Pollution monitoring and optimization of technology of membrane water desalting of production installation

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Summary. The majority of installations of the reverse osmosis take root into production without preliminary approbation. In this regard optimization of the equipment operation is performed in the conditions of commercial operation. The possible solution of this problem is use of test membrane installations of JSC NPK Mediana-Filter for evaluating intensity of pollution of membrane elements and the directed choice of the washing solutions of production installations.

Introduction
One of the main factors influencing stability, efficiency and operation period of membranes is their pollution by inorganic, organic and biological deposits [1]. Chemical cleaning of reverse osmosis installations is an integral part of technology of the reverse osmosis (ROI). Especially significant it is in the conditions of the changing quality of initial water, unstable work of system of retraining and also in the multistage systems of the reverse osmosis working with the high-concentrated solutions of salts [2].

As the majority of installations of the reverse osmosis are introduced into production without preliminary approbation, optimization of operation of the equipment are performed in the conditions of industrial operation. Therefore application of test installations for the purpose of optimization of technological parameters of the operating of reverse osmosis installations is the relevant direction of researches [3].

Results of researches
Test installation of JSC NPK Mediana-Filter allow:
– to define primary deposits on membrane elements;
– to pick up the optimum cleaning solutions;
– to define an order and working parameters of cycles of cleaning and number of their repetitions.

The hydraulic scheme of the test two-level installation of the reverse osmosis is provided on figure 1.
Figure 1. The hydraulic scheme of two-level installation of the reverse osmosis. Control panel pump H2; BP1 adjusting valve for installation of pressure of the feeding solution on the membrane devices MM1 and MM2

The laboratory and test installation "worked" with production installation of the reverse osmosis. The hydraulic scheme of the production installation of the reverse osmosis (IRO) is provided on figure 2.

Figure 2. The hydraulic scheme of a production installation of the reverse osmosis

The test installation was connected in two points of production installation: to initial solution after five micron filters and on a concentrate after the first step. The results of tests at connection of the test installation after five micron filters are given in table 1.
Table 1. The results of tests at connection of test installation after five micron filters

| Indicators | Initial solution | concentrate | Permeate | Initial solution | concentrate | Permeate |
|------------|-----------------|-------------|----------|-----------------|-------------|----------|
|            | Beginning of work | Completion of work |             |                  |             |          |
| SDI        | 6               | 9           | –        | 6               | 10          | –        |
| \(\text{J}_{\text{Ko}}, \text{mg-ekv/dm}^3\) | 3,40           | 4,60        | 0,02     | 4,50            | 6,40        | 0,02     |
| \(\text{J}_{\text{KCa}}, \text{mg-ekv/dm}^3\) | 2,40           | 3,40        | 0,01     | 3,00            | 4,80        | 0,01     |
| \(\text{J}_{\text{KMg}}, \text{mg-ekv/dm}^3\) | 1,00           | 1,20        | 0,01     | 1,50            | 1,60        | 0,01     |
| \(\text{II}_{\text{O}}, \text{mg-ekv/dm}^3\) | 2,6            | 3,4         | 0,1      | 3,0             | 4,8         | 0,2      |
| Chlorides, mg/dm3 | 13,0        | 22,0        | 2,0      | 1,0             | 32,5        | 0,4      |
| Salinity, mg/dm3  | 733           | 1000        | 9        | 523             | 770         | 6        |
| pH           | 7,4            | 7,6         | 5,1      | 7,7             | 7,7         | 5,8      |
| Expense, l/h  | 62,8           | 43,4        | 19,4     | 37,7            | 23,3        | 14,4     |
| Conversion, % | 31             |             |          | 38              |             |          |
| Selectivity of membranes % | 98,7          |             |          | 98,9            |             |          |

In the course of operation of the test installation conversion, selectivity of membranes and technological indicators of the permeate have slightly changed (table 1). Productivity of the test installation after its operation within 45 days (for 12 hours a day) on a concentrate decreased twice. At deterioration in technological indicators of a concentrate by 1,4-1,6 times the chemical cleaning of membranes is carried out. The results of the analysis of tests of the washing solutions are given in table 2.

Table 2. The structure of pollution of the washing solutions of membrane elements of the test installation

| Indicator/solution | The acid washing solution | Alkaline washing solution |
|--------------------|---------------------------|---------------------------|
| pH                 | 2,5                       | 12,0                      |
| Fe is the general, mg/dm3 | 0,2                      | 0,1                       |
| SiO2, mg/dm3       | 0                         | 0                         |
| The weighed substances, mg/dm3 | 2                        | 7                         |

For realization of a chemical cleaning the membrane element have been connected to the station of a chemical cleaning (figure 3).

Figure 3. The station of a chemical cleaning of JSC NPK Mediana-Filter
The chemical cleaning was carried out in several steps:

- circulation of alkaline MF-A-T10 solution of JSC NPK Mediana-Filter through a membrane element;
- soaking of a membrane element with the subsequent circulation of alkaline solution through a membrane element;
- circulation of acid MF-B-L20 solution of JSC NPK Mediana-Filter through a membrane element;
- soaking of a membrane element with the subsequent circulation of acid solution through a membrane element;
- washing of membranes the distilled water to values \( \text{pH} = 6-7 \) after circulation of alkaline and acid solutions.

