Dry process research about UO_2 powder production with GFX-200 devices

W. Bangwu & Z. Shangxiang

CNNC Jianzhong Nuclear Fuel Co,. Ltd.

INTRODUCTION

In order to meet the requirements of rapid increasing demands of domestic nuclear fuel markets, and keep in step with the developing situation of chemical conversion in the world, CNNC Jianzhong Nuclear fuel Co., Ltd. has launched the expanding strategy which mainly aims to develop dry process to improve capacity of its kiln from 90tU/y to 200tU/y.

CHARACTERISTICS OF GFX-200 DEVICES

A. Autoclaves

Autoclaves are horizontal and electric heating. Its safety and stability has greatly improved.

B. Kiln

The diameter and length of kiln have been enlarged in order to be suitable for larger capacity.

C. Nozzle

The diameters of inner pipe and out pipe, inner pipe guiding van, the taper angle have been changed to increase reaction efficiency.

EXPERIMENTS

A. Purpose and methods

- To research influences of different process parameters (temperature, flow) upon performances of UO_2 powder which produced by GFX-200 devices.
- Orthogonal experiment has been applied in the research in order to find the most optimized parameters.

B. Process principle

The following process is the main reaction occurred during the conversion.UF_6 gas reacts with steam and then the reaction product UO_2F_2 is reduced and defluorinated by steam and H_2.

Serial No	Kiln Temperatures (A)	Flow Ratio of UF6 Gas to Steam From the Nozzle (B)	Defluorination Steam Flow (C)	H_2 Flow (D)
1	A1	B1	C1	D1
2	A2	B1	C2	D3
3	A3	B1	C3	D2
4	A1	B2	C2	D2
5	A2	B2	C3	D1
6	A3	B2	C1	D3
7	A1	B3	C3	D3
8	A2	B3	C1	D2
9	A3	B3	C2	D1

Table I. Orthogonal experiment flexible parameters list.

Serial No	H_2O %wt	U %wt	F μg/gUO_2	O/U	ρa g/cm³	ρt g/cm³	SSA m²/g	d μm	Matrix Density %T.D.
	≤0.4	≥87.00	≤100	2.02~2.05	0.80~1.30	1.50~2.50	2.0~3.0	/	≥96.5[a]
1	0.2	87.7	11	2.15	1.01	1.50	2.4	13.9	97.8
2	0.3	87.2	13	2.10	0.88	1.39	2.1	11.5	98.1
3	0.3	87.4	9	2.13	0.99	1.26	3.8	12.3	98.4
4	0.3	87.6	7	2.14	1.05	1.50	2.3	13.2	98.4
5	0.2	87.4	5	2.13	0.96	1.44	2.5	21.4	98.5
6	0.3	87.3	17	2.12	0.95	1.37	3.1	10.6	98.4
7	0.2	87.7	17	2.14	1.09	1.58	2.6	12.6	98.2
8	0.3	87.7	6	2.14	1.15	1.62	2.1	11.6	98.2
9	0.3	86.1	416	2.28	0.89	1.29	3.1	10.0	/

a. Technical Requirments for UO_2 performances

Table II. Orthogonal experiments UO_2 performances.

$$UF_6(g) \rightarrow UO_2F_2(S) \rightarrow UO_2(S)$$

C. Devices

GFX-200 Devices: Autoclaves, nozzle, kiln, hopper, mixer, filter, graphite heat exchanger.

D. Experiment parameters

There are fixed and flexible parameters in the experiment; flexible parameters include kiln temperatures, flow ratio of UF_6 gas to steam from the nozzle, defluorination steam flow and H_2 flow. Four factor and three level orthogonal [$L_9(3^4)$]

Experiment has been designed.

E. Experiment Results

- Experiments have been done under the sequence illustrated in Table I. Experiment results data is listed in Table II.
- According Table II, orthogonal analysis for Matrix density results

Serial No.	Experiment Parameters				Matrix Density %T.D.
	A	B	C	D	
1	A1	B1	C1	A1	97.8
2	A2	B1	C2	A2	98.1
3	A3	B1	C3	A3	98.4
4	A1	B2	C2	A1	98.4
5	A2	B2	C3	A2	98.5
6	A3	B2	C1	A3	98.4
7	A1	B3	C3	A1	98.2
8	A2	B3	C1	A2	98.2
9	A3	B3	C2	A3	/
I	98.13	98.10	98.13	98.15	I+II+III=786
II	98.27	98.43	98.25	98.33	/
III	98.40	98.20	98.37	98.23	/
Range	0.27	0.33	0.24	0.17	/

Table III. Orthogonal analysis for matrix density results.

