivanki

Corresponding Author Address: Iran Samen co, No. 7, 2nd fl., 4., cross of
Shadabst., Gharanist., Tehran- Iran

Corresponding Author E-mail: gieahpour@mail.ru

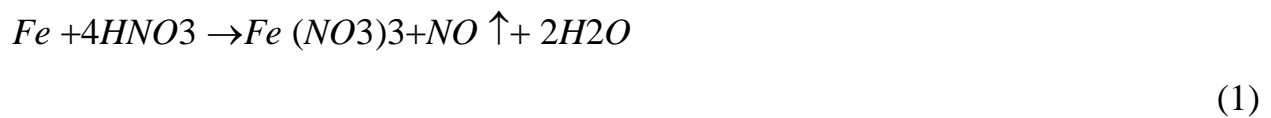
Abstract

Acid treatment is widely used for enhancing oil recovery. One of the progressive methods of acid treatment employed presently is the productive formation bottom hole zone treatment by nitric acid. In spite of many advantages such as decreasing oil viscosity, it leads to corrosion and failure of sealing elements. To prevent these occurrences the nitric acid before being injected into a well is converted to an inactive form - its complex with Carbamide or, in other words, to Carbamide nitrate. The technology is highly efficient and can be used to treat efficiently bottom-hole zones of beds in porous, fissured porous and fissured reservoirs, at different depths, pressure and temperature. It is acceptable for both common fields and high-viscous oil fields at different climatic conditions. Results show that utilization of Carbamide nitrate for formation acid treatment provides greater vertical sweep than when treating by solutions of hydrochloric and nitric acid. In this paper, method of increasing well productivity by using Carbamide nitrate is investigated.

Keywords: EOR, Acid treatment, Carbamide nitrate, Injection well

Introduction

Iran, with a record of over one century of oil production, is currently one of the major oil producing countries of the world [1]. Primary crude-oil production typically recovers only 15 to 20% of the oil originally in place thus some methods for Enhancing oil recovery are used [2]. Acid formation treatment used for increasing the productive capacity of producing wells and the intake capacity of injection wells is in wide use and is displayed by a great number of different methods. One of the progressive methods of acid treatment is the productive formation bottom hole zonetreatment by nitric acid. The efficiency of using nitric acid and compositions based on it provides decrease of oil viscosity with a considerable content of asphalt-resinous substances. Besides, products of nitric acid reaction with brown nitrogen oxides:



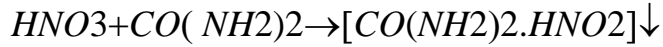
The resulting ferric nitrate in the worked out solution is hydrolyzed along with the precipitation of the basic saltinsoluble in water and plugging the bottom-hole pore space of the formation:



To prevent these occurrences the nitric acid before being injected into a well is converted to an inactive form, Carbamide nitrate. In this paper, technology of using Carbamide nitrate is discussed.

Theory

Carbamide nitrate is a fine-dispersed, precipitated product insoluble in hydrocarbon liquids which produces by following reaction:



(3)

Only nitric acid gives such a complex with a precipitate when obtaining from mineral acids. From equation 3, it follows that nitric acid and Carbamide interact in the proper proportion: 1 mole of nitric acid reacts with 1 mole of Carbamide. As established by investigations, Carbamide nitrate is a white crystalline substance of 1746 kg/m³ density. The corrosion activity of wet powder (before drying) makes up 3989 g/m.h. The content of nitric acid in the dried product was determined by alkali titration (1 - normal solution of KOH) in the presence of an indicator - methyl orange. It showed that there was 48% of nitric acid in the dried product. Another factor serving to increase the coverage of acid treatment is that during the complex destruction, when being diluted with water, the nitric acid concentration in the solution decreases. Hence, it is possible to regulate the depth of vertical sweep of formation nitric acid treatment by the dilution extent. The relationship between nitric acid concentration and the solution's temperature is expressed by the formula:

$$C_{an} = 0.000074T^3 - 0.012T^2 + 0.885T - 8.6$$

(4)

Where T (C°) is the temperature of the solution.

Operation

To increase the productivity of the formation its bottom hole equipment techniques were connected to the wellhead, high pressure manifolds and communications were pressed to a value of one and a half working pressure. The liquid circulation in the well was reestablished and the formation intake rate was determined. If there was no bed intake an acid bath was installed. In this case the tubing reached the lower perforated holes. Then the equipment was pressed to a value of one and a half working pressure and an acid solution was injected into the tube. The well was shut-in and left under pressure for 2 hours at the rock carbonate content exceeding 10 % and for 4-8 hours at carbonate content less than 10 %. After acid treating time at the bottom hole the acid was washed out from the well and the intake rate was determined. If there was a bed intake rate, solutions of hydrochloric acid and Carbamide nitrate dissolved in pure oil, diesel fuel or condensate in the ratio of not more than 1 m³to 500 kg of powder, were separately injected into the tubing. After acid treatment, the well was shut-in for acid neutralization for 2hours at the rock carbonate content less than 10 % and for an hour - more than 10 %. Figure 1 shows acid treatment operation.