The tests' results at connection of the test installation on a concentrate after the first step are given in table 3.

Table 3. The results of tests at connection of the test installation on a concentrate of the first step

| Indicators | Concentrate | Permeate |
|-----------|-------------|----------|
| Initial solution | Beginning of work | Completion of work |
| \( \text{Жо}, \text{mg-ekv/dm}3 \) | 17,00 | 19,00 | 0,07 | 17,00 | 24,00 | 0,30 |
| \( \text{ЖCa}, \text{mg-ekv/dm}3 \) | 11,00 | 14,50 | 0,03 | 11,00 | 18,50 | 0,30 |
| \( \text{ЖMg}, \text{mg-ekv/dm}3 \) | 5,50 | 4,50 | 0,04 | 5,50 | 5,50 | 0,03 |
| \( \text{Що}, \text{mg-ekv/dm}3 \) | 11,0 | 13,5 | 0,3 | 11,0 | 15,0 | 0,3 |
| Chlorides, mg/dm3 | 102,0 | 124,0 | 1,4 | 102,0 | 150,0 | 3,5 |
| Salinity, mg/dm3 | 1437,5 | 1725,0 | 11,5 | 1437,5 | 1950,0 | 11,5 |
| pH | 7,7 | 7,7 | 5,3 | 7,7 | 8,0 | 6,4 |
| Expense, l/h | 41,5 | 31,0 | 10,5 | 39,8 | 33,4 | 8,9 |
| Conversion, % | 98,6 | | | 96,6 |
| Selectivity of membranes % | | | | | |

During the operation the following parameters of work of the test installation have been traced: expenses of streams, pressure on mechanical filters, the size of conversion and selectivity of membrane elements.

The criteria to carrying out a chemical cleaning have been: decline in production of test installation on a permeate for 9%; decrease in selectivity of a membrane element by 2% and deterioration of the permeate.

The results of researches of tests of solutions after a chemical cleaning are given in table 4.

Table 4. The structure of pollution of the washing solutions of membrane elements of test installation

| Structure of pollution | Unit of measurements | Acid solution | Alkaline solution |
|------------------------|----------------------|---------------|------------------|
| 1. Calcium             | mg/dm3               | –             | –                |
| 2. Sulfates            | mg/dm3               | 26            | –                |
| 3. Iron                | mg/dm3               | 0,24          | –                |
| 4. sio2                | mg/dm3               | –             | 3,2              |

The researches of tests of solutions after a chemical cleaning have revealed that on membrane elements of the first installation and, therefore, on membranes of the second stage of production UOO silicon oxide deposits prevail. The received results demonstrate expediency of reduction of chemical
cleanings of membranes with acid solutions. The reduction of duration of contact of membranes with the acid washing solution will provide increase in duration of their work on the water treatment equipment of the metallurgical enterprise at stable quality of the desalinated water.

The results of tests at connection of the test installation on a concentrate after the first step after a chemical cleaning are given in table 5.

Table 5. The parameters of tests after chemical cleaning at connection of the test installation on a concentrate of the first step

| Indicators            | Concentrate after the first steps of the production installation | Permeate from the test installation | Concentrate from the test installation |
|-----------------------|-----------------------------------------------------------------|-------------------------------------|----------------------------------------|
| Жо, mg-ekv/dm3        | 18,00                                                           | 0,14                                | 23,00                                  |
| ЖCa, mg-ekv/dm3       | 14,00                                                           | 0,10                                | 17,00                                  |
| ЖMg, mg-ekv/dm3       | 4,00                                                            | 0,04                                | 6,00                                   |
| Що, mg-ekv/dm3        | 13,0                                                            | 0,5                                 | 18,0                                   |
| Chlorides, mg/dm3     | 128,5                                                           | 2,2                                 | 155,0                                  |
| Salinity, mg/dm3      | 1260,0                                                          | 12,5                                | 1680,0                                 |
| pH                    | 7,55                                                            | 5,85                                | 7,80                                   |
| Expense, l/h          | 36,4                                                            | 10,2                                | 26,2                                   |
| Conversion, %         | –                                                               | 28,7                                |                                        |
| Selectivity of membranes, % |                                                | 98,6                               |                                        |

After a chemical cleaning the selectivity of membranes and quality of the permeate have been restored (table 5). By results of researches it is established that in the course of work as production UOO the second stage is most polluted. It is promoted high extent of saturation of the concentrate of the first stage of UOO compounds of iron and oxide of silicon and the overestimated conversion of production installation (80%).

Conclusions

As a result of researches the efficiency of application the test installation of JSC NPK Mediana-Filter for definition of primary deposits on membrane elements of installation of the reverse osmosis of metallurgical production is shown.

Need of decrease in size of conversion of production installation to 65-75% and change of the modes of carrying out chemical cleaning due to reduction of number of cleanings with acid solutions is revealed. These actions will provide reduction of deposits of oxide of silicon and iron on membrane elements, will increase the term of operation of membrane elements of the water treatment equipment of the metallurgical enterprise at stable quality of the desalinated water.

References

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