10.3 Some Aspects of Beryllium Disposal in Kazakhstan

V.Shestakov [1], Y.Chikhray [1], Yr.Shakhvorostov [2]

1). National State University

480012, 96A Tolebi Str, Almaty, Kazakhstan

2). JSC "Ulba Metallurgical Plant"

492026, 102 Abai Ave, Ust-Kamenogorsk, Kazakhstan

TEL/FAX: +7-3272-924827; E-mail: chikhray@ntsc.kz

Abstract

Historically in Kazakhstan all disposals of used beryllium and beryllium wasted materials were stored and recycled at JSC "Ulba Metallurgical Plant". Since Ulba Metallurgical Plant (beside beryllium and tantalum production) is one of the world largest complex producers of fuel for nuclear power plants as well it has possibilities, technologies end experience in processing toxic and radioactive wastes related with those productions.

At present time only one operating Kazakhstan research reactors (EWG1M in Kurchatov) contains beryllium made core. The results of current examination of that core allow using it without replacement long time yet (at least for next five-ten years). Nevertheless the problem how to utilize such irradiated beryllium becomes actual issue for Kazakhstan even today. Since Kazakhstan is the member of ITER/DEMO Reactors Projects and is permanently considered as possible provider of huge amount of beryllium for those reactors so that is the reason for starting studies of possibilities of large scale processing/recycling of such disposed irradiated beryllium. It is clear that the Ulba Metallurgical Plant is considered as the best site for it in Kazakhstan.

The draft plan how to organize experimental studies of irradiated beryllium disposals in Kazakhstan involving National Nuclear Center, National University (Almaty), JSC "Ulba Metallurgical Plant" (Ust-Kamenogorsk) would be presented in this paper as well as proposals to arrange international collaboration in that field through ISTC (International Science Technology Center, Moscow).

Beryllium in Kazakhstan

Despite the fact that the Kazakhstan during the last decades is the biggest beryllium manufacturer (and supplier) in the world the issue of beryllium utilization and especially its recycling were not considered here as national priority or as the object of public interest at least. Possibly it could be explained with the fact, that those and similar issues were successfully solved by beryllium manufacturer itself, i.e. by JSC "Ulba Metallurgical Plant" (Ust-Kamenogorsk, Eastern Kazakhstan). The big advantage of Ulba's beryllium production is its closed process loop where scrap and wastes from beryllium casting and machining processes are recycled and returned back into technological process.

Unpromising or hard to recycle wastes are stored at special UMP storage.

The most of beryllium and beryllium containing products UMP exports abroad. The Kazakhstan itself has not any enterprises yet which are using beryllium in any way in significant amount in its production which is liable to reprocessing and utilization after lifetime according to actual in Kazakhstan regulatory documents and sanitary rules.

As regards the irradiated beryllium then its amount in Kazakhstan is approximately less than 30-40 kilos. Such a quantity indicates clearly that there not commercial interest at present moment to organize its recycling with purpose of further use. Proposed hereafter technical and organizational measures of such recycling are our very first attempt of preliminary studies of possibility of middle-scale or industrial recycling in Kazakhstan of beryllium irradiated in future fusion reactors. We would like to use experience, possibilities and knowledge of UMP, National University and National Nuclear Center of Kazakhstan. We have to underline here that at present moment this attempt is not supported yet with appropriate legislations and/or decision of Kazakhstan Government.

Proposal on Studies of Irradiated Beryllium in Kazakhstan (Step 1)

At present time NNC keeps several samples of distilled beryllium (DShG-200, UMP product) irradiated with fast neutrons in BN-350 (when it was operating yet). We propose as the first step to examine closely theirs current status (prehistory, spectrum of irradiation, chemical composition etc.) in UMP, in Institute of Nuclear Physics NNC and in National University with purpose to understand better the role of each admixture in overall activity and its influence on beryllium recycling.

