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DEVELOPMENT TECHNOLOGY FOR PRODUCING VANADIUM FIVE OXIDE FROM MINERAL AND TECHNOGENIC RAW MATERIALS

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Abstract. This article discusses the possibility of extracting vanadium pentoxide from mineral and industrial raw materials. Based on the study of this topic and the analysis of the results of the studies, the author came to the conclusion that medium temperature roasting of the ore is carried out by vanadium water-soluble sodium vanadate ($NaVO_3$) and the subsequent leaching of the metal using sulfuric acid increases the vanadium extraction 76,5 to 90,2%. It was also revealed that in the process of firing vanadium as a binder material, the most effective reagent is technical soda. It was found that the solubility of sodium vanadate is more effective than the sulfuric acid medium than conventional aqueous leaching of the product. Nevertheless, a special combined technology of selective sintering and leaching of the cinder has been determined and worked out: the selective deposition of vanadium and its separation from unnecessary impurities and the calcination of the precipitate bring a high-frequency production of V_2O_5 of 98-99%.
Keywords: mining and metallurgical waste, slag, vanadenite, limestone, vanadium pentoxide, roasting, leaching, recovery.

Introduction. The analysis of the current state of the technology of processing of vanadium raw materials shows that the best way to involve waste and ore raw materials into processing and to extract five or more of the acidic vanadium is to explore or create the best or worse solution and technology of clean vanadium.

Objectives of the study. At present, the demand for iron and its alloys in the world is increasing every year. Ferroalloys are of great importance for the production of strong refractory iron alloys. There is a growing demand for steel alloys containing vanadium. Therefore, in the conditions of Uzbekistan, great importance is attached to the extraction of vanadium and the production of various steel grades from it. In addition, vanadium is used as a catalyst in the production of sulfuric acid.

Method used. The scientific work uses modern integrated methods, analysis of scientific and technical data on the enrichment of vanadium ores, theoretical studies using analytical methods, experimental studies, chemical and physico-chemical methods, methods of spectrophotometric analysis, methods of magnetic enrichment.

Research results. Today, the problem of increasing the development of the processing of technogenic raw materials is important for the mining industry and includes the saving of mineral resources that are not renewable in nature. According to the diluted stock of vanadium-containing ore is sufficient for the production of large-scale industrial production. In the

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proposed development of a technology for extracting vanadium from ore, the technology of initial roasting of the ore and subsequent leaching of vanadium from the cinder was taken as the basis. The technology developed in this way (see Fig. 1.) is based on the roasting of vanadium ore in order to convert vanadium into water-soluble sodium vanadate ($NaVO_3$) and subsequent leaching of the metal using sulfuric acid with an increase in the extraction of vanadium from 76.5 to 90.2%. As a result, the technology makes it possible to organize the production of vanadium. The technology for obtaining vanadium pentoxide from spent vanadium catalysts, developed and mastered in the sulfuric acid production shop of the Northern RU, does not provide the required amount of V_2O_5. Therefore, refractory vanadium-containing ores can become a source of obtaining vanadium in NMMC. One of these deposits is the Madani (Rudnoye) deposit.

Before sampling for technological research, the laboratory took 9 samples from different parts of the deposit and analyzed for vanadium content. The content of vanadium in the samples was in the range of 2000-9900 g/t [1. P.70]. The chemical analysis of the R-9 sample is presented in Table 1.

Table 1. Chemical composition of vanadium ores.

Component	(V_2O_5)	Cu	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	S_{com}	S_S	C_{com}	C_{org}
Component Content, %	0,93 (1,66)	0,28	80,5	5,1	3,5	0,8	1,6	0,5	0,1	1,1	1,0

The object of the mechanism is vanadium-exchanged ore with NaCl and Na_2CO_3. At a temperature of 800-850 ^{0}C, a reaction occurs in an oxidizing atmosphere, resulting in the formation of sodium peroxide Na_2O.

