FIELD STUDY OF MECHANOCHEMICAL PROCESSING EFFECT ON NATURAL QUARTZITES TO THE PURIFICATION EFFICIENCY OF NPP'S AEROSOL RELEASE

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Abstract.
Our researches have shown that the specific algorithm of mechanochemical treatment of quartzites surface can lead to considerable change of both the surface charge and the chemical activity providing high efficiency of cleaning (up to 98 %) of NPP aerosol releases by the filter bed, which create an aerodynamic resistance (ΔP= 0,4÷0,6 kPa) noticeably less than one from standard fibrous Petrianov filter (PF), which was used at NPP. Application of bulk granular filters (BGF), for example as a buffer filter, would allow to avoid choking PF with large dispersed aerosols, especially during planned preventive maintenance, for increasing both the release cleaning efficiency and prolonging PF service life. There are a lot of reasons for using the BGF as a basic filter as well.

1.**Introduction**.

The level of NPP radiation safety for environment is defined by operational reliability of protective barriers and by effectiveness of technological systems work, which were designed for absorption and disposal of radionuclides that have passed through the protective barriers. The state of radiation situation both on NPP's area and on radiation-control area substantially depends on capability of long-lived radioactive aerosols release into the coolant and subsequent spreading into NPP's compartments and into environment.

The radioactive aerosols are created as a result of machining various surfaces during planned preventive maintenance, by the penetration of the dust into NPP compartments, which were not intercepted by filters of blowing ventilation, by the drying and following blowdown of various liquids sediment and also as a result of mechanical deterioration of working machinery.

For the subsequent statement about research issue, we need to point out that aerosols created at NPP besides usual tribocharge acquire also an additional charge by exposure of various ionizing radiations. Thus the radioactive aerosols are present at ventilation system of NPP as a rule have a surface electrostatic charge.

It should be noted that NPP's aerosols have special features, basically they are superfine ($D < 1$ μm) and fine-dispersed ($5\ \mu m \geq D \geq 1 \mu m$) aerosols and their concentration is rather low (< 90 $\mu g/m^3$). However at start-up operation (the first operation and after scheduled repair) ones may observe considerable increase of concentration and size of aerosols, which usually are not radioactive.

Above-mentioned conditions lead to filter clogging and to premature failure of filter to normal function replacement. At present almost all modern technology of NPP air cleaning are based on using of Petrianov filter fabric.

Economic conditions stimulate the search of more acceptable version of NPP aerosols release cleaning, both by cost and service life. Of course, we have to give preference to local materials and also to technologies, which are able to settle most questions of regeneration and utilization of used filters without significant increase of radwaste volume.

The performed critical ALARA-analysis of existing aerosol filter systems of NPP has revealed the following conclusions:

⇒ The increasing of aerosol filters efficiency directly influence on the decreasing of release activity into environment;

⇒ Implementation of the used radioactive aerosol filter remote replacement ability will eliminate extra occupational exposure of personnel performing this operation.

⇒ The reduction of radwaste volume on used aerosol filter disposal also reduces the environmental risk;

⇒ The commercial availability of the aerosol filter specifies the possibility of optimum replacement frequency thus increasing filters efficiency and therefore also decreasing the release activity.

The abovementioned conclusions have allowed considering enough expedient the performance of researches on definition of capability increasing of NPP's aerosol filter efficiency.

As a result so-called "bulk granular filters" (BGF) were selected, which are made of mineral raw materials, for example, of splintered quartzites.

Reasoning from that we started the research on efficiency of granular filters use in NPP aerosols release cleaning system. It is known the use of BGF, which are sand, gravel, scoria, and splintered rock as filtering material. However for assurance of cleaning efficiency not less than 90 % you need to have a filter bed at least such height which creates an initial resistance above 4kPa, whereas at ventilation system of NPP in operation have a rarefication no more than 3kPa.

That is why the application of BGF for cleaning NPP's radioactive aerosol release was considered ineffective since it was required to have a depth of the BGF bed creating aerodynamic resistance that was much more than NPP ventilation system rated capacity. On the other hand it was well known that using the mechanochemical processing of solid body surface could increase both chemical and catalytic activity and surface static charge as well [1,2]. In addition, such selection was made since the BGF are the least expensive filters, create small amount of solid radwaste, allow a remote replacement of the spent filters, in addition to that, such type of filters is also enough multipurpose and can be used both as a buffer filter and a as basic filter.

