An Activation Analysis of the Beam Dump by a 20 MeV Proton Beam

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1. Introduction

The beam dump in KOMAC[1] is considered to be made of copper or graphite brazed by copper for cooling. At the first stage, the proton energy and average current of KOMAC are planned to be 20 MeV and 4.8 mA, respectively. The activation of copper and graphite is one of the important standards for the choice of the beam dump material. To assess the activation of the beam dump, two slab calculation models of copper and graphite-copper irradiated by a 20 MeV proton beam were employed. The activations by the protons and by the secondary neutrons produced by the proton irradiation were calculated with the MCNPX code[2]. To validate the calculations, the activities of copper at the NAA hole of HANARO were calculated and compared with the experiments. The copper of 3.623 mg was irradiated at the NAA hole for 1 minute and the activity of the Cu-64 was counted in the experiment.

2. Radioisotopes from Copper and Graphite

Radioisotopes are produced from copper by 20 MeV protons as well as by the secondary neutrons. The radioisotopes by the 20 MeV protons from copper are Cu-62, Cu-64, Zn-62, Zn-63 and Zn-65. Figure 1 shows the radioisotopes produced from copper by the secondary neutrons. Fortunately, radioisotopes are hardly produced from graphite by 20 MeV protons and the secondary neutrons are also produced in relatively small numbers when compared with those from the copper.

3. Activation Calculations

The activations are calculated for several slab geometries using the MCNPX code with LA150[3] data libraries. To calculate the activity of copper, a proton beam of 20 MeV, 4.8 mA was irradiated with copper. The reaction rates of the radioisotopes were calculated according to the penetrating depths of the copper. Figure 2 shows the activities per unit volume of the radioisotopes produced by the secondary neutrons in 2 mm copper. The activations of the copper by the 20 MeV protons were compared with those by the proton induced neutrons in Figure 3.

Another choice of the beam dump material is graphite brazed by copper for cooling. The radioisotopes are hardly produced in graphite by 20 MeV protons. However the radioisotopes would be produced in the brazed copper by the secondary neutrons from the graphite. The activations at the brazed copper behind the graphite of the 1 and 3 cm thickness were calculated. Figure 4 shows the total activities at the brazed copper with the graphite thicknesses.

4. Discussions

The activations of copper are mainly made by the Cu-64 and Cu-66 isotopes produced by the neutron capture reactions of Cu-63 and Cu-65, respectively. Figure 4 shows that the activations of the beam dump of copper can be reduced to 1/100 ~ 1/10,000 if graphite-copper is used as the material of the beam dump for a 20 MeV proton beam.

The experiment was carried out for the validation of the activation calculation with the neutron spectrum of the NAA hole. Figure 5 compares the calculated and experimental activities of Cu-64. The calculated activities of Cu-64 agree well with the experiments to within 10%.

5. Conclusions

An activation analysis was performed for the candidate materials of the beam dump of KOMAC. The radioisotopes are produced from copper by 20 MeV protons as well as by the secondary neutrons. However the activations of copper are mainly caused by the secondary neutrons induced by the incident protons.

The beam dump of graphite-copper can reduce the activation by more than 100 times that of the copper beam dump.

Acknowledgement

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References

[1] . KOMAC : KOrea Multipurpose Accelerator Complex
[2] MCNPX : Monte Carlo N-Particle Transport Code System for Multiparticle and High Energy Applications, CCC-715
[3] LA150 : LA150N, LA150H, LA150U – 150 MeV neutron, proton, photonuclear data libraries.

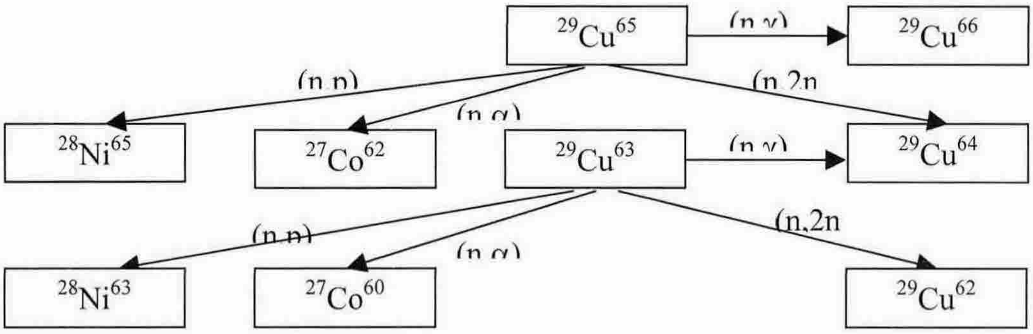

Figure 1. The Radioisotopes Produced in Copper Irradiated by Neutrons

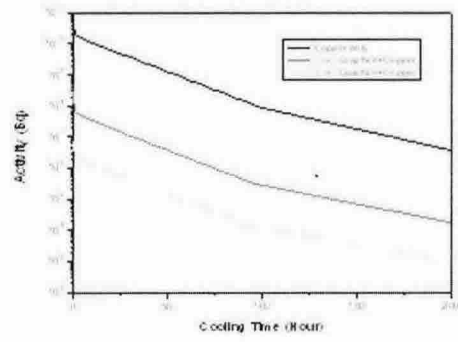

Figure 2. Activity of the Copper Irradiated by a 20 MeV, 4.8 mA Proton Beam

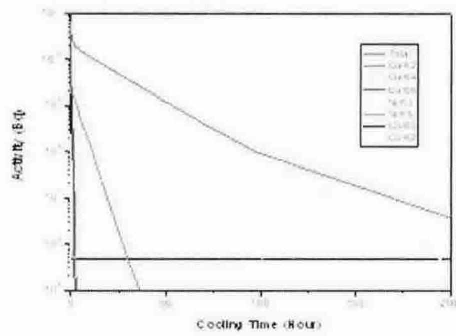

Figure 3. Comparison of the Activities of Copper by the 20 MeV Protons and the Proton Induced Neutrons

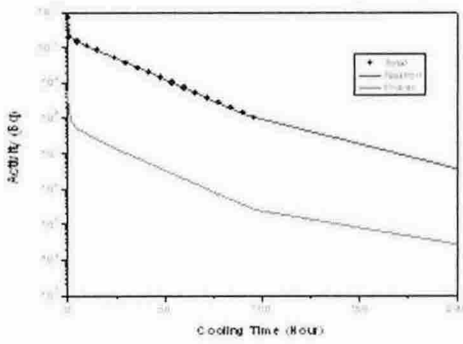

Figure 4. Comparison of the Activities at the Copper and the Copper behind the Graphite

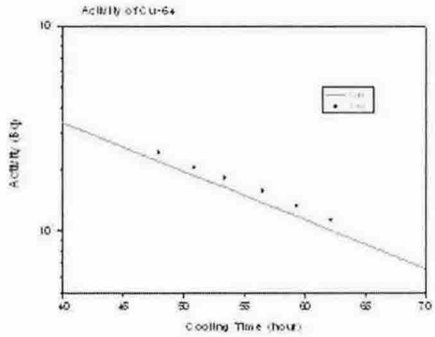

Figure 5. Comparison of the Calculated and Experimental Activities of Cu-64.