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PROGRESS ON DEVELOPING SAFE STORAGE METHODS FOR URANIUM METAL CHIPS IN CONNECTION WITH AUTO-IGNITION OCCURRENCE

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1. Introduction

Auto-ignition of a uranium metal chip generated from a cutting by a band sawing machine occurred in the cutting area of the HANARO fuel production facility of KAERI at round PM 7:00, On August 18, 2005. Fortunately on radioactive contamination took place in the fuel-making room to the human body as well as the outside atmosphere because the fuel-making room is confined without a ventilation and nobody's allowed to enter the inside of the facility while the burning uranium metal chip is taking place.

After finding the ignition occurrence on the morning of the next day the facts were reported to the MOST and the KINS according to the regulatory guide. And then the KINS and the MOST investigated the ignition phenomenon, the ignition cause, and so on. As a result some special safety measures regarding the remaining chips and the generated chips were issued out. In order to carry out the above measures an investigation on the property of the uranium chip was performed and the generated chips were characterized. An effort was made to safely find interim and long time storing methods for the uranium chips. For the long-time storage a conversion from unstable chips to a stable uranium oxide form was taken into consideration.

In this paper, activities and results related to the uranium chips are described.

2. Properties of uranium chips

In general, a uranium chip is more liable to ignite with a finer particle. Reportedly uranium metal powder with about a 10 μm size can ignite at lower than 100 °C[1]. Uranium metal is reacted with oxygen in air as well as water as follows:

$U+O2 \rightarrow UO2 + \triangle Q$ ---(1)

$U+2H_2O \rightarrow UO_2 + 2H_2 + \triangle Q$ ---(2)

$U+3/2H_2 \rightarrow UH_3 + \triangle Q$

$4UH_3 + 7O_2 \rightarrow 4UO_2 + 6H_2O + \triangle Q$

The above reaction equations represents that water reacts with uranium more vigorously than air. Storing a uranium chip in a humid air can result in an enhanced ignitable situation. Accordingly the most reliable storage would be under an inert atmosphere[2]. In some cases a immersion method in mineral oil has been applied because oil can prevent a uranium chip from contacting with air or water. It is known that Y-12 plant in USA has used the water immersion method without any problems[3]. Presumably the reaction rate is very strongly dependant on the temperature so that enough water can keep it at relatively low temperature.

3. Characterization of uranium chips

In KAERI uranium chips were mainly generated from cutting a uranium metal ingot or lump by a band sawing machine. The morphology of the uranium chip was observed as in Fig. 1. The particle size is estimated to be between 10 to 300 (m and the shape of the chip is plate-like and longish. Thus, it would be very ignitable due to so large specific surface area.

After storing a uranium chip in water for long time, the uranium chip became much finer due to a reaction with water as shown

3. Interim and long-term storage methods

In KAERI, uranium chips have been generated from 1983 and stored under a immersion of water

as in Y-12 in USA. The important point would be keeping a low temperature in water without allowing the U chip to surface. It was considered

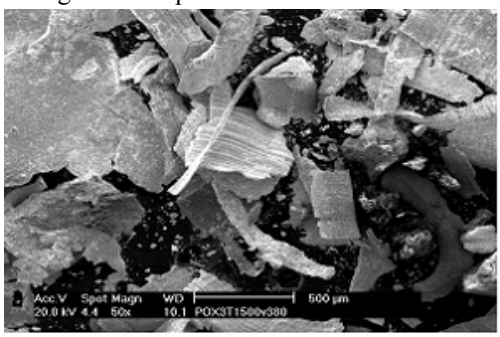

Fig. 1. Morphology of U chip obtained from band saw machine.

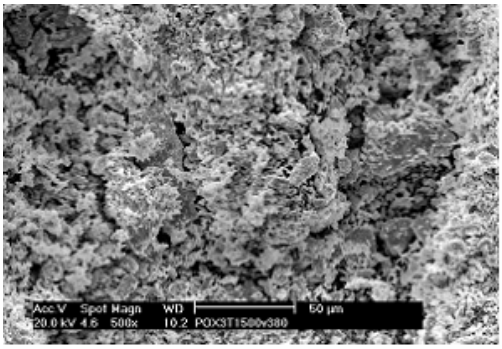

Fig.2. Morphology of U chips after complete reaction with water

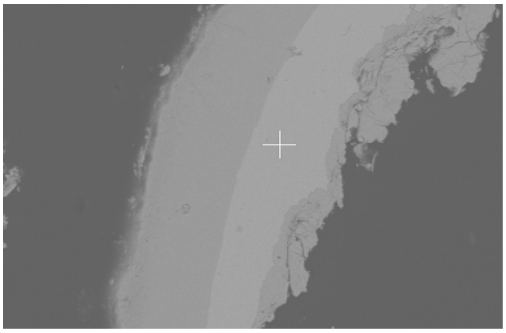

Fig.3. Morphology of U chips under reaction with water.

that a U-chip storage under an abundant amount of water could be available. From the safety aspect the amount of water for storing the U-chip was taken as two times of the theoretical amount for consuming water when assuming a complete reaction of the uranium chip with water. Additionally in order to secure the safety credibility, a monitoring system of the water temperature was equipped.

For a long-time storage method, a stable form like uranium oxide would be appropriate. In general a uranium chip is oxidized with air by a heating. Uranium chip is so vigorously burnt that an atmosphere controlled system should be applied. Also the out-emitting gas containing some radioactive dust should be filtered properly.

As an alternative way for the reduction of the out-emitting gas, a kind of elaborate controlling atmosphere furnace was suggested. If almost pure oxygen gas is fed into the furnace accurately, the out-emitting gas could be dramatically reduced. Therefore, a conceptual design for an accurately controlling oxygen furnace was carried out and then a procurement order was placed.

As another alternative way for converting a U-chip to a stable oxide form, an air injection method under a immersion in water was proposed because a U-chip contacting with water and air simultaneously was considered to promote the oxidizing reaction. An experimental apparatus was designed and manufactured as shown in Fig. 4.

Fig. 4. Air injection experimental apparatus

Fig. 5. . The reacted uranium powder is floated in the water.

uranium metal powder obtained by atomization process was used. The particle shape is almost spherical. After reacting it for about one week, the powder was completely reacted to very fine particles with suspending it in water. This result is considered to be very fruitful because the abundant U-chip stored in drums at KAERI could be efficiently oxidized without any further handling. The water co-existing with the oxidized uranium can be filtered out or decanted and then sent to a vaporization disposal facility.

4. Summary

U-chips generated from a band sawing machine were observed as plate-like and longish, which shows they are very ignitable. As a interim storing method of the U-chips, immersing method in an abundant amount water was implemented due to the availability of keeping then at a low temperature. However, as a long-term storage method, conversion method to stable uranium oxide form was proposed. For the conversion of U-chips to uranium oxide, an oxidation in a furnace and an air injection to a U-chip immersed water were taken into consideration. Accurately controlled oxygen furnace would be preferable. A preliminarily air injection reaction test showed the result to be very promising. This method would be efficient for a disposal of the U-chips at KAERI.

Reference

[1] In-Hyung Moon, “Powder Metallurgy”, 1981, p49
[2] “Primer on Spontaneous Heating and Pyrophoricity”, DOE Handbook, “DOE-HDBK-1081-94”, 1994, Dec.
[3] Statement of Work, Treatment and disposal of uranium and thorium chips at various department of energy sites, Nov. 8, 2001