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Increasing productivity through acid treatment

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Annotacion: This article provides information about the most common method of treating the bottom of the well, acid treatment. The well was exposed to various surfactants along with acids and their effect on erosion was determined. The dependence of erosion on temperature was also studied experimentally.

Key words:

A great responsibility is required to meet the demand for oil and oil products in our republic. To meet the demand for oil and oil products, the wells used are treated with chemical methods to increase production. If attention is not paid to the quality of the discovery of productive layers, permeability will deteriorate, which will lead to an increase in the cost of money and materials, and a lengthening of the discovery time.

One of the methods for increasing permeability and accelerating the flow of products in productive layers consisting of carbonate rocks is to treat this layer with acid.

In general, there are the following types of well acid treatment [1, 2, 3]:

1. Conventional acid treatment;
2. Acid bath;
3. Pressure acid treatment;
4. Intermediate or step acid treatment;
5. Hot acid treatment;
6. Acid treatment using hydromonitor transmitters.

Conventional acidizing is a widely applied stimulation technique that relies on the capacity of hydrochloric acid (HCl) to dissolve carbonate formations, particularly limestone and dolomite ($CaMg(CO_3)_2$). When HCl reacts with these minerals, the resulting products are highly soluble in water, which facilitates their removal from the near-wellbore zone during subsequent flowback and well clean-up operations. The dissolution process is especially effective within existing pore channels, where the acid enlarges the conduits and progressively transforms them into narrow, elongated cavities [4].

The principal objective of conventional acid treatment is to ensure acid penetration into the reservoir beyond the immediate wellbore wall, thereby enlarging microfractures and natural flow channels while simultaneously improving their interconnectivity. Such structural modifications enhance the overall permeability of the porous medium, which translates into increased well productivity in producing wells or higher injectivity in injection wells.

Acidizing under pressure is a stimulation method designed to force acid into low-permeability intervals of the productive formation by artificially increasing the injection pressure, typically in the range of 15–30 MPa. The application of elevated pressure during acid injection leads to a reduction in the overall reaction rate between the acid and the rock matrix. As a result, the acid is able to penetrate deeper into the reservoir, ensuring more uniform coverage of low-permeability layers and previously inaccessible zones. This improved penetration and diversion significantly enhance the overall effectiveness of acidizing treatments [5, 6].

Acid emulsions are applied in pressure acidizing to divert acid from high-permeability layers into tighter zones. They are usually prepared from a 12% HCl solution and degassed oil in a 70:30 volumetric ratio. If the oil is too light, heavy additives such as oxidized fuel oil or tar are used. Emulsifying agents improve stability, while mixing time determines dispersion and viscosity. Prolonged mixing yields fine emulsions with viscosities up to 10 Pa·s, ensuring effective diversion and deeper acid penetration.

Zonal or stepwise acidizing is applied in wells that penetrate multiple independent layers characterized by either a common filter or an open-hole completion. When a single hydrochloric acid treatment is performed across the entire interval, the treatment effect is typically concentrated in the most permeable layer, while less permeable intervals remain practically unaffected due to their lower transmissibility.

To ensure effective stimulation of these less permeable layers, isolation techniques are employed. Specifically, two packers are set at the boundaries of the target interval or sublayer to isolate it from the rest of the formation. Acidizing is then conducted within this confined zone. Following the treatment of one interval, a short-term well test is usually carried out to evaluate the response of the treated layer. Subsequently, the process is repeated for the next interval, ensuring that each sublayer receives targeted acid treatment.

This method provides a more uniform stimulation of multilayer reservoirs, thereby improving the overall sweep efficiency of the acid solution and enhancing the productivity of the entire well [7, 8].

Acid treatment of the formation uses 15% inhibited technical hydrochloric acid. In formations with low permeability and high density, treatment is more effective when carried out in conjunction with surfactants, which penetrate deeper into the wellbore.

Recently, due to the shortage of hydrochloric acid, the difficulty of importing it from Russia and China, and the increase in its cost, experimental work has been carried out with phosphoric acid instead of hydrochloric acid in order to accelerate the production of oil and oil products.

Phosphoric acid is produced in our Republic at the Almalyk "Ammophos" production association and the Samarkand chemical plants.

According to the results of experimental work, it was found that phosphoric acid reacts with carbonate rocks and erodes them slightly slower than hydrochloric acid. We can also see the effect of phosphoric acid on carbonate rocks from its chemical formula.

$$2H_3PO_4 + 3CaCO_3 = Ca_3(PO_4)_2 + 3HCO_3 \quad (1)$$

$$4H_3PO_4 + CaMg(PO_3)_2 = Mg_3(PO_4)_2 + 6H_2CO_3 \quad (2)$$

The formed salts $Ca_3(PO_4)_2$ and $Mg_3(PO_4)_2$ are in a mobile state due to their difficulty in dissolving in water. Therefore, these salts have the property of being washed out during the washing process or when there is a flow from the productive layer to the bottom of the well.

