An Investigation on the Casting Process of of Uranium Foils for Mo-99 Irradiation Target

K.H. Kim, M.G. Sohn, E.S. Kim, S.J. Oh, B.C. Lee and C.K. Kim
Korea Atomic Energy Research Institute, 150 Deogjin-dong, Yuseong-gu, Daejeon 305-353, khkim2@kaeri.re.kr

1. Introduction

Generally, the conventional fabrication method for uranium foils [1-2] has the disadvantages of complicated processes such as the following: casting the uranium; cutting the resulting ingot to a suitable size for hot rolling; rolling a thick piece of the ingot through many passes to gradually thin it to fabricate a uranium foil with a thickness of about 100 μm; and finally heat-treatment at ~800 °C and quenching the fabricated uranium foil to produce the required gain size and orientation.

In the conventional method, the uranium must be heated and rolled under a vacuum or in an inert atmosphere because it is a reactive material. The hot rolling is repeated several times to obtain a suitable thickness of the uranium foil. As the hot-rolling process takes a long time, productivity is relatively low.A washing/drying process must be done to remove the surface impurities after hot rolling. In order to obtain a fine polycrystalline structure which has a more stable behavior during irradiation, heat-treatment and quenching must be performed. The high hardness and the low ductility of the uranium make it difficult to roll the foil. The foil is liable to crack owing to residual stress during the process, resulting in a low yield.

An alternative fabrication method for polycrystalline uranium foils has been investigated using a cooling-roll casting method in KAERI since 2001 [3], in order to produce a medical isotope ^{99}Mo, the parent nuclide of 99^{m}Tc. In the present study, the fabrication method of wide uranium foils produced by cooling-roll casting has been investigated to improve the quality of uranium foils and the economic efficiency of the foil fabrication with the modifications of the casting apparatus and the variations of the various process parameters. The wide U foils have been obtained through a rapid cooling directly from a melt.

2. Experimental Process

Uranium lumps (99.9 % pure) were charged and induction-melted in a high-temperature-resistant ceramic nozzle. The superheated molten U metal was discharged through a small slot in the nozzle onto a rotating cooling-roll under the condition where the slot was located close to the cooling roll. The U foil was rapidly cooled by contact with the rotating roll driven by an electric motor in an inert atmosphere so that the fine crystalline grains of the uranium foil with an irregular orientation are formed. The rapidly solidified foil was collected in a container. The thickness of the foils was measured at several positions along each foil using a micrometer. The foils were polished to 0.3μm in diamond paste, and the metallographic observation was performed for the sections of the foils, using a scanning electron microscope (SEM). X-ray diffractometer (XRD) using Cu K_{α}radiation and a Ni filter were used to determine the phase and the preferred orientation for both the surfaces of the foils.

3. Results and Discussions

The injection control devices of the uranium melt was applied to cooling-roll casting apparatus, in order to stabilize the fabrication process and to increase the yield of uranium foils through the prevention of the melt leakage [Fig. 1].

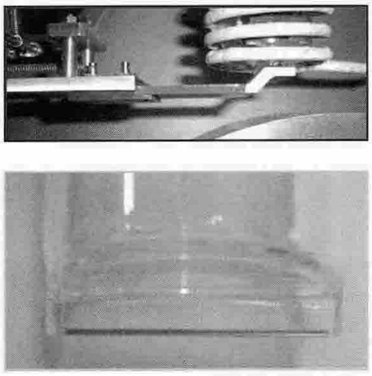

Fig. 1. The injection control device (a) using pouring lid, and the injection control part (b) of using rigid foil of the uranium melt.

As the uranium has a low thermal conductivity, the collection apparatus was modified to fabricate the uranium foils without great defects soundly, leaded to improve the quality and the yield of the uranium foils. The dimension and the surface state of the uranium foils were also adjusted with the revolution speed of cooling roll, the ejection pressure of melt, the gap distance between nozzle slot and cooling roll, the superheat of the metal, and the atmosphere of melting and casting [Fig. 2].

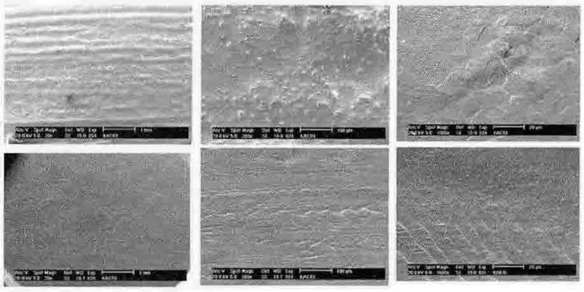

Fig. 2. Scanning electron micrographs of the free surface (upper) and the wheel-side surface (downer) of obtained uranium foils with various magnifications.

Then, continuous polycrystalline uranium foils with a thickness range of 100 to 150μm and a width of about 50 mm were fabricated with a better quality of uranium foils and a higher economic efficiency of the foil fabrication, through the modifications of the casting apparatus and the variations of the various process parameters [Fig. 3].

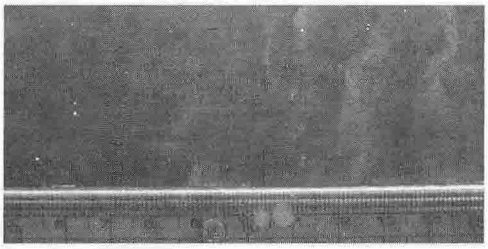

Fig. 3. Uranium foil fabricated by an injection control and a preheating of cooling-roll.

4. Conclusion

1) The continuous polycrystalline uranium foils with a thickness range of 100 to 150μm and a width of about 50 mm were fabricated, by adjusting the process parameters of the cooling-roll casting apparatus and the variations of the various process parameters.
2) The dimension and the surface state of the uranium foils were also adjusted with the revolution speed of cooling roll, the ejection pressure of melt, the gap distance between nozzle slot and cooling roll, the superheat of the metal, and the atmosphere of melting and casting.
3) The uranium foils had a good roughness on the surface, with a few impurities.

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Reference

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