2. **Description of method and results.**

With the purpose of the research on efficiency of mechanochemical processing for radioactive aerosols filters we have designed a measuring bench (diagram of that is presented in Fig.1), which permit to perform the research with real aerosol releases of NPP.

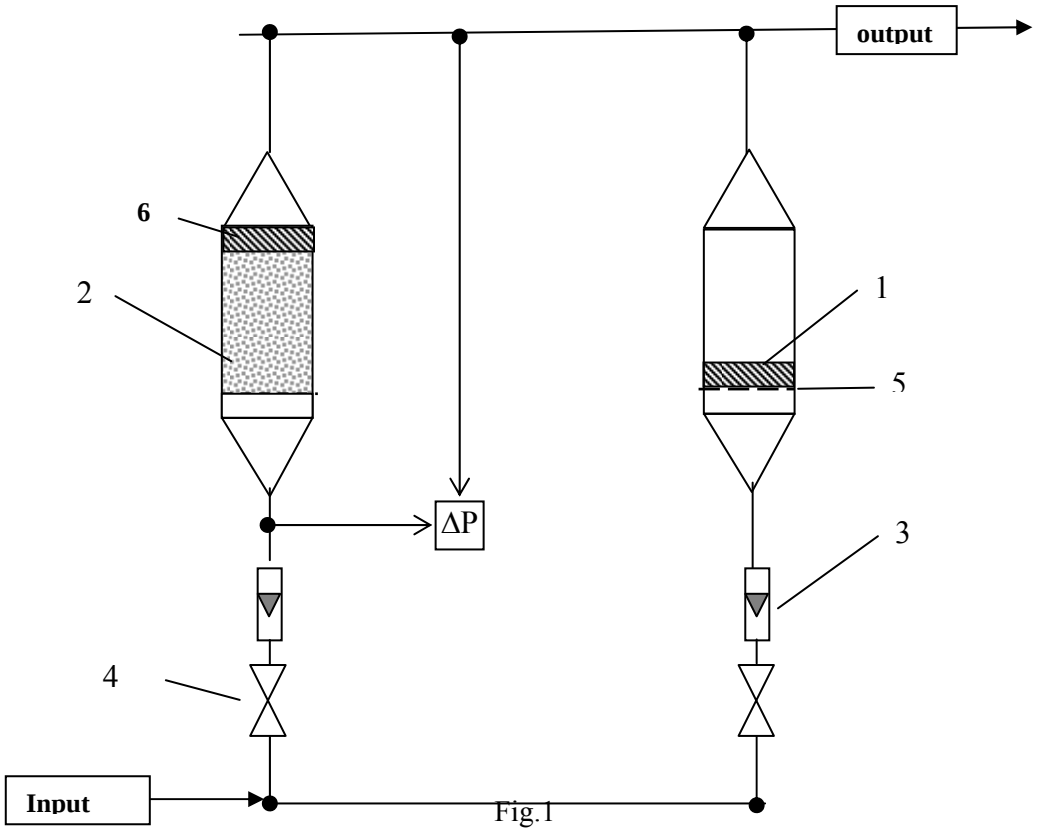

Fig.1

In the figure 1 we have designated as position 1 and 6 – Petrianov filter; as a position 2- BGF; as a position 3 – rotameter; as a position 4 – valve; as a position 5 – the grid; as a ΔP - liquid differential manometer;

The experiments were performed with nature quartzites from one of Armenian ore deposit. The quartzites were splintered until medium-size about 1 mm. The chemical composition of the natural quartzites is: SiO_2 – 95.14 %; Al_2o_3 –1.13 %; Fe_2O_3 –0.57%; CaO – 0.41%; MgO- 1.04%; TiO_2 – 0.07%; calcination loss is 0,48%.

The grinding is performed with a jaw crusher and with a planetary-motion ball grinder at the various value of power density. The chemical activity was defined with solubility of SiO_2 surface, which became amorphous because of mechanochemical treatment.