The process of salt acid treatment in wells consists of pumping a salt-acid mixture into the layer or, if the layer pressure is low, sending it with its own flow.

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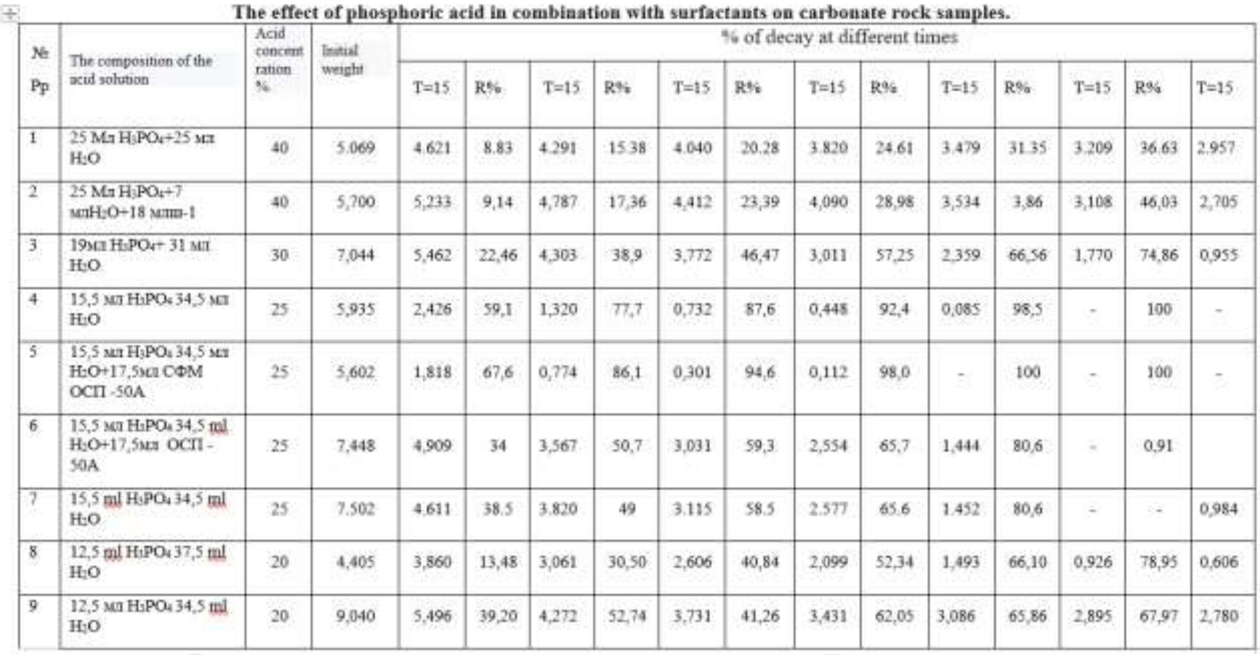
The procedure is as follows: The well is cleaned of sand, impurities, paraffin and corrosion products. To clean the well wall from the layer of cement, mud and corrosion products, an "acid bath" is made at the bottom of the open well. In this case, the acid mixture is pumped to the bottom of the well and held there without entering the formation. After a few hours, the affected acid, together with the reaction products, is pumped to the back of the well casing by flushing the washing liquid (oil or water) and brought to the surface by backwashing.

Table 1 below shows the effect of phosphoric acid at various concentrations in combination with surfactants on carbonate rocks.

Table 1.

The effect of phosphoric acid in combination with surfactants on carbonate rock samples.