Proposal on Trial Recycling of Irradiated Beryllium in Kazakhstan (Step 2)

As we believe now, the activation of beryllium reflectors in fission reactors occurs under impact of neutron irradiation mainly via (n,γ) and (n,p) reactions with nickel and iron mainly. Irradiation of ^{58}Fe produces ^{60}Co at the end of transformations chain:

$$^{58}Fe + n \rightarrow {}^{59}Fe + \gamma$$

$$^{59}Fe \rightarrow {}^{59}Co + \beta^- + \gamma \ (T_{0.5} = 45 \text{ days})$$

$$^{59}Co + n \rightarrow {}^{60}Co + \gamma$$

$$^{60}Co \rightarrow {}^{60}Ni + \beta^- + \gamma \ (T_{0.5} = 5.2 \text{ yrs.}),$$

while the (n,p) reactions at ordinary nickel (^{58}Ni) and iron (^{54}Fe) produce also important radio-nuclides ^{58}Co and ^{54}Mn:

$$^{58}Ni + n \rightarrow p + {}^{58}Co$$

$$^{58}Co \rightarrow {}^{58}Ni + \beta + \gamma \ (T_{0.5} = 71 \text{ days})$$

$$^{54}Fe + n \rightarrow p + {}^{54}Mn$$

$$^{54}Mn \rightarrow {}^{54}Cr + \beta^- + \gamma \ (T_{0.5} = 300 \text{ days}).$$

At the same time tritium is retained in beryllium due to well known sequence of reactions:

$$^{9}\mathrm{Be}\,(n,\alpha) \rightarrow {}^{6}\mathrm{He}$$

$$^{6}\mathrm{He} \xrightarrow{\beta^-} {}^{6}\mathrm{Li}, \qquad T_{1/2} = 0.8\ \mathrm{sec}$$

$$^{6}\mathrm{Li}\,(n,\alpha) \rightarrow {}^{3}\mathrm{H}$$

$$^{3}\mathrm{H} \xrightarrow{\beta^-} {}^{3}\mathrm{He}, \qquad T_{1/2} = 12.33\mathrm{yr}$$

$$^{3}\mathrm{He}\,(n,p) \rightarrow {}^{3}\mathrm{H}.$$

So, if we presume that the beryllium in fusion reactor will be decommissioned every operation year, then the concentration of ^{60}Co, ^{58}Co, ^{54}Mn and others will be low enough to implement any method of direct remelting: distillation refining or zone smelting.

We propose (as Step 2) to carry out a law-scale distillation refining of irradiated beryllium samples in special installation with high-frequency currents. Such a trial recycling will be carried out in the same laboratories under all available control (gas analysis, parameters etc.) with purpose to check the idea in practice.

Proposal on Recycling of Irradiated Beryllium in Kazakhstan (Step 3)

In case of positive results at Step 2 we propose to arrange middle scale recycling of irradiated beryllium using much bigger installation. That installation is designed and manufactured by WNIITWCh (Russian Research Institute of High-Frequency Current, St-Petersburg, Russia) for distillation refining of metals using induction heating. The amount of raw metal load could be up to 2500 kilos.

Since the most of tritium and helium will be released during such distillation refining so the installation is equipped with effective getter and ion pumps allowing complete isolation of melting zone from environment and providing needed ecological non-pollution (with respect to gases). Maybe at that stage it will be possible to filter tritium (using Pd-Ag filters) and to store it in getters. Vacuum system provides the pressure level in technological chamber lower than $5*10^{-5}$ torr. Radiation protection will be provided using other known methods. Surely the installation will be equipped with gamma-meters for control of gamma-radiation levels in recycled beryllium and in waste. The residue from distillation process is supposed to be packed and passed to the Institute of Atomic Energy NNC (Kurchatov, Kazakhstan) for safekeeping in special storage.

At this time we invite all who is interested to participate with us in joint international project within IPP, ISTC, CRDF or similar frames.

Conclusions

- The amount of irradiated beryllium in Kazakhstan does not exceed 30-40 kilos and has low radioactivity level
- Kazakhstan is not in a position to import irradiated materials for storage or recycling

- As a participant of ITER/DEMO activity Kazakhstan is interested in studies of recycling possibilities of irradiated beryllium
- We propose to arrange international R&D on beryllium recycling studies using Kazakhstan samples, experience and possibilities