COGEMA GROUP EXPERIENCE IN URANIUM METALLURGY

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ABSTRACT

In this paper, COGEMA shows how its experience in Uranium metallurgy and in spent fuel reprocessing has contributed to the development of economically and technically efficient solutions for treating Aluminum-base spent fuels.

Indeed, for more than 30 years, SICN, a COGEMA Group subsidiary has operated a plant dedicated to the melt, forming, machining and assembly of Uranium metal parts. It has operated safely and efficiently at its 1000 MTU/year capacity throughout this period. The original purpose of this plant was the manufacture of Aluminum-Base nuclear fuel. Since then, it has produced various items such as canisters, balls (for ball-mill), all of which have proven to be economically viable recycling options for depleted Uranium metal.

In addition, with more than 40 years experience designing, building and operating nuclear fuel cycle facilities, particularly reprocessing plants, COGEMA Group has acquired extensive experience in high activity level operations that is truly unique.

Combining these two complementary skills allows COGEMA to make use of its high-level activity expertise in Uranium metallurgy, including operations in shielded cells, melting furnace design, ingot handling, and off-gas treatment related to melting operations, to name a few.

INTRODUCTION

First of all, we will give an overview of SICN's experience in Uranium metallurgy with a special emphasis on production means available in SICN workshops.

Then, the COGEMA Group's abilities to design and operate facilities where high radioactivity levels are present will be highlighted through significant examples.

Finally, we will illustrate how the combination of these experiences could be used to define a cost-effective alternative treatment or spent MTR fuels in the USA.

EXPERIENCE IN URANIUM METALLURGY

History

The SICN company was created in 1957 to manufacture the fuel assemblies for the French nuclear reactors G1, G2 and G3 of Marcoule. Since 1960, SICN has been mainly involved in manufacture of the fuel element for the French Gas Cooled Reactor (GCR) and was the only supplier in France for this kind of fuel.

SICN became a 100% COGEMA-owned subsidiary in 1983.

GCR fuel element production stopped in 1991, since the shutdown of the last GCR was planned for 1994. At that time, 18 000 t of Uranium had been melted in SICN furnaces.

As the GCR fuel element production began to slowly decline in 1975, SICN developed new activities, not directly related to nuclear fuel fabrication. Currently, its facility is still in operation for various products, including, for example: Uranium penetrators, for military applications - balls for dry milling master mix in MOX fuel fabrication - canisters, containers, and shielding.

The design and manufacture of specialized machines also has become one of SICN's main activities. By the end of 1997, SICN had become the leader in this field and the parent company of a group of mechanical industry companies.

SICN has also developed top-level skills in quartz technology and plasma deposit.

Organization

The company has facilities in several places. The uranium facility is located in Annecy, France. Others premises exist in Veurey near Grenoble and Codolet, near Marcoule.

Uranium Metallurgy Capabilities

The Annecy SICN facility is fully equipped to supply uranium metallurgy related products.

The founding workshop, with an expandable capacity of 1000 tU/year includes 6 melting furnaces. Their main characteristics are given in the following table.

Quantity	Size (mm)	Capacity (kg)	Max T° (°C)	Vacuum (Torr)	Product
2	Height : 900 Diameter : 690	up to 1000 (Uranium)	1500 (expendable to 1900)	5.10^{-2}	Uranium alloys Special alloys
4	Height : 1000 Diameter : 370	up to 400 (Uranium)	1600 (expendable to 2000)	1.10^{-2} to 5.10^{-2}	Uranium alloys Special alloys

Table 1: Characteristics of SICN Melting Furnaces

The furnace capacity in mass depends on the density of the molten material. The previous table shows what the case would be for uranium.

The furnaces are using specially designed long-life graphite crucibles, heated by induction. The melt is processed under vacuum atmosphere for safety reasons. Indeed, Uranium is known as a pyrophoric metal. In addition, because of a low convection in the furnace, the heat of the furnace walls is also reduced.

The molten metal is mechanically stirred, which is a key factor for ensuring a high quality product.

Various Uranium alloys have been melted, including U-Mo, U-Ti, U-V, U-Nb, etc.

The molten metal can be poured in a cast shaped according to the design of the part to be produced. The molded pieces of metal can then be transformed into finished parts.

The machining workshop is equipped with a 600 metric ton flattening mill, a 700 metric ton vertical drawing press and many tooling machines such as saws, lathes, and marking machines. An assembly workshop is also available.

Various tests can be performed, including dimensional inspection, chemical analysis of metals, micrographic and macrographic examination.

Quality assurance

The Uranium division of SICN is certified according to ISO 9002 standards.

EXPERIENCE IN HIGH LEVEL ACTIVITY PROCESSES

The La Hague facility is the largest reprocessing plant in the world with a nominal capacity of 1600 tU per year of LWR fuel assemblies. The plant, whose first line started up in 1966 and was successfully ramped up in 1989-1990 (UP3) and in 1992 (UP2 800), has reprocessed 1670 tU in 1997, and is scheduled to operate far into the second decade of the next century.

Over 14,700 tHM of fuel have been reprocessed at La Hague as of October 1, 1999.