№ Pp	The composition of the acid solution	Acid concentration %	Initial weight	% of decay at different times												
				T=15	R%	T=15	R%	T=15	R%	T=15	R%	T=15	R%	T=15	R%	T=15
1	25 Мл H_3PO_4+25 мл H_2O	40	5.069	4.621	8.83	4.291	15.38	4.040	20.28	3.820	24.61	3.479	31.35	3.209	36.63	2.957
2	25 Мл H_3PO_4+7 млH_2O+18 мпш-1	40	5,700	5,233	9,14	4,787	17,36	4,412	23,39	4,090	28,98	3,534	3,86	3,108	46,03	2,705
3	19мл H_3PO_4+ 31 мл H_2O	30	7,044	5,462	22,46	4,303	38,9	3,772	46,47	3,011	57,25	2,359	66,56	1,770	74,86	0,955
4	15,5 мл H_3PO_4 34,5 мл H_2O	25	5,935	2,426	59,1	1,320	77,7	0,732	87,6	0,448	92,4	0,085	98,5	-	100	-
5	15,5 мл H_3PO_4 34,5 мл H_2O+17,5мл СФМ ОСП -50А	25	5,602	1,818	67,6	0,774	86,1	0,301	94,6	0,112	98,0	-	100	-	100	-
6	15,5 мл H_3PO_4 34,5 ml H_2O+17,5мл ОСП -50А	25	7,448	4,909	34	3,567	50,7	3,031	59,3	2,554	65,7	1,444	80,6	-	0,91	
7	15,5 ml H_3PO_4 34,5 ml H_2O	25	7.502	4.611	38.5	3.820	49	3.115	58.5	2.577	65.6	1.452	80,6	-	-	0,984
8	12,5 ml H_3PO_4 37,5 ml H_2O	20	4,405	3,860	13,48	3,061	30,50	2,606	40,84	2,099	52,34	1,493	66,10	0,926	78,95	0,606
9	12,5 мл H_3PO_4 34,5 ml H_2O	20	9,040	5,496	39,20	4,272	52,74	3,731	41,26	3,431	62,05	3,086	65,86	2,895	67,97	2,780

Based on the results presented in the table, it was found that a 20-25% concentration of phosphoric acid is effective and is close to hydrochloric acid in terms of corrosion. When 50 ml of 20-25% phosphoric acid was exposed to rocks weighing 5.7-7.5 g, the rock sample immersed in acid for 15 minutes was corroded by 45-55% of its initial weight, and within 150 minutes, an average of 85-90% was corroded.

The results of the investigation of the effect of phosphoric acid on metal in order to protect pipes used in the well from corrosion are presented in Table **2.**

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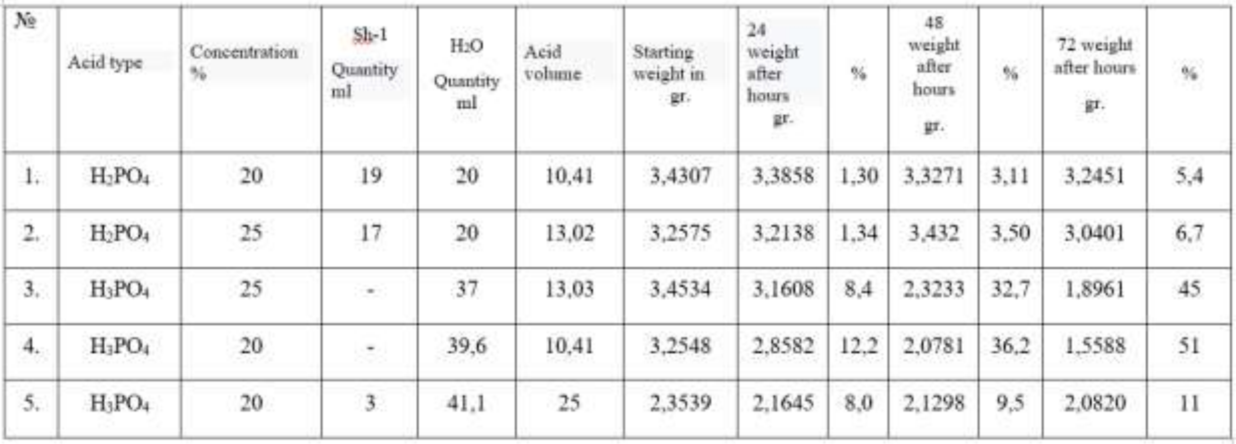
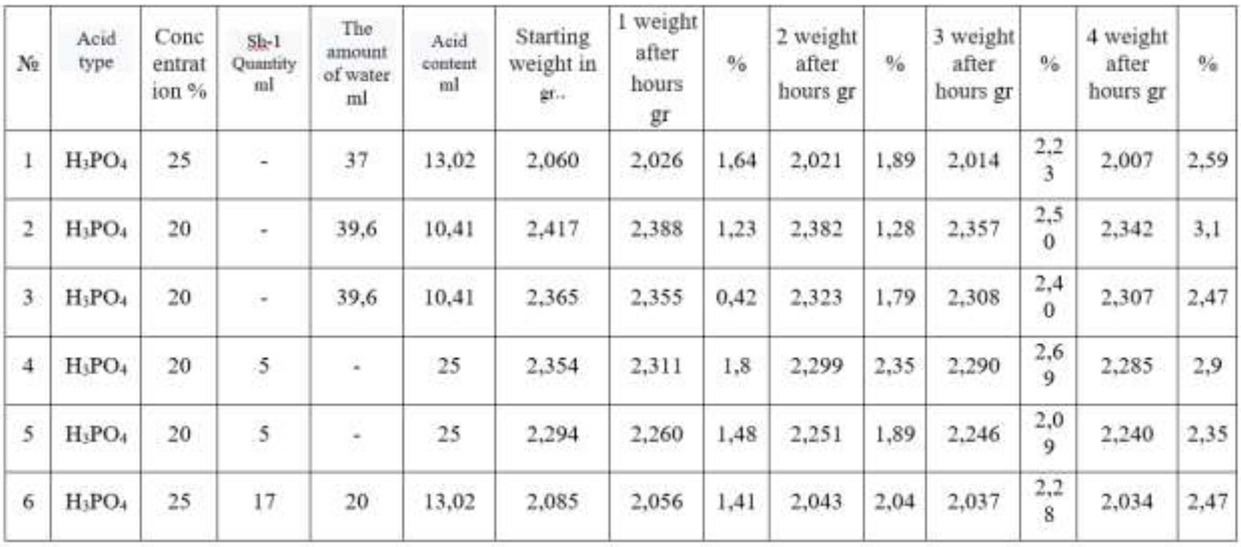
The temperature for testing the effect of phosphoric acid in combination with SAF on metal corrosion is 20±5 ⁰C