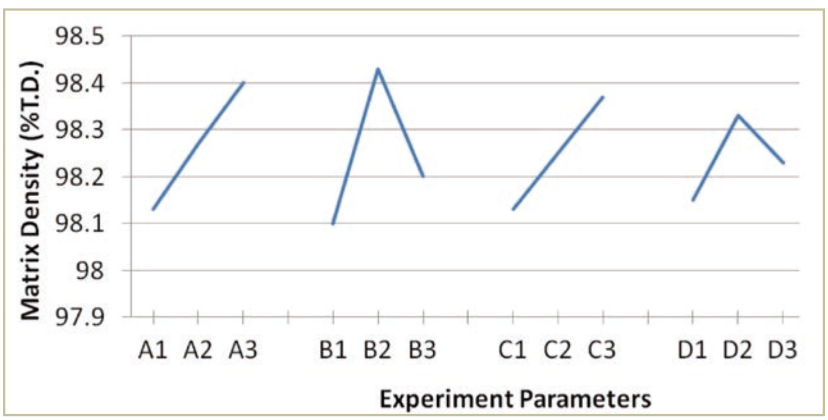

Figure 1. Influences of different parameters upon matrix density of UO_2

Parameters	H_2O %wt	U %wt	F μg/gUO_2	O/U	ρ_a g/cm³	ρ_t g/cm³	SSA m²/g	d μm	Matrix Density %T.D.
	≤0.4	≥87.00	≤100	2.02~2.05	0.80~1.30	1.50~2.50	2.0~3.0	/	≥96.5
A1 B3 C3 D2	0.10	87.62	<3	2.08	1.0	1.6	2.2	12.1	98.1

Table IV. Verification test UO_2 powder performances

Parameters	U %wt	O/U	Total Hydrogen μg/gUO_2	Impurities	Metallograph μm	Thermo-stability %T.D.
A1 B3 C3 D2	88.14	1.998	0.16	OK	9.4	0.34

Table V. Corresponding UO_2 pellets performaces.

could be done. And Figure 1 shows the influences of different parameters upon matrix density of UO_2 powder.

1) *Kiln Temperature*: UO_2F_2 reduction occurs normally under 600~700°C [1,2], with the rising of kiln temperature,matrix density of UO_2 powder decreases,because partial sinterization become easier to happen under higer temperature;
2) *Flow Ratio of UF_6 Gas to Steam From the Nozzle*: with the flow ratio rising, matrix density of UO_2 powder increases firstly and after reaching one balance point, matrix density decreases;
3) *Defluorination Steam Flow*: matrix density increases with flow of deflurination steam increasing;
4) *H_2 Flow*: with H_2 flow rising, matrix density of UO_2 powder increases firstly and then decrease after another balance point.
5) *Optimised parameters group*: As the most important performance of UO_2 powder, Matrix density indicates sintering ablity of UO_2, higher matrix density means higher sintering activity[3]. According the experiment results the optimised parameters group is A3, B2, C3 and D2 .

VERIFICATION TEST

In order to choose verification test parameters, two factors should be concerned, one is about capacity, and another is UO_2 performance, so the optimized parameter is amended to A3, B3, C3 and D2, because UF_6 gas flows in B2 parameter is lower than capacity's need.

According to the experiences of manufacturing UO_2 pellets and test date, corresponding UO_2 pellets have good performances in next processes in manufacturing of nuclear fuel elements.

REFERENCES

[1] I.E. Kanudsen et al., Nuc. Sci Eng., 20,3,259~265(1964)

[2] I.E. Kanudsen et al., AEC-Rep. ANL-6606(1963)

[3] Wu Zhiming et al, Manufactral Experiences About UO2 Fuel Pellets Used In PWR, Nuclear Energy Publisher, Beijing, China (2005).

Reduction of radioactive waste by improvement of conditioning facilitites

E. Radde

Nuclear Engineering Seibersdorf

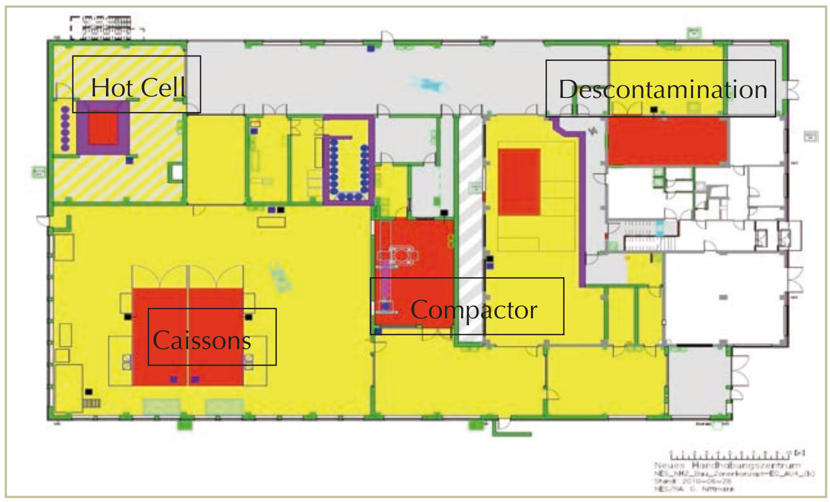

Figure 1: Schematics of the NHF with 3 Zones.

