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Extraction of Vanadium from Fly Ash Produced in Heavy Fuel in Power Generation Station

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Abstract
In the present research work, extraction of vanadium from fly ash produced in heavy fuel in power generation station was carried out. Effects of sodium hydroxide concentration, temperature and leaching time on the extraction percentage of vanadium have been investigated. The results show that the optimal conditions of extraction as follows: the concentration of sodium hydroxide is 12M, the ratio of liquid to solid is 5, the temperature100 °C and leaching time four hours. Under these conditions, the extraction of vanadium can reaches 98%.

Keywords
vanadium, heavy fuel, fly ash, leaching, extraction

1. Introduction

The power generation station that uses heavy oil produces a solid residue called fly ash [1]. Fly ash generated during oil combustion. Fly ash is rich in Ni, V, Fe, Mo, Mg, Na and C and among these metals Ni and V are the most valuable. In terms of resource recovery and environmental impact, Fly ash is attracting much attention due to disposing problems and its harmful impact on the soil because of metal leaching [2, 3].

Therefore, before disposing fly ash into the environment, it is important to extract/separate the valuable elements like V and Ni [4].

Vanadium is used widely in industrial processes including the production of special steels, temperature-resistant alloys, in glass industry, in the manufacture of pigments and paints, for lining arc welding electrodes and is used as an additive in titanium alloys (for aerospace applications) and as catalysts (in the chemical and polymer industries) [5, 6].

Adding vanadium to ferrous and non-ferrous alloys can improve their physical properties such as tensile strength, hardness, fatigue resistance and wear resistance [7].

The overwhelming majority of vanadium produced is used in steel products to improve their performance. It is an important micro-alloying element and alloying element in the steel. The addition of vanadium into steel can enhance the strength, toughness and plasticity of steel hardness and fatigue resistance of the steel. The vanadium refines the grain size that increases the strength of the steel and also forms carbides which increase the hardness [8, 9].

Vanadium is widely used in the high strength hot rolled ribbed rebar, high-strength low-alloyed steel, alloyed structural steel, micro-alloyed forging steels, spring steel, steel bolts, super-high strength steel, die steel, high speed steel, martensite heat-resistant steel and other types [9].

The aim of this work is to extract vanadium from fly ash of heavy fuel. The effect of the concentration of sodium hydroxide, reaction temperature, time, and liquid-solid ratio was researched.

2. Experimental

2.1. Materials

Fly ash used in this study was obtained from Al-Muusyyib Thermal Electrical power station, Iraq. Mineralogical and chemical analyses of the fly ash were done using X-ray diffraction analyser (a Japanse SHIMADZU LabX XRD-6000,) and X-ray fluorescence spectroscopy that was carried out in Razi

Metallurgical Research Center, Iran. Figure 1 shows the result of XRD which revealed that the major phases in the fly ash of heavy fuel are vanadium oxide. The main chemical compositions of fly ash (Table 1) show that the content of vanadium pentoxide is 4.6%.