Figure 1- Acid treatment operation

The corrosion activity of Carbamide nitrate powder settled on the filter without being dried is $60 \text{ g/m}^2\cdot\text{h}$. For reference the corrosiveness of 40% nitric acid is $5292 \text{ g/m}^2\cdot\text{h}$. Temperature dependence of corrosiveness of Carbamide nitrate dried at a temperature of 60°C to residual humidity of 32.22% is represented in Fig 2.

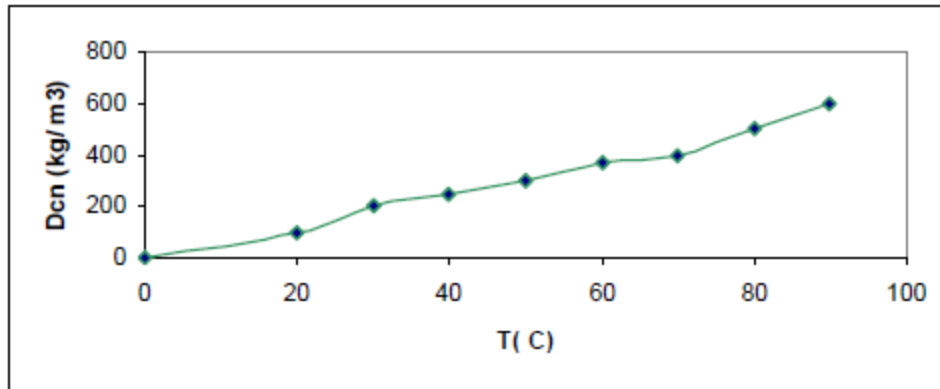


Figure 2- Temperature - dependence of Carbamide nitrate corrosiveness

Figure 2 reveals that the corrosion rate of Carbamide nitrate is increased with increasing temperature.

Temperature-dependence of corrosion rate of a steel plate at different Carbamide nitrate concentration in solutions is shown in figure 3.

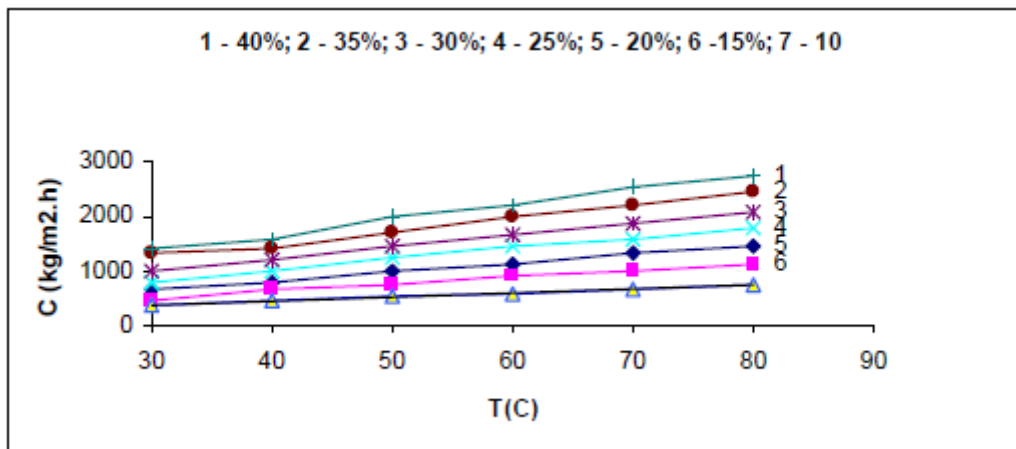
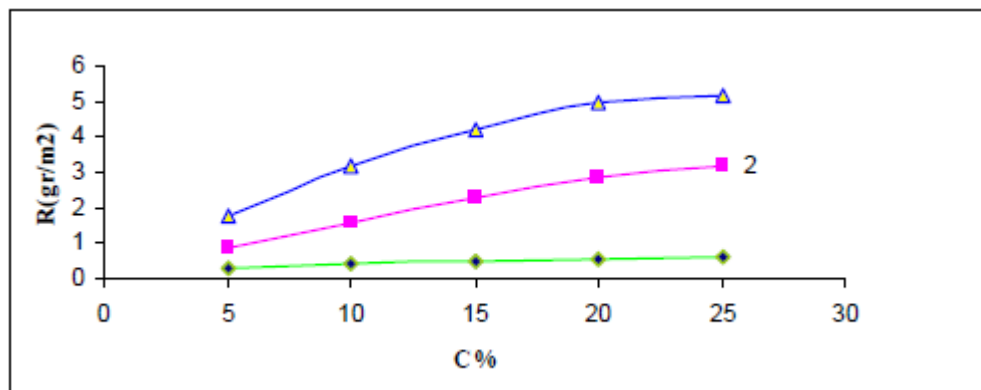