Let notice that all used equipments were production equipment and so it was easy to make an appraisal of expenditure for production such filtering material. The filters worked 10÷15 days then after removal of the used filter from the bench the filter's activity was measured in 24 hours.

According to value of measured activity was counted the efficiency of cleaning from aerosols. We obtained the following results on value of cleaning efficiency (the initial resistance of BGF is 0,4÷0,5 kPa):

⇒ filter made of crushed quartzite without mechanochemical activation– 45÷50% cleaning efficiency

⇒ filter made of crushed quartzite with mechanochemical activation - 80÷98% cleaning efficiency

The efficiency was defined relatively of Petrianov filter, which was set after BGF (see Fig. 1, position 6) and one more, which was set in parallel device (see Fig.1, position 1) of the measuring bench.

The chemical and catalytic activity of quartzite that was acquired by mechanochemical crush was estimated by the increasing of X-ray diffraction pattern width that indicated on crystal structure disorder. With increasing the structure disorder of quartzite, formation of amorphous phase on quartzite surface increase as well. You may estimate the efficiency of mechanochemical treatment by measuring solubility (and its speed) of treated quartzite in water at temperature 25^{o}C.

The operating conditions of planetary-motion grinder is defined by number of revolutions around own axes 230÷390 revolutions per minute, by number of revolutions around main axes 190÷320 revolutions per minute, by treatment time 2÷10 minutes and by mass of grinding spheres 60÷130 g.

Our working model considered that short-lived nuclide are substantially by superfine aerosols (average size D<1 μ) and long-lived nuclide are more coarse aerosols. Therefore the granular filter, which entrap coarse aerosols (d >1 μ) more efficiently, will infiltrate superfine aerosols and this model was corroborated with measuring the activity of Petrianov filter, which was set after granular filter:

⇒ cleaning efficiency of the granular filter, which was measured in one hour (time–lag is 1 hour), was 74÷78% ;

⇒ cleaning efficiency of the same granular filter, which was measured in 24 hour (time–lag is 24 hour), was 83÷84% ;

However the granular filters, which were made of mechanochemical activated quartzites didn't have such difference as they have acquired greater surface static charge.

Some results of measured BGF efficiency are presented in the table 1.

Table 1.

filter qualification	cleaning efficiency (%)	filter in work (day)	retention interval before measure (hour)	chemical activity
quartzite without activation	45÷50	10	24	0%
Mode 1	85÷87	10	24	25%
Mode 2	73÷75	10	24	8%
Mode 3	96÷98	10	24	40%

Capacity for dust of filtering material is one of main characteristic therefore we have performed the testing for this parameter: several BGF have been set during preventive maintenance and them have been kept for six months. We were checking the cleaning efficiency every month and its value was 97÷98 % for whole time of testing (six months).

The operating costs for making the mechanochemical activated quartzite are 0,3 kilowatt-hour per kg and our estimate of net cost is 8÷10 cent per kg. By our estimate the BGF cost will be at least ten times less than Petrianov filter material, which is needed for making one aerosol filter. In addition both

loading procedure and replacement procedure of BGF may be easily automatized for excluding the extra exposure of personal. The material of the BGF may deactivate with minimal volume of radwaste and then this deactivated material may be utilized as mortar sand. The following technical applications are possible as well:

⇒ mobile device for air local cleaning during execution of welding and shaving work at NPP control area;

⇒ application as a buffer filter in ventilation system with PF for increasing of PF service life and its efficiency;

⇒ application in NPP ventilation system instead of PF;

⇒ application as a filter in NPP input ventilation system so that may decrease the dustiness of reactor building and sludging-up of floor drain.

Thus our researches have shown that the specific algorithm of mechanochemical treatment to quartzites surface can lead to considerable change both the surface charge and the chemical activity of specimen and providing the high efficiency for cleaning (up to 98 %) of radioactive aerosol release but by the layer which create an aerodynamic resistance (ΔP =0,4÷0,6 kPa) noticeably less than one from standard Petrianov filter (PF) which was used at NPP.

Application of BGF, for example as a buffer filter, in particular during preventative maintenance, when the PF may be quickly clogged with large aerosols, would permit increase both the release cleaning efficiency and the prolonging of PF service life.

References:

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