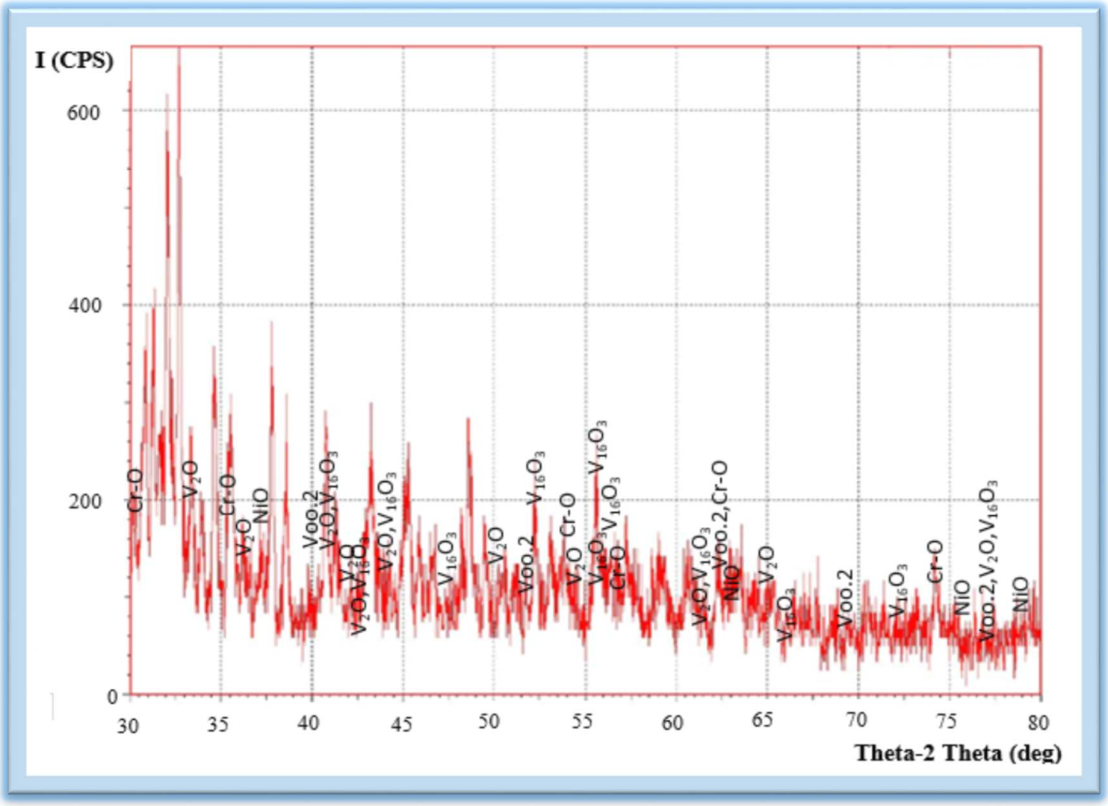

Fig. 1. X-ray diffraction analysis of fly ash

Table 1. Chemical composition of fly ash powder

Compound	Weight %	Compound	Weight %
Na_2S	16.9	Al_2O_3	0.11
K_2O	0.17	V_2O_5	4.6
NiO	1	La&Lu	<1
MgO	1.3	SO_3	43.7
CaO	4.3	Fe_2O_3	19.1
C	8.8	-	-

2.2. Experimental Procedure

The crushed fly ash was leached in sodium hydroxide at a certain temperature, S/L ratio and time. The leaching experiments were performed in a reflux with 2 necks, one for the condenser to prevent losing in solvent solution, and the other for thermometer to control the temperature. The mixture of fly ash and sodium hydroxide solution was put in a reflux. After that, a reflux condenser was put on an electric heater in order to heat the mixture. After the specified time finishes, a funnel with a filter papers was used for the filtration Step. Filtering process was done to separate non-solved solid materials from Vanadium-laden solution resulted from solving process. The filtrate was analysed by (AAS) to determine the amount of vanadium in the leaching solution. The final leaching solution of fly ash has particle size (45-75µm) was cooled to 5°C for 1 hour under mild agitation, alkali precipitate containing vanadium was precipitate. The precipitate was separated from the leach solution by filtration. The precipitate (sodium vanadate) was dissolved in 5% HNO_3 to get a solution with a pH8, solid ammonium sulphate

($(NH_4)_2SO_4$) was added to the solution. Ammonium meta-vanadate (NH_4VO_3) produced was precipitate, separated by filtration. Ammonium meta-vanadate has been dried at 90°C for 30 mintes. After the drying process, ammonium meta-vanadate was placed in ceramic crucible, and then it was place in the burning furnace for calcination process has been done at a temperature of 690 °C for 30 minutes. After the end of the calcination process was obtained on vanadium pentoxide (V_2O_5).