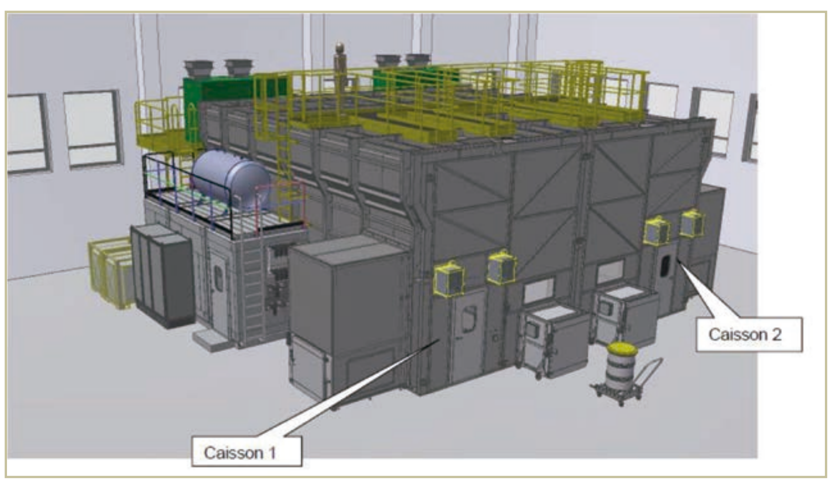

Figure 2: A drawing of the Caissons, with the people lock system.

INTRODUCTION

The NES (Nuclear Engineering Seibersdorf) is the only radioactive waste conditioning and storage facility in Austria. It manages waste originating from research, industry and medicine. Its main goal is, not only to treat and store waste safely, but also to optimize processes to further reduce the waste volume. To achieve this goal, the New Handling Facility was built. In this paper we will show how the waste volume can be easily reduced by optimizing the conditioning and waste stream process. The NES owns a water treatment plant for cleaning of active waste water, an incineration plant that is used to burn radioactive waste.

SCOPE

Since 2003 the NES is handling and storing radioactive waste. The conditioning process includes a water treatment, a burning facility and a pre- and or post-conditioning facility for non-burnable wastes, as well as pre-conditioning for burnable wastes. For all waste that is non burnable or needs pretreatment in form of decontamination, demounting, cutting, or post treatment(drying) it was decided in 2008 to further improve the conditioning facility and build the New Handling Facility (NHF), to enhance radiation protection, to reduce the waste volume further, and to have a state of the art facility.

In the paragraphs below the main steps and improvements of this project will be described.

MAIN STEPS

The New Handling Facility (NHF) will improve the waste management of the NES tremendously. The NHF consists of 3 separated underpressurized areas, which will prevent any radioactivity from being emitted uncontrolled into the environment. In Figure 1 the different zones are shown. Red has the highest underpressure, and those are the zones where work with open radioactive sources is possible, and it includes additional locks for the personnel. The yellow areas represent a lower contamination risk; in grey areas no work with radioactive material is foreseen. In the next paragraphs I will shortly present the major improvements of the NHF.

IMPROVEMENTS

Caissons

It is necessary for further conditioning processes to pretreat waste, even if waste is contaminated. To enable theses processes without enhancing the risk of exposing workers to contamination the caissons were built. This system enables to unload waste contamination free from barrels inside or outside of the caisson, if outside with the help of a "Double-lid Transfer Lock" (see figure 3), if inside with the help of a barrel lock. It is also possible to bring shipping containers or bigger material into the caisson and unload and treat waste that is delivered with. There are two Caissons (see figure 2) built back to back which enables quick and safe working. All personnel works with full protective suits and breathing air supply. All work inside the caisson is meant to demount and deconstruct material that is too big to enter the incineration facility directly or for further compaction in the compactor. Plasma oxygen cutting, welding, and all kind of cutting or sawing are possible inside.

Highpressure Compactor

The most important device for reducing the waste is the new high pressure compactor. It is used for automated compaction of 170 l barrels with 1500 t. It replaces the old 1000 t press. In addition all barrels are pierced before compaction to enable gasses and liquids to exit. With a mobile offtake, it is ensured, that all gasses and aerosols are filtered and sucked into the building ventilation system, and a continuous liquid offtake removes all liquids into the liquid treatment facility. All components that are in contact with possibly contaminated materials can be exchanged, and the compactor has features for handling several dimensions.