These positive results are directly related to the capability to design and operate these facilities in high activity level conditions. This is particularly true for the R7 (UP2 800) and T7 (UP3) vitrification facilities of La Hague. Each of them has three vitrification lines, and since their commissioning, more than 6,700 glass canisters have been produced.

A series of relevant issues can be highlighted to show COGEMA's ability to manage high-level activity processes.

1. Spent fuel handling and interim storage:

   COGEMA performs these operations on a daily basis at the UP2 and the UP3 reprocessing plants at La Hague. The receipt and transfer to interim storage is performed in either wet or dry conditions. The plant processes more than 1 600 tHM of spent fuel per year, meaning more than 3500 spent fuel assemblies.

2. Spent Fuel shearing and dissolution :

   For reprocessing, the first step of the process is the shearing and dissolution of the spent fuel in boiling nitric acid solution.

3. HLW Vitrification

   This step of the reprocessing process is one of the most relevant with regard to alternative MTR spent fuel conditioning.

- In the vitrification facilities, glass is poured into canisters which are then handled by cranes with specialized handling device*s*, and moved from cell to cell. The maintenance of these cranes is performed by remote operation. The canister lids are also closed by a remote welding machine, and a non-contamination test is performed. If necessary, canisters are decontaminated by various methods. Canisters are cooled before being stored in an interim storage facility. All these operations are done automatically.
- The vitrification process requires an efficient off-gas treatment unit. The different pieces of equipment involved in the vitrification process are kept under negative pressure to ensure a dynamic containment. All the gases are collected and treated. Then the collected dusts are recycled in the calciner. Finally, the gases are filtered with three level*s* of HEPA filters and sent to the stack.
- All the melters used in COGEMA's vitrification facilities are heated by induction. The electric power is supplied by two parallel copper water-cooled pipes. The inductor coil and the conductors can be remotely unplugged for maintenance. The insulation between these conductors is maintained by using appropriate material.
- Particularly when dealing with high level radioactive waste, maintenance is as important as the process itself. Small size equipment facilitates remote maintenance and reduces plant shut-down periods. Components are designed for a long life service. Their reliability has been demonstrated over the last ten years of industrial operation.

4. MTR spent fuel management:

   The Marcoule UP1 plant has reprocessed more than 12,800 kg of MTR spent fuel from various origins. Now the Marcoule plant is shut down, and the COGEMA La Hague plant is taking over the MTR spent fuel reprocessing activity.

   More recently, new contracts have been signed between COGEMA and some research reactor operators, based on La Hague capability. MTR spent fuel assemblies have already been received and are now stored in the La Hague storage pools. This has been accomplished with only minor modifications to the handling device and the pool storage baskets to accommodate the various sizes and shapes of the MTR fuel elements.

SPENT MTR FUEL MANAGEMENT APPLICATION

The DOE owns aluminum-base MTR spent fuel from the US and many other foreign Research Reactors that will be sent to the Savannah River Site (SRS) for interim storage, further treatment, and that will eventually be sent for geological final disposal at Yucca Mountain.

Three main technical solutions have been studied for the treatment at SRS in the draft EIS published in 1998 (1). First, the reprocessing in the Canyons, a second possibility is the direct disposal of this fuel; the third possibility is the so called "Melt and Dilute". Because of the specific US context and criticality considerations (some of the assemblies are HEU fuel), the preferred option in the draft EIS is the "Melt and Dilute".

This process consists of melting the spent fuel while adding depleted uranium to decrease the final enrichment of the product (for criticality and non-proliferation concerns) and also aluminum to reduce the melting temperature of the U-Al alloy.

The melt of spent MTR fuels could be carried out with a process similar to one used by SICN. The melting temperatures are almost the same as for the Uranium alloy produced in the SICN facility. Using a graphite crucible already employed for many years would both take advantage of its proven success and would significantly increase its service life. Thus it can help-reduce one of the main secondary wastes of this process. Other improvements may be achieved through high temperature processing, which allow for final isotopic adjustment without large additions of Aluminum, thus reducing the amount of final waste packages.

As the spent MTR fuel also contains a given amount of fission products, SICN technology should be adapted to high activity constraints. However, the difficulties encountered are similar to those that have been successfully addressed in various COGEMA facilities. Remote operations and maintenance and an efficient off-gas treatment would be necessary.

This kind of conventional process adaptation to high activity has already been performed successfully by SGN, the engineering subsidiary of COGEMA. This was the case with the vitrification process, and also with the metallic waste compaction process. For both of these developments, SGN's two applied research centers have played an important special role.

CONCLUSION

In conclusion, we can say that COGEMA and its subsidiaries have developed all the skills required to efficiently manage the design, building and operation of a facility dedicated to uranium metallurgy in high irradiation level conditions.

We are confident in our ability to manage processes like Melt and Dilute.

SICN experience with depleted uranium can also be used for many different purposes.

REFERENCE :

1. Spent Nuclear Fuel Management - Savannah River Site.
Draft Environmental Impact Statement - Summary
Department of Energy - Savannah River Operations Office. December 1998.