3. Results and Discussion

3.1. Effect of sodium hydroxide concentration

Figure 2 illustrates the recovery curves of vanadium as a function of sodium hydroxide concentration from fly ash of heavy fuel for particle size (45-75 µm), at100 °C, time 4 hours and L/S ratio 5. As seen the vanadium recovery increased with increasing the NaOH concentration. The maximum extraction has been done at 12M as shown in this figure.

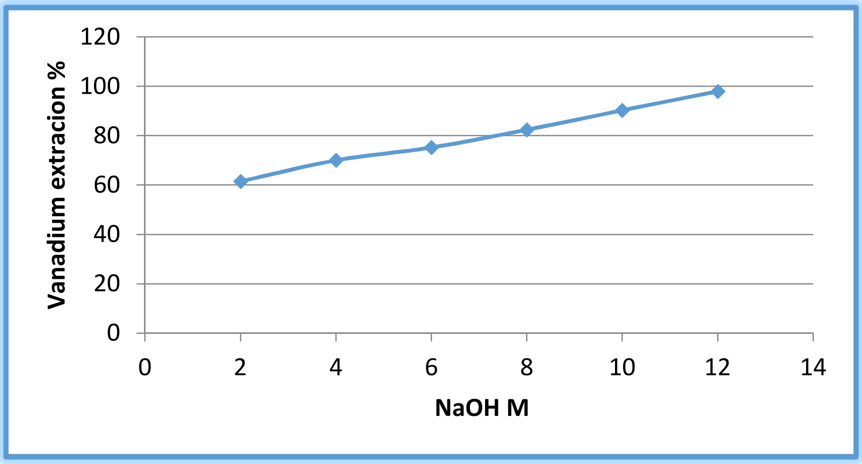

Fig. 2. Effect of NaOH concentration on the vanadium extraction. Other constant parameters are: temperature 100 °C, L/S ratio 5, solving time 4 h, and particle size of 45-75 µm

3.2. Effect of leaching temperature

Effect of temperature on vanadium extraction is shown in Figure 3**.** Other parameters constant: sodium hydroxide concentration 12M, time 4 hours and L/S ratio 5, particle size 45-75 µm. As the figure shows the temperature has a significant effect on the extraction of vanadium, so that the extraction percentage increases from 68.3% to about 98% as the temperature increases from 60 °C to 100 °C.

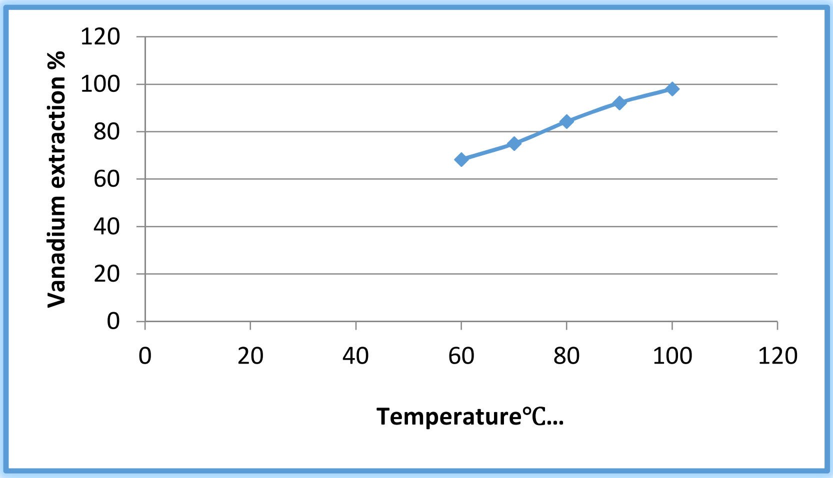

Fig. 3. Effect of temperature on the vanadium extraction. Other constant parameters are: concentration of NaOH 12 M, L/S ratio 5, solving time 4 h, and particle size of 45-75 µm

3.3. Effect of liquid/solid ratio in vanadium extraction

Effect of L/S ratio on percentage of vanadium at 100 °C, time 4 hours and particle size 45-75 µm is presented in Figure 4. This figure shows that increasing this ratio increases the extraction percentage. The maximum of liquid to solid ratio that give the best extraction was 5 and above this ratio the extraction percentage decreases.

