**Academia Open**
Vol 6 (2022): June
DOI: 10.21070/acopen.6.2022.4730 . Article type: (Engineering)

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ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

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ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

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# Method of Nickel Extraction from Industrial Waste and its Application in Production

## *Metode Ekstraksi Nikel dari Limbah Industri dan Penerapannya dalam Produksi*

**Bekhzod Farmanov Ilkhomovich, dildora@gmail.com, (1)**
*, Bangladesh*

**Tavashov Shakhzod Khujaxmatovich, dilbar.kuchkarova@mail.ru, (0)**
*, Uzbekistan*

(1) Corresponding author

**Abstract**

The article describes the process of extracting nickel from the composition of the used waste of the GIAP-8 catalyst in the form of nickel nitrate, in which it not only does not affect the environmental environment, but is also a cost-effective solution for the production of nickel catalysts. The obtained catalysts were tested in laboratory conditions, the activity of the catalyst in this converted residual methane was 35,7% at T =500 °C and 6,5% at T= 700 °C.

Published date: 2022-06-30 00:00:00

ISSN 2714-7444 (online), https://acopen.umsida.ac.id, published by Universitas Muhammadiyah Sidoarjo

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# Introduction

The development of modern science and technology leads to the fact that the need for non-ferrous and rare metals increases from year to year. Processing of non-ferrous metals leads to a reduction in deposits of rare earth metals. One of the urgent problems at present is the development and introduction into practice of energy-resource-saving technologies for processing rare metals contained in secondary raw materials into finished or semi-finished products. Rational integrated use of raw materials, transition to production are one of the most urgent problems of waste-free technologies of its processing and recycling of technogenic formations. Processing of raw materials and materials is of great economic and environmental importance.

According to numerous studies, the best catalyst for the conversion of methane is a nickel catalyst. And in the catalyst in the form of nickel oxide. The catalyst accelerates the conversion of methane. Therefore, in the process before starting the conversion, hydrogen together with the catalyst is reduced to nickel oxide, $NiO + H_2 = Ni + H_2O$, for 2-4 hours at a temperature of 300-400 °C. The process can also be anhydrous, in which it is carried out with a working mixture (methane and water vapor) at 700-800 °C.

If nickel is not in the form of oxides, but in the form of their compounds with aluminum oxide (spinel), then a high temperature (800-900 °C) is required for its recovery. In this case, the recovery process is slow. The formation of $H_2$ when the nickel-aluminum catalyst is heated above 600 °C.

The GIAP-8 catalyst is designed for the conversion of natural gas. The composition of the catalyst is nickel and aluminum oxide. The mass fraction of NiO in the catalyst is 6-10%.

And in the catalyst used, the nickel oxide content is 5.5-6.5% of the total weight of the catalyst. Given that nickel is purchased abroad at a high price, it is undesirable to throw it away. As a result of scientific research, the extraction of $Ni(NO_3)_2$ with nitric acid from the GIAP-8 catalyst used was carried out. As a result, the concentration of acid, its norm, and the ratio of liquid phases are determined.

The resulting $Ni(NO_3)_2$ solution was impregnated with a catalyst carrier (alumina-calcium-manganese alloy) CHKR-06 (improved). To extract GIAP-8 from spent catalysts, the method of dissolution in nitric acid was used in the central laboratory of JSC “Maxam-Chirchik”. Catalyst for the development of GIAP-8 20%, 30%, 40%, 50% it dissolves in concentrated nitric acid [4]. The results shown in Table-1 show that washing with boiling water after separation in a 40% solution of nitric acid for 4 h. the conversion of 90-95% nickel into solution is achieved (Table 1).

The GIAP-8 catalyst, which was originally used for the process, was crushed and placed in a glass with distilled water in a ratio of 1 to 4 and evaporated by boiling water. History 20%, 30%, 40%, 50% in concentrated nitric acid, insist, stirring for 4 hours. Gives color, slowly passing into the solution for 4 hours. Then the mixture was divided into liquid and solid phases in a vacuum filter. $Ni(NO_3)_2$, forming the composition of the liquid phase, was analyzed by titration.

| The mass of the spent catalyst GIAP-8, g | Concentration of HNO3, % | Amount of acid, ml amount of water, ml | Amount of water, ml | Amount of NiO remaining in the solid phase, % | Amount remaining in acid, g/dm3 | Degree of extraction Ni, % |
|---|---|---|---|---|---|---|
| 100 standard | | | | | | |
| 10 | 20 | 106,75 | 40 | 0,967 | 16,42 | 82,84 |
| 10 | 30 | 71,16 | 40 | 0,6716 | 26,53 | 91,6 |
| 10 | 40 | 53,375 | 40 | 0,42 | 43,824 | 95,12 |
| 110 standard | | | | | | |
| 25 | 20 | 266,87 | - | 1,6 | 14,15 | 78,27 |
| 25 | 30 | 178 | - | 1,56 | 21,45 | 79,537 |
| 25 | 40 | 101,34 | - | 1,02 | 40,172 | 88,75 |
| 25 | 50 | 106,75 | - | 0,93 | 43,824 | 90,05 |
| 25 | 20 | 293,56 | 100 | 2,328 | 12,1 | 72,036 |
| 25 | 30 | 195,8 | 100 | 0,827 | 21,4 | 90,33 |
| 25 | 40 | 146,74 | 100 | 0,714 | 35,38 | 92,43 |