Figure 3- Temperature dependence of corrosion rate of a steel plate at different Carbamide nitrate concentrations in solution

Figure 3 demonstrates that when concentration of Carbamide nitrate increases the corrosion rate of steel plate is increased. The study of the dissolving power of Carbamide nitrate and acid compositions based on relative to carbonates, quartz and clay minerals showed that marble dissolution rate in Carbamide nitrate solutions is 9 times lower than in hydrochloric acid and 4.5-5.5 times lower than in nitric acid (fig 4).

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**Figure 4- Concentration - dependence of marble dissolution rate in solutions
of 1) hydrochloric
acid; 2) nitric acid and 3) Carbamide nitrate**

This clearly demonstrates that utilization of Carbamide nitrate for formation acid treatment provides greater vertical sweep than when treating by solutions of hydrochloric and nitric acid. At the same time Carbamide nitrate and a composition based on it dissolve silicate rock components forming productive formations rather well (Table1).

Table 1- Solution of clay minerals and quartz in acids

Agent	Content реагента в растворе, %	Solution, %			
		montmo- rillonite	Kaolinite	Hydromica (glaucinite)	quartz
Hydrochloric acid (HCl)	12,0	1,53	0,88	0,73	0,22
Hydrochloric acid (HCl) + Hydrofluoric acid (HF)	12,0+ + 4,0	32,34	24,57	31,13	4,22
Carbamide nitrate	5,0	6,11	1,21	3,43	0,39
..	7,5	8,86	1,24	4,62	0,42
..	10,0	8,94	1,28	4,64	0,67
..	15,0	9,26	1,33	4,92	0,74
Hydrochloric acid + Carbamide nitrate	12,0				
..	+ 5,0	11,75	1,33	3,92	0,63
..	+ 7,5	12,34	1,52	4,76	0,79
..	+ 10,0	13,23	1,55	4,89	0,94
..	+ 15,0	14,41	1,57	5,58	1,03

Results of field tests of bottom-hole zone treatment technologies at production and injection well by acid composition based on Carbamide nitrate is shown in table 2.

Table2- results of field tests of bottom-hole zone treatment technologies at production and injection well by acid composition based on Carbamide nitrat

Type of well	Production rate (intake capacity) oil/water, t/day		Productivity, t/day, MPa		Injection Pressure MPa	
	Before treating	After treating	Before treating	After treating	Before treating	After treating
producing	0.5/0.0	60./0.0	0.11	101.9		
producing	12.5/0.0	39.5/8.5	58/80	294.2		
producing	0.3/4.7	10.5/71.5	1.62	27/30		
producing	0.7/0.6	1.5/0.5	0/48	0.75		
producing	0.0/0.0	0.01/9.99	0	3.3		
injecting	30	50			13	06-Jul
injecting	60	May-74			12.7	7.6
injecting	86	100			25	24/0

It is clear that production rate after acid treatment are increased in both production and injection wells. Figure 3 shows the hydrocarbon production after acid treatment with utilizing Carbamide nitrate:

Table 3- Hydrocarbon production after acid treatment with utilizing Carbamide nitrate

Amount of wells	Additional production			Additional production per one treatment		
	oil, m	water, m ³	gas, thous. m ³ .	oil, m	water, M ³	gas, thous.. M ³
3	4	5	6	7	8	9
3	923,5	6119,0	174,4	307,8	2039,7	58,1
7	13648,9	50884,0	2922,7	1949,8	7269,1	417,5
3	1356,1	2354,0	300,4	452,0	784,7	100,1

The figure reveals the additional hydrocarbon production after acid treatment with utilizing Carbamide nitrate

Conclusions

Analyzing the data obtained after testing the technologies for increasing well productivity by utilizing powderlike

Carbamide nitrate the following may be concluded:

- Decrease in oil viscosity with a considerable content of asphalt-resinous substances
- Reduction of emulsification of watered oil
- Absence of corrosion of the oil-field equipment
- Safe storage and transportation of acids to a place of application
- High chemical activity of acid structure directly in a process able layer of a wall
- Ecologically favorable, safe and harmless system of rendering of services
- It can be used in Sandstone reservoirs & carbonate reservoir, Porous, fissured-porous and fissured reservoirs, at different depths, pressure and temperature

- Acceptable for both common fields and high-viscous oil fields and at different climatic condition
- Considering the calculations performed in the mentioned project and having the advantages mentioned, the cost of this method compared to the method of using HCL liquid acid is about 20-25% more economical.

References

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