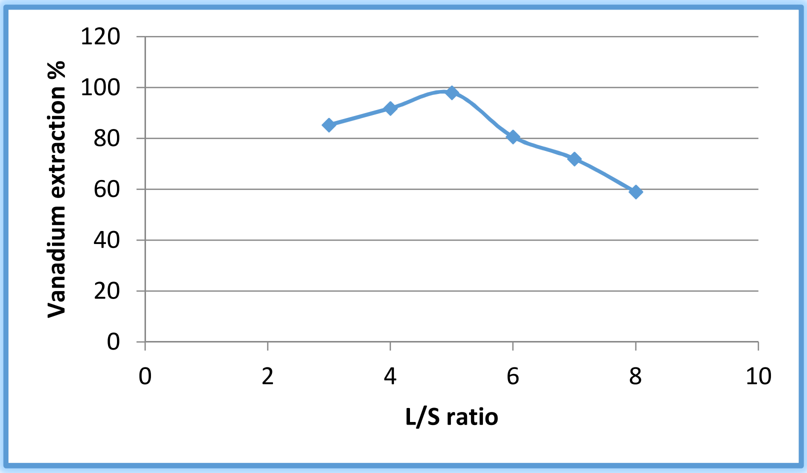

Fig. 4. Effect of L/S ratio on the vanadium extraction. Other constant parameters are: concentration of NaOH12 M, temperature 100 °C, solving time 4 h, and particle size of 45-75 µm

3.4. Effect of solving time in vanadium extraction

The effect of solving time on the extraction percentage of vanadium illustrates in Fig. 5other constant parameters are: sodium hydroxide concentration 12M, temperature 100°C, L/S ratio 5, particle size 45-75 µm. It can be seen from this figure that the extraction of vanadium reaches 98% at 4 hours.

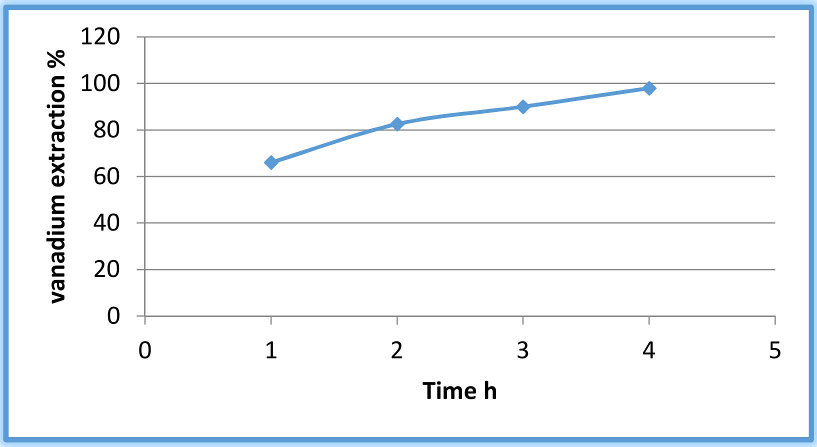

Fig. 5. Effect of solving time on the vanadium extraction. Other constant parameters are: concentration of NaOH12 M, temperature 100 °C, L/S ratio 5, and particle size of 45-75 µm

4. Conclusions

The extraction of vanadium from fly ash produced in heavy fuel in power generation station is investigated using leaching process by alkaline leaching to dissolve vanadium. Experimental results showed that increase of sodium hydroxide concentration, temperature, liquid to solid ratio and leaching time increase the extraction percentage of vanadium. Optimum conditions which bring about around 98% recovery was concluded as: sodium hydroxide concentration 12M, temperature 100 °C, liquid to solid ratio 5, leaching time 4 hours.

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