^{99}Tc TRANSMUTATION IN HIGH FLUX REACTOR SM

A.A. Kozar[1], V.A. Tarasov[2], Yu.G. Toporov[2], V.F. Peretroukhine[1],

V.M. Radchenko[2], E.A. Karelin[2], E.G. Romanov[2]

1 – Institute of Physical Chemistry of Russian Academy of Science, Moscow, Russia

2 – State Scientific Center of the Russian Federation “Research Institute of Atomic Reactors”, Dimitrovgrad, Russia

^{99}Tc total contents in the spent fuel of nuclear power stations will reach 250 t by 2010. Possibility of ^{99}Tc destroying by transmutation to stable ruthenium by thermal and resonance neutrons irradiation is described in a number of papers. The transmutation product ruthenium is noble metal, its price has increased approximately in 3 times during the last decade and has reached about $30 per gram. World ruthenium production and ^{99}Tc accumulation rate in nuclear power reactors are close during last years and make about 8 t/yr. Thus, if ^{99}Tc nuclear burning rate will be sufficiently high, then synthetic ruthenium production can reach the level which is close to its industrial extraction from ores.

The experimental demonstration of fast ^{99}Tc transmutation is realized by us in the neutron trap and in the reflection shield of high flux reactor SM-3 (Dimitrovgrad). Thermal and resonance neutrons flux densities in the trap were $1.8*10^{15}$ $cm^{-2}*s^{-1}$ and $1.65*10^{14}$ $cm^{-2}*s^{-1}$ accordingly. These parameters in the reflection shield were $1.1*10^{15}$ $cm^{-2}*s^{-1}$ and $3.5*10^{14}$ $cm^{-2}*s^{-1}$ accordingly.

Technetium targets have been taken in the form of metallic disks of 0.3 mm width and 6 mm diameter. The targets were divided into two batches and are packed in 4 ampoules till 7 disks in everyone. Sample orientation in ampoules corresponded to irradiation in thin layer geometry. Total technetium loading was about 5 g. Two ampoules of the first batch were irradiated in the neutron trap during 72 effective days in recalculation for nominal thermal power of the reactor of 100 MW. The second targets batch was irradiated first during 80 effective days in the reflection shield and then during 180 effective days in the neutron trap.

At the moment of loading the average thermal neutrons flux densities inside samples were $1.14*10^{15}$ $cm^{-2}*s^{-1}$ in the neutron trap and $6.8*10^{14}$ $cm^{-2}*s^{-1}$ in the reflection shield accordingly. These values for resonance spectrum were equal $1.09*10^{14}$ $cm^{-2}*s^{-1}$ and $4.02*10^{13}$ $cm^{-2}*s^{-1}$ accordingly. Thermal flux inside targets was increased during irradiation less than at 15 % as a result of ^{99}Tc burning, but resonance neutrons flux remained almost constant within the limits of a statistical error.

The electrochemical cell with electrolyte cooling was applied for dissolution of the irradiated targets. The samples were dissolved completely for 2 hours in HCl with concentration of 6 mol/l by the current of 2.5 A and at voltage of 70 V. The average dissolution rate has made 42 mg/hour. Emission spectral analysis has shown that ^{99}Tc burnups have made 34±6 and 65±11 % for the first and second targets batches accordingly. The obtained experimental data have confirmed a correctness of preliminary calculation of ^{99}Tc transmutation dynamics on two positions of reactor SM (see figure).

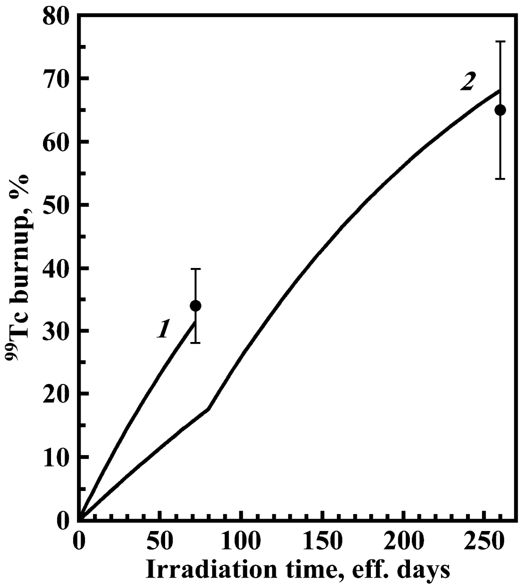

Figure. The calculated transmutation dynamics of the first (*1*) and the second (*2*) ^{99}Tc targets batches (—) and experimental values of burnups (•).

From point of view of radiation hygiene ruthenium from irradiated targets with ^{99}Tc burnups of 34±6 and 65±11 % can be applied without limitations after purification with Tc-Ru separation factors of $(3.3\pm0.9)*10^8$ and $(9.2\pm4.4)*10^7$ accordingly. These values decrease in 5 times for usage of the obtained noble metal in nuclear branch only.

The record ^{99}Tc burnups are reached and about 2.5 g of transmutation ruthenium are accumulated as a result of experiments on reactor SM. These values are significally higher of burnups 6 and 16 % achieved on HFR in Petten earlier. The targets had no destructions after their irradiation, therefore their radiation stability is sufficient for planning of transmutation campaigns with high burnups. In this case the amount of cycles of targets irradiation and reprocessing will decrease for obtaining of commodity ruthenium and then this precious metal production by ^{99}Tc transmutation becomes cheaper. Ruthenium world reserve is insignificant and is estimated as $(3 – 5)*10^3$ t only, therefore the new method of its production can make a competition to mining extraction in the future.