**Table 1.** *Spent catalyst GIAP-8 for 4 hours 20%, 30%, 40%, 50% dissolution in concentrated nitric acid*

The solid phase was also analyzed for the content of NiO in it. The rate of nickel release from the catalyst was calculated by the formula:

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*where , C is the mass of nickel oxide isolated from the catalyst ( NiO ), g;*

*$C_1$ is the mass of nickel oxide ( NiO ) remaining in the solid phase after filtration of the used GIAP-8, giap .*

To calculate the degree of dissociation, given that the mass fraction of NiO in the GIAP-8 catalyst used is 6.5%, a mass fraction of 6% NiO was isolated in it. The mass concentration of $Ni(NO_3)_2$ in solution is (200-550) g/dm$^3$. The mass of nickel oxide remaining in the solid phase is (20-30) g/dm$^3$. The nickel nitrate solution was evaporated and the $Ni(NO_3)_2$ nickel nitrate content was adjusted to 2-490 g/dm$^3$. This solution was immersed twice in the carrier, and the catalyst was dried and cooled in the control mode.

The mass fraction of NiO is 10%, and the mass fraction of $SO_3$ is 0.004%. CHCR-21 catalyst was obtained. The catalyst test is performed in Figure 1.

*Supplementary Files*

**Figure 1.** The scheme of testing the catalyst in the laboratory

The results of the catalyst tests obtained in the central laboratory of JSC "Maxam-Chirchik" are shown in Table 2.

The table of test results of the catalyst ChKR-06 (advanced) test facilities were tested and put into operation. Prepared to work with nitrogen. Hydrogen was given and the temperature began to rise to 500 °C.

Tsh 0020368-15:2014 according to the enterprise standard, the test result of the CHCR-06 (improved) catalyst should not exceed 37% of the residual methane content, which does not decompose at a temperature of 500 °C. At a temperature of 700 °C, the content of non-decomposed residual methane should not exceed 8%. Based on the test results of the catalyst CHKR-06 (advanced), the test result indicators showed that at a temperature of 500 °C, the content of non-decomposed residual methane was 35.7%, and at a temperature of 700 °C, the content of non-decomposed residual methane was 6.5%.

| Time | Temperature mode, °C | | | Water mode | | | Gas mode | Note |
|---|---|---|---|---|---|---|---|---|
| | In the reactor | Sulfur purification | In xylene | Diffmanometer pressure, mm | Measurement of the water level in the burette, ml | Water flow, ml | CH4 | |
| 1030 | 500 | 250 | 180 | 61 | 19 | 17 | 30 | Exit №1-35,3% |
| 1100 | 500 | 250 | 180 | 84,5 | 23,5 | 20 | 30 | Exit №2-36,1% |
| 1130 | 500 | 250 | 180 | 100/6,5 | 22 | 17 | 30 | Exit №3-35,8% |
| 1200 | 600 | 250 | 190 | 25 | 18,5 | 11,5 | 30 | |
| 1230 | 675 | 250 | 190 | 48,5 | 23,5 | 13,5 | 30 | |
| 1300 | 700 | 250 | 190 | 70 | 21,5 | 13,5 | 30 | |
| 1330 | 700 | 250 | 185 | 96 | 26 | 15 | 30 | |
| 1400 | 700 | 250 | 185 | 100/21 | 25,5 | 13 | 30 | Exit №1-5,6% |
| 1430 | 700 | 250 | 185 | 44,5 | 24 | 14 | 30 | Exit №2-6,8% |
| 1500 | 700 | 250 | 185 | 70 | 24,5 | 14 | 30 | Exit №3-7,2% |
| 1530 | 700 | 250 | 185 | 93 | 23 | 13 | 30 | Exit №4-6,5% |

**Table 2.** *Results of indicators of catalyst activity*

# Conclusion

The I contained in the GIAP-8 catalyst separated with nitric acid was separated. To do this, water is placed in the catalyst in a ratio of 1: 4 and boiled water is evaporated, then nitric acid is added and infused, stirring for 4 hours. The solid phase was then separated from the liquid phase in a vacuum filter, and the solid phase was analyzed for the $Ni(NO_3)_2$ g/dm$^3$ content in the liquid phase. In the case of $Ni(NO_3)_2$ the resulting solution was evaporated and

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adjusted to $Ni(NO_3)_2$ = 490 g/$dm^3$, and a CHCR-06 (improved) catalyst was installed on the carrier. The impregnation of NIO meets the requirements of GOST. The level of operation of the resulting catalyst in laboratory testing equipment was checked. As a result, the indicators meet the requirements of the enterprise standard.

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