TECHNOLOGY OF PROCRSSING URANIUM HEXAFLUORIDE USING TO AMMONIUM FLUORIDE

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Abstract

Currently in production technology of hexafluoride uranium has some problems connected with the expenses for its production and safety. Uranium – 235 has extensive use in separation of isotopes, because it is only one volatile compound of uranium wherein fluoride which has only one isotope. At the present time production technology of UF_6 needs a lot of elemental fluorine and this requires more money. [1]

In this science work we examined the ability of production of hexafluoride uranium in connection with ammonium fluoride, which is received by extracting the fluorine ion from depleted hexafluoride uranium. This process offers the challenge to utilize accumulated depleted hexafluoride uranium. In Russian there are hundreds of tons of accumulated depleted hexafluoride uranium.

Key words: Uranium hexafluoride, depleted uranium, triuranium octoxide, ammonium fluoride.

Introduction

The object of the work is to develop a method of obtaining hexafluoride uranium in connection with ammonium fluoride which is received by extracting the fluorine ion from depleted hexafluoride uranium, and also to convert depleted UF_6 to safe form for storage.

Development

Currently in Russian there is based obtaining of uranium hexafluoride. It is fluorination to triuranium octoxide in connection with elemental fluorine by reaction (1):

$$U_3O_8 + 9F_2 = 3UF_6 + 4O_2 \qquad (1)$$

This technology has some disadvantageous, namely it is a lot of fluorine for fluorination and high aggression technologic of gas (mix of hexafluoride and oxygen). [2]

Also a technological scheme has been developed, which got its spread in American manufacturing, wherein uranium dioxide is exposed to hydrogen fluorine with formation of uranium tetrafluoride, after that uranium hexafluoride is exposed to fluorination by elemental fluorine with formation of UF_6 by reaction (2) and (3):

$$UO_2 + 4HF = UF_4 + 2H_2O \qquad (2)$$

$$UF_4 + F_2 = UF_6 \qquad (3)$$

However this method has some disadvantageous whish are connected with the usage of hydro fluoride and separation hydro fluoride – water mix. [3]

In the developed technology one considered the possibility of fluorination of triuranium ocoxide by ammonium fluoride without prior recovery, since the decomposition of ammonium fluoride is followed by

hydrogen formation, which restores the uranium fluoride to uranium dioxide. This process can be expressed by the formula:

$$U_3O_8 + 6NH_4F \cdot HF = 3UF_4 + 8H_2O + 3N_2 + 7H_2 \quad (4)$$

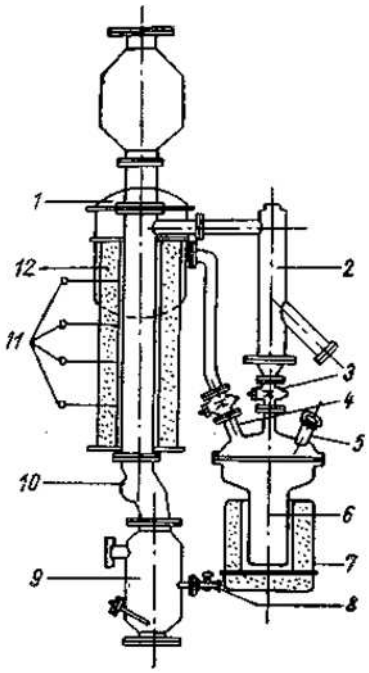


Fig. 1.Vertical reactor for breakerless fluorination in connection with steams of ammonium fluoride.

1 — condenser; 2 — gasfilterforammoniumfluoride; 3,4 — shutoff cocks; 5 — port for ammonium fluoride embark ; 6 — reactor for sublemationammonium fluoride; 7 — incinerator; 5 — inputnoble gas; 9 — box for product; 10 — equipmentfor ex-denning ; 11 — thermocouples; 12 — vertical burner

When properly using this technology it is possible to obtain a qualitative product when there is low content of uranium dioxide fluoride and ammonium fluoride. The final product UF_4 is produced by purity of about 99,4 %. This product is possible to use for getting uranium hexafluoride and uranium oxides.

The process of fluorination in connection with steams of ammonium fluoride is possible to realize in vertical reactor (fig. 1). [2]