Hot Cells

The new hot cell has a direct storage facility underneath the cell. The cell can be operated from two sides, facing a 90° angle. All motors and electrical parts for the crans and controlling devices of the cell are mounted outside to enable easy and safe maintenantce. It is used for the handling of High activity sealed radioactive sources (HASS).

WASTE STREAM IMPROVEMENT

The NHF enables a clear waste stream management. With the definition of 3 zones (red, yellow, grey) it was made clear how to transport and manage the different waste categories. Several lock systems ensure that no radioactivity can be released uncontrolled into the environment.

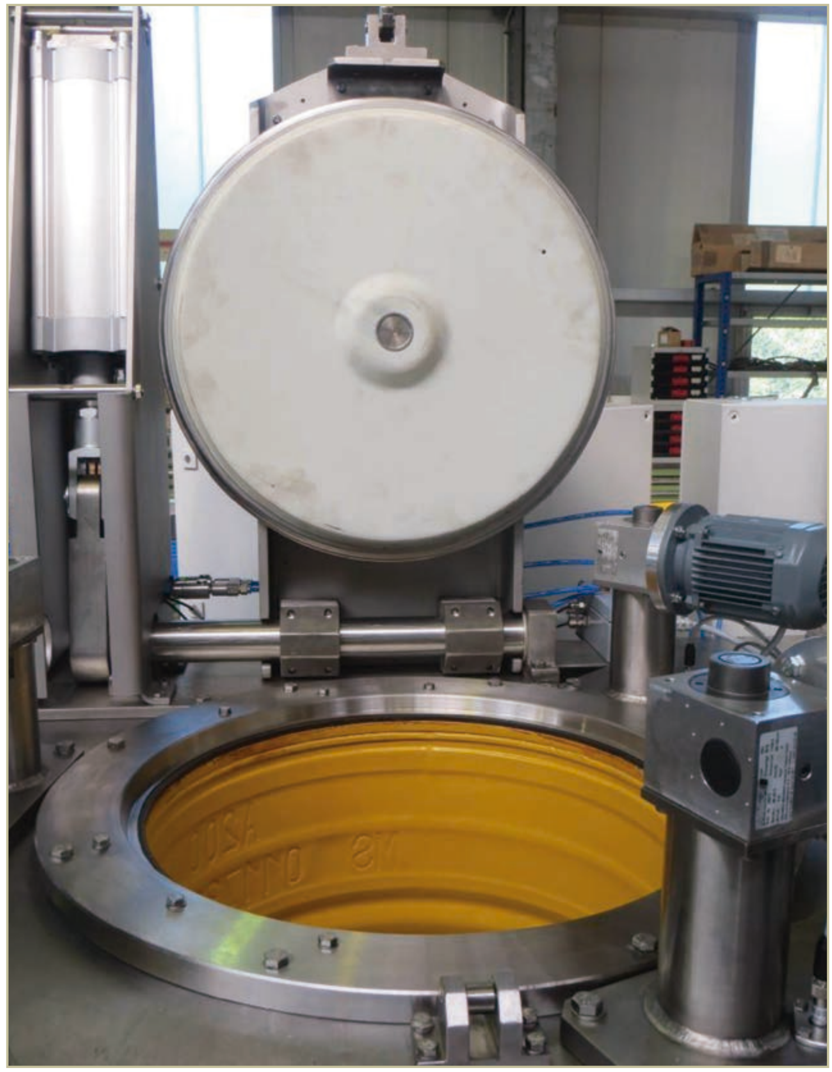

Figure 3: Double - lid Transfer Lock.

All fork lifts and transportation systems are clearly dedicated to the zones and are not allowed to cross barriers. An interlocking systems of the doors ensured the underpressure zones.

Material will enter the the NHF either through a barrel lock or is brought in by trucks thorugh the material lock. The barrels will then move in direction of the caissons, where the double –lid transfer lock or the barrel lock ensure that no contamination exits the caissons uncontrolled.

Waste will exit the caisson the same way it entered, and moves then in direction of the high pressure compactor and afterwards into the drying facility.

Also a decontamination room is available on site. This makes it possible that all major waste streams are performed in one building. Raw waste that is delivered can be cleaned, demounted without exposure or contamination risk, compacted and dried. HASS sources can be handled and stored safely without exposure risk in the hot cells. All burnable waste is preconditioned and prepared for the incineration plant.

CONCLUSION

The NHF enables a smoother and safer conditioning of radioactive waste. It is a state-of the-art facility and the most modern in Europe. Due to new facilities like the Caissons and the high pressure compactor it is easily possible to sort and treat waste to a minimum volume. This ensures a safe conditioning process of all kinds of waste for later storage.

REFERENCES

[1] R.Koppitsch, Neues Handhabungszentrum Nuclear Engineering Seibersdorf, vorläufige Sicherheitsanalyse, Seibersdorf (2014).