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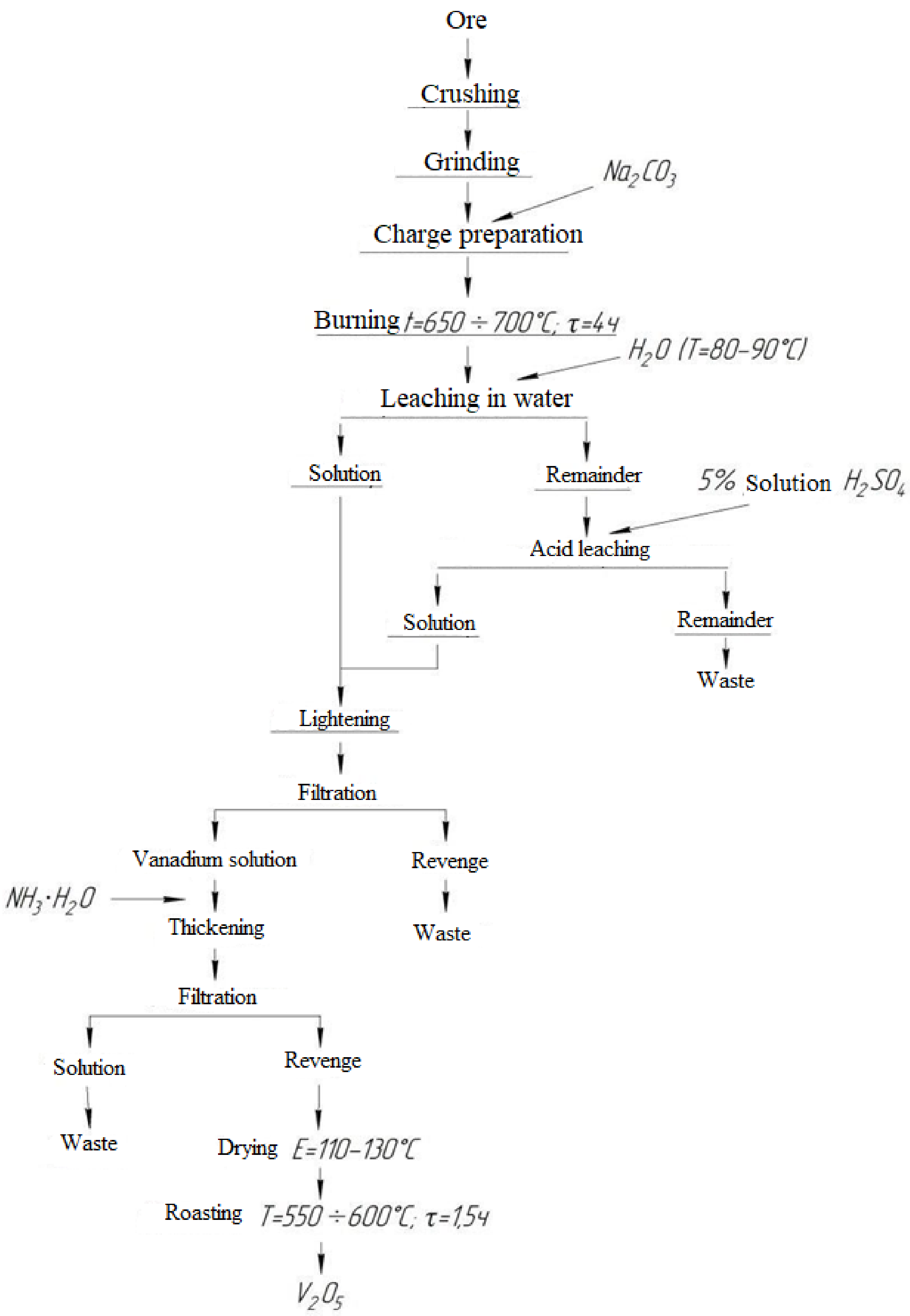

Figure 1. Technological scheme for the extraction of vanadium pentoxide from mineral and technogenic raw materials.

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Gaseous chlorine will be removed. The resulting peroxide Na_2O reacts with vanadium according to the reaction [2. pp.23-25]:

$$2\ NaCl + 0.5O_2 = Na_2O + Cl_2$$

$$Na_2O + V_2O_5 = 2NaVO_3$$

The sodium vanadate formed as a result of the reaction is highly soluble in water. The firing process was carried out in different temperature conditions 600-650^{0}C and 700-800^{0}C. According to laboratory experience, it was determined that the optimal conditions for firing are 700-750^{0}C for 4-5 hours and the flow rate of the NaCl reagent is 8-10%. At temperatures above 750^{0}C, the mixture melts due to the formation of insoluble vanadium silicates. Below 7000C, the output of vanadium decreases [3. pp.16-33].

For the experiment we prepare the charge: 100 gr. ore supplement 5 gr. technical soda and mix. We substitute on the muffle furnace and carry out firing in different temperature conditions of firing from 600^{0}C to 850^{0}C for 2-5 hours. The firing results are shown in Table 2.

Table 2. The results of the kinetics of firing vanadium-containing raw materials.
Initial content of vanadium 6400 g/t; t=700 ^{0}C. Consumption of technical soda Na_2CO_3 50 g/kg^3.

№	Roasting time, min	Quantity and weight of charge		Quantity of Na_2CO_3, g/kg	Ogre mass	
		charge weight, gr	[V] mg/kg		Weight of cinder, gr	Cinder yield, %
1	50	100	6,400	5	98,5	93,8
2	150	100	6,400	5	95,7	91,1
3	200	100	6,400	5	93,8	89,3
4	240	100	6,400	5	92,6	88,1
5	300	100	6,400	5	91,3	86,9

It can be seen from the table that the optimal parameter for roasting vanadium ores is 700 0C, at which it is well associated with technical soda with the formation of sodium vanadate [4. pp.67-72].

After firing, the resulting product - sodium vanadate is dissolved in aqueous solutions according to technological schemes, after which the insoluble part - the residue is dissolved already in a sulfuric acid solution in order to completely transfer vanadium into the solution. With the simplicity and efficiency of the water leaching scheme, it has one drawback - a relatively low extraction of vanadium into the solution during the leaching operation (40-45%) [5.p.30-36].