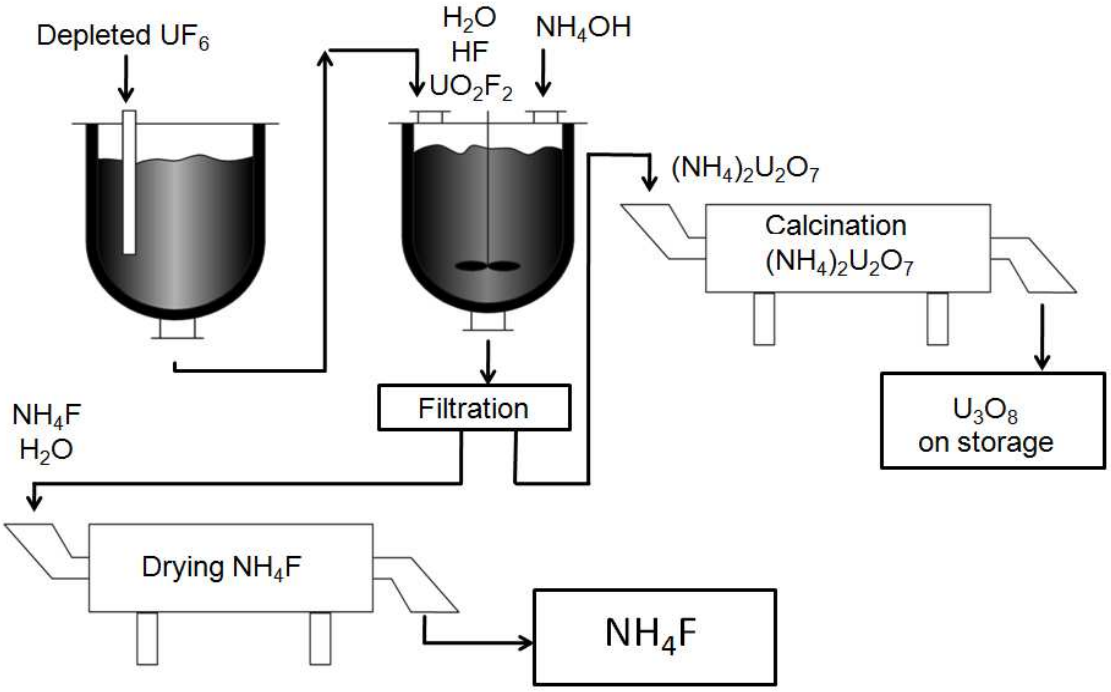
This fluorination technology was developed in 1967 and then it did not have actual use, but currently this method is possible to connect with processing of depleted uranium hexafluoride. Depleted uranium hexafluoride is a waste product of fuel production for nuclear power plants. [3]

Fluorine ion is extracted from depleted UF_6 while uranium is converted to triuranium octoxide in the combined technology. The method consists in dissolving UF_6 in water to give a solution of HF and UO_2F_2 (5). The received hydro fluoride is exposed to gas – liquor with formation of solution of ammonium fluoride (7).

$$UF_6 + 2H_2O = UO_2F_2 + 4HF \quad (5)$$

$$2UO_2F_2 + 6NH_4OH = (NH_4)_2U_2O_7 + 4NH_4F + 3H_2O \quad (6)$$

$$HF + NH_4OH = NH_4F + H_2O \quad (7)$$



$$3(NH_4)_2U_2O_7 = 2U_3O_8 + 6NH_3 + O_2 + 3H_2O \quad (8)$$

The solution is processed with ammonia water to obtain a solid diuranate of ammonium and solution of NH4F (6). Ammonium diuranate is separated by filtration from the solution of ammonium fluoride and calcined to uranium oxide. U_3O_8 is possible to use in uranium metallurgy.

The solution was evaporated to a solid ammonium fluoride (7). The process scheme is shown in Fig. 2.

Fig. 2. Schemeprocessingofdepleted uranium hexafluoridewith obtaining ammonium fluoride

Ammonium fluoride obtained by the reaction of (7) will just be used in fluorination technology which has been described above in reaction (4). This technology will make it possible to use depleted uranium hexafluoride in a factory for obtaining ammonium fluoride. Besides, saving on HF and F_2 will increase the volume of production of UF_6. As we can see in fig. 2, after calcination of ammonium diuranate $(NH_4)_2U_2O_7$ the triuranium octoxideis formed, which is safer than depleted uranium hexafluoride for storage in the fresh air. For realization of the process we can use typical and cheap equipment of chemical technology.

It must be also specified that the reduction and fluorination by ammonium fluoride vapors the explosiveness of production decreases. In case of depressurization of apparatus ammonium fluoride is desublimatedin the atmosphere without presenting a significant risk to personnel.

In the process of research we calculated mass balance of a hydrolysis of depleted uranium hexafluoride to obtain ammonium fluoride (fig. 3) and mass balance of uranium hexafluoride obtaining using ammonium fluoride.

Looking at fig.3 and we can see that when processing about one ton of depleted UF_6, we get 631 kg of ammonium fluoride and 886 kg of triuranium octoxide. In the result 96 % of fluorine ion can be extracted from depleted uranium. It must be noted that the resulting ammonium fluoride is 3 times cheaper than the

factory's one.

Fig. 4 shows the material balance of ammonium fluoride fluorination of uranium oxide, which contains uranium - 235. With the help of ammonium fluoride, which was obtained in the first process diagram (Fig. 3) we can be fluorinate 1198 kg of triuranium octoxide to obtain 1138 kg of uranium tetrafluoride.

Conclusion

Thus, with the help of developed technological scheme it is possible to utilize depleted uranium hexafluoride. Depleted uranium is converted to triuranium octoxide form and extracted fluorine ion in the form ammonium fluoride will allow to expand production of uranium hexafluoride.Also the developed scheme for UF_6 is safer than the existing methods of preparation. Moreover the technological scheme is based on typical and cheap equipment of chemical technology.