№	Acid type	Concentration %	Sh-1 Quantity ml	H₂O Quantity ml	Acid volume	Starting weight in gr.	24 weight after hours gr.	%	48 weight after hours gr.	%	72 weight after hours gr.	%
1.	H_2PO_4	20	19	20	10,41	3,4307	3,3858	1,30	3,3271	3,11	3,2451	5,4
2.	H_2PO_4	25	17	20	13,02	3,2575	3,2138	1,34	3,432	3,50	3,0401	6,7
3.	H_3PO_4	25	-	37	13,03	3,4534	3,1608	8,4	2,3233	32,7	1,8961	45
4.	H_3PO_4	20	-	39,6	10,41	3,2548	2,8582	12,2	2,0781	36,2	1,5588	51
5.	H_3PO_4	20	3	41,1	25	2,3539	2,1645	8,0	2,1298	9,5	2,0820	11

2.3 – table

The temperature for testing the effect of phosphoric acid in combination with SAF on metal corrosion is 100± 5 ⁰C



№	Acid type	Concentration %	Sh-1 Quantity ml	The amount of water ml	Acid content ml	Starting weight in gr..	1 weight after hours gr	%	2 weight after hours gr	%	3 weight after hours gr	%	4 weight after hours gr	%
1	H_3PO_4	25	-	37	13,02	2,060	2,026	1,64	2,021	1,89	2,014	2,23	2,007	2,59
2	H_3PO_4	20	-	39,6	10,41	2,417	2,388	1,23	2,382	1,28	2,357	2,50	2,342	3,1
3	H_3PO_4	20	-	39,6	10,41	2,365	2,355	0,42	2,323	1,79	2,308	2,40	2,307	2,47
4	H_3PO_4	20	5	-	25	2,354	2,311	1,8	2,299	2,35	2,290	2,69	2,285	2,9
5	H_3PO_4	20	5	-	25	2,294	2,260	1,48	2,251	1,89	2,246	2,09	2,240	2,35
6	H_3PO_4	25	17	20	13,02	2,085	2,056	1,41	2,043	2,04	2,037	2,28	2,034	2,47

The results presented in Tables 2.1, 2.2, 2.3 show that when phosphoric acid is used in combination with the surfactant Sh-1 to repair a metal pipe section sample (at room temperature), the corrosion rate increases over time, but this corrosion is much less than the corrosion in experiments conducted under the influence of pure hydrochloric acid. These indicators are also confirmed by experiments conducted at high temperatures.

Tables 2.1, 2.2, 2.3 show that when tested in combination with the surfactant "Sh-1" reagent to reduce the effect of phosphoric acid on the metal, the Sh-1 reagent reduces the effect of phosphoric acid on the metal by 5-6 times.

A 20% solution of phosphoric acid diluted with water at a temperature of 800±50°C corroded the metal by 11.91%, and a 25% solution by 13.08% within 5 hours, rendering it unusable.

When these processes were repeated with the Sh-1 reagent, the amount of acid corrosion of the metal was 3-5%. Based on the results of the experiments in the tables, it was concluded that phosphoric acid can be used in the chemical treatment of productive layers, and when used together with the "Sh-1" reagent, the Sh-1 reagent reduces the effect of phosphoric acid on the metal, and therefore the corrosion is minimal.

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