Samples of the first aqueous and sulfuric acid leaching dissolved and the results of the leaching are shown in table 3.

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Table 3. Results of the kinetics of sulfuric acid leaching of cinder. Experimental conditions: H_2SO_4 = 55 g/l, S:W= 1:3, (V)=6400 g/t.

№	Leaching time, min	Original product		Solution after leaching	
		[V], gr/t	pH	V, mg/l	E, %
1	30	6400	5,4	2785,6	43,5
2	60	6400	5,9	3592,3	56,1
3	80	6400	6,0	4389,7	68,6
4	100	6400	6,5	4987,9	77,9
5	120	6400	6,8	5385,9	84,2

It follows from the table that after firing at 650-700^{0}C, obage cinder is leached under conditions of 40-55^{0}C and in a phase ratio T:L = 1:3, in acidic solutions - with a sulfuric acid content H_2SO_4 = 55 g / l.

In laboratory studies, the optimal leaching parameters were determined and the process time was 2 hours. At the same time, it was found that the degree of vanadium solubility (E, %) increases by 42.1% due to sulfuric acid leaching of the cinder, compared with aqueous leaching, and at the same time, the through extraction of vanadium (E, %) reached up to 84.2%. The results of sulfuric acid leaching of the cinder are presented in table 3.

To determine the optimal conditions for the leaching of metal and residual vanadium from three tailings with a residual vanadium content, a sample of tailings with a residual vanadium content of 0.51% (5100 g/t) was produced. The sample was produced under the established optimal conditions for roasting the ore and subsequent water leaching of the cinder [6. pp.221-224].

Metal leaching was carried out using sulfuric acid in thermostatically controlled reactors with stirrers at a stirring speed of n=500 rev/min and T:W=1:3. Upon completion of leaching, the pulp was filtered, the precipitate was washed with water at a ratio of S:W=1:3. The first filtrate and precipitate (after drying) were analyzed. Table 4 shows data on the kinetics of vanadium leaching at different temperatures and a constant initial concentration (H_2SO_4) = 40 g/l.

Table 4. Kinetics of sulfuric acid leaching of metal and vanadium from aqueous leaching tailings.

Experience conditions: S:W= 1:3; C(H_2SO_4) = 40 g/l; τ=2-4hours; initial content V=5100 g/t.

t	20-25^{0}C			40-50^{0}C			80-90^{0}C		
№	α, gr/t	E, %	time, min	α, gr/t	E, %	time, min	α, gr/t	E, %	time, min
1	2100	58,8	120	1100	78,4	120	980	80,8	100
2	1700	66,7	160	800	84,3	140	500	90,2	120
3	1500	70,6	200	800	84,3	160	500	90,2	120
4	1200	76,5	240	700	86,2	180	500	90,2	120

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As can be seen from Table 4, from the point of view of vanadium recovery, increasing the leaching temperature from 20-25^{0}C to 80-90^{0}C allows you to reduce the leaching time from 4 to 2 hours, while the extraction of vanadium in the operation of sulfuric acid leaching increases from 76.5 to 90.2 % [7. pp.165-167].

After the transition of vanadium into solution, it is sent to the clarification process in order to remove fine-grained tailings, and the resulting product is separated through filtration into the cake phase and the purest vanadium solution. The cake is thrown into the tailing dump. The vanadium solution is sent to the selective precipitation of vanadium using an ammonia solution. At the same time, we extract the complex of vanadium precipitate, freed from non-delicate harmful substances. After that, the precipitate is dried at a temperature of 110-130 ^{0}C and sent to the last stage of purification from impurities by calcination. We calcinate the product at 550-600 ^{0}C for 60-90 minutes. to the formation of sandy V_2O_5 with a degree of purity of 98-99% that meets the requirements of GOST. The resulting finished vanadium pentoxide was subjected to IR spectroscopy in order to clarify the exact determination of the composition of the product.

The difference between the proposed technology and the existing one lies in the fact that vanadium-containing ores are sent to direct leaching without preliminary roasting, according to which the degree of solubility of the base metal is very low and at the same time through extraction of vanadium is reduced. The use of a combination of aqueous and sulfuric acid leaching of vanadium cinder increases the volume of produced material by 2 times compared to the traditional scheme for processing vanadium by direct leaching of the ore. According to the developed technology and the results of this work, the following conclusions can be drawn:

– researched and developed a simplified technology for the extraction of pentoxyvanadium;
– the optimal reagent mode of dissolution of vanadium cinder by the sulfuric acid method was determined;
– initial aqueous leaching of the cinder followed by sulfuric acid leaching increases the degree of extraction of vanadium to 42.1%, while the through extraction of vanadium is achieved up to 84.2%;
– selective precipitation of vanadium with ammonium hydroxides followed by calcination ensures the production of purified V_2O_5 with a purity of 98-99% that meets the requirements of GOST;
– a deep hydrometallurgical purification of the resulting vanadium pentoxide has been developed;
– a new technological scheme has been developed for the processing of mineral and technogenic raw materials with the production of a finished product.

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