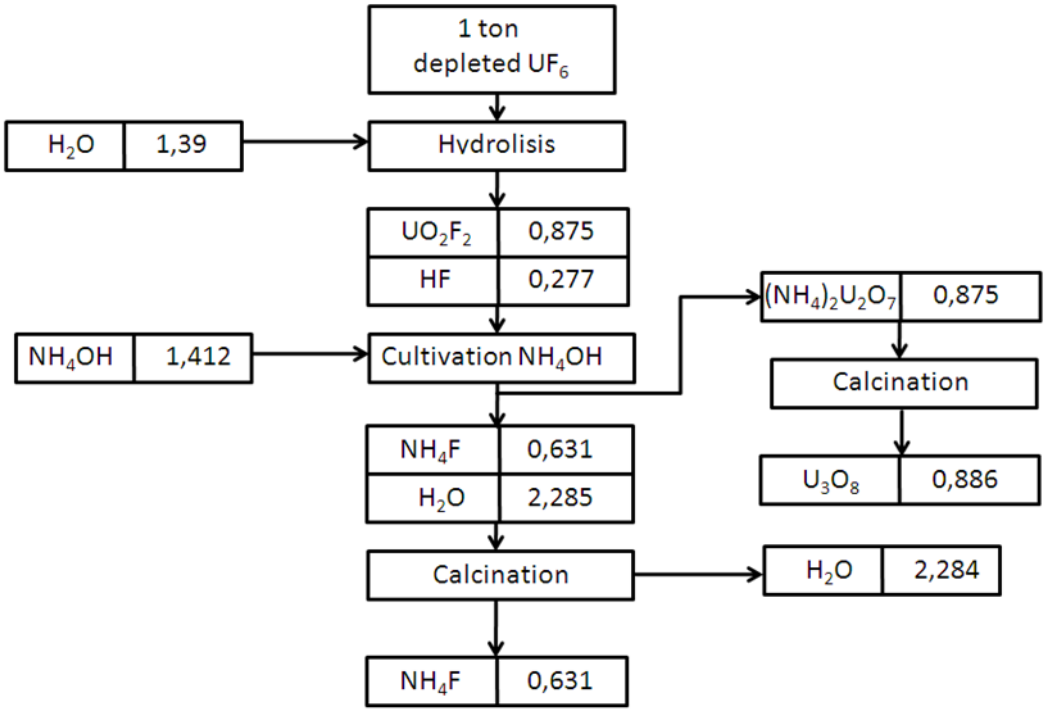


Fig. 3. Scheme of mass balance of processing hydrolysis depleted uranium hexafluoride and ammonium fluoride obtaining

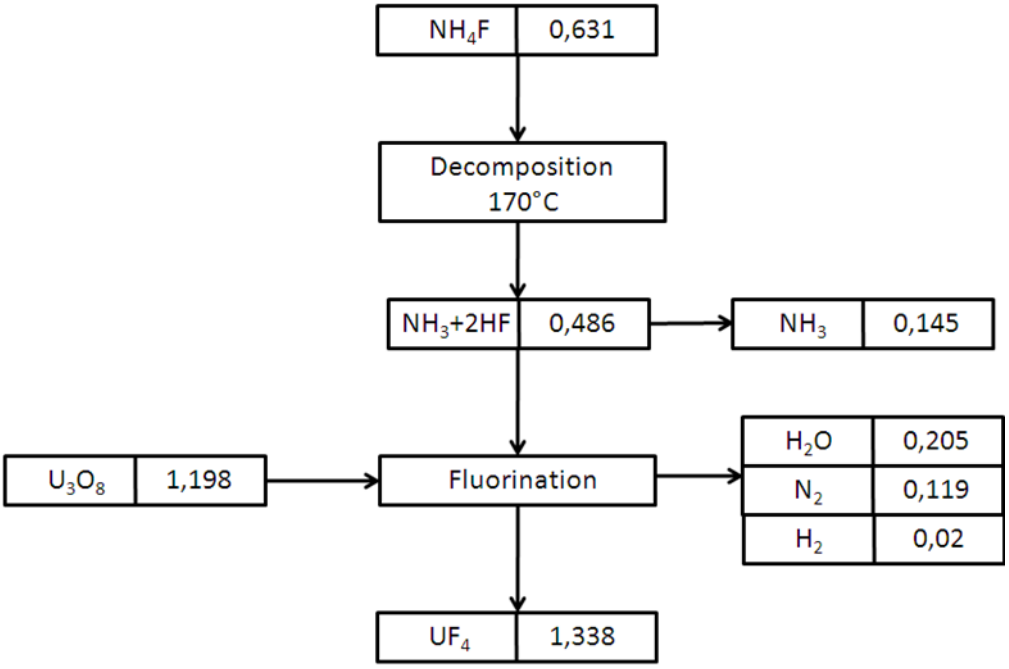


Fig. 4. Scheme of mass balance of processing fluorination triuraniumoctoxide in connection with ammonium fluoride

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