IMPLEMENTATION OF INDUSTRIAL REPROCESSING : LESSONS LEARNED FROM COGEMA'S EXPERIENCE

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ABSTRACT

Industrial reprocessing activities began in France in the middle of the '60s, with the start of UP2-400 plant using the Purex process. This first generation plant, with a capacity of 400 t/y, demonstrated the efficiency of the Purex process first for uranium metal fuels and then for oxide fuels. In the '80s, COGEMA designed and built a second generation of plants; UP3 and UP2-800 were operational at the end of the '80s and the beginning of the '90s. With a capacity of 850 t/y each, the design of these plants took into account all the experience from UP2-400 operation.

The goal of this paper is to present the huge experience acquired by COGEMA in researching, designing, developing, industrializing, building and operating reprocessing plants.

In the first part of the paper, we present the main evolutions between first generation (UP2-400) and second generation (UP3 and UP2-800) plants. Adaptations made to the Purex process permitting higher capacities are highlighted. Efforts were also made to reduce individual dose rates to workers, guarantee equipment availability and simplify maintenance.

In a second part, we present the continuous improvements realized on UP3 and UP2-800 during the last fifteen years and present those planned in the next few years. Such improvements and adaptations notably concern process efficiency and waste management. These improvements have been allowed by continuous R&D efforts as well as through continuous analyses of operation experience and optimized engineering services.

The important industrial experience acquired by COGEMA allows us to imagine and sketch a third generation of plant, more flexible and cheaper both in terms of investment and operating cost keeping a high standard of safety and quality. Our vision will be presented in the third part of this paper. This new generation plant, based on hydrometallurgical processes, could be easily adapt to specific needs for reprocessing linked to different spent fuel management such as recycling (Pu or Pu + Np), waste management, advanced partitioning of minors actinides and long live fission products for future transmutation.

The first studies are in progress at COGEMA, in collaboration with the CEA and SGN, COGEMA's engineering subsidiary, to define the best processes required to satisfy these needs.

As a conclusion, we summarize the key factors required to assure the success of the next generation reprocessing plants. Continuous collaboration between R&D, engineering and operation teams is one of the most important one. After thirty years experience in the design and operation of reprocessing facilities, COGEMA and its French partners are best suited to participate to new industrial projects with cost effectiveness and risks reduction.

INTRODUCTION

The bases of PUREX process were established in the 50's, with plants designed for defence purposes. In the middle of the '60's, industrial reprocessing began in France with the start of UP2 plant using the Purex process. This first generation plant demonstrated the efficiency of the Purex process. The second generation plants (UP3 and UP2-800) were operational at the beginning of the '90's. The design of these plants took into account all the experience from UP2 operations.

The requirements for process performances are

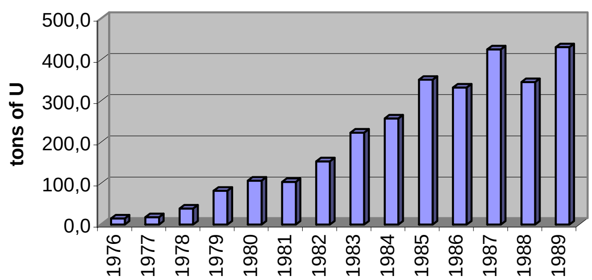

Fig. 1 UP2 400 production record

Stringent :

- very high purity of U and Pu end products and high recovery ratio,
- authorised limits for release becoming more and more severe,
- necessity to condition all waste.

Moreover, numerous risks, such as criticality, contamination or irradiation have to be taken into account and mitigated with requirements more and more stringent, especially concerning dose to operators and impact on the environment. To comply with these difficulties and to become more and more efficient in the reprocessing business, COGEMA had a permanent concern to analyse its operating experience in the frame of continuous progress and maintained a high level of R&D and is continuing his effort today to prepare the future.

To illustrate this, we first present the main evolutionary differences between first generation (UP2) and second generation plants (UP3 and UP2-800).Then, we present the improvements implemented during the last fifteen years and present those planned in the next few years.

Consequently, the important industrial experience acquired by COGEMA allows us to sketch a third generation of plant, more flexible and cost effective than second generation plants, both in terms of investment and operating cost while keeping a high standard of safety and quality. Several tracks of improvements will be presented.

Second generation plant: the industrial maturity

At the end of the 70's, the bases of the second generation of commercial reprocessing plants were launched.

The main lessons from previous plants of COGEMA, i.e. UP2 in La Hague were as follows:

- Good safety records. No significant incident has been recorded, and release to the environment were significantly below authorised limits,
- Design capacity was reached slowly due to insufficient availability during the very first years of operation. Indeed, UP2 reached nominal capacity roughly ten years after its start-up, as shown as fig. 1,
- Process performances were met; however solvent quality was an item of concern and frequent renewal of solvent hold-up was necessary to maintain performances of extraction process,
- The process and technological waste were only partially conditioned. For example, Fission Products were stored in tanks, waiting for final conditioning in a vitrification facility.

Therefore the following objectives have been set up for the new plants:

- Increase plant availability through:
  - the use of corrosion free materials, especially for the equipment with boiling nitric acid solutions,
  - fully remote maintenance,
  - duplication of most sensitive equipment,
- Improve process performances by adopting fully continuous process and through stable performances of extraction process,
- Increase safety records: reduction of dose rate to operators and of release to the environment,
- Condition all process and technological waste.

A huge R&D effort for more than 10 years and a strong co-operation between design team and operators from previous plant result in the construction of the two new reprocessing plants UP3 and UP2-800, entering commercial operation in 1990 and 1994.

The main features of both plants are:

- Continuous dissolution process using a rotary dissolver,
- New extraction equipment such as geometrically safe pulsed columns with efficient packing,
- Improved solvent management including a distillation unit able to purify and recycle both solvent and diluent,
- Conditioning process for all waste: for instance vitrification for high active process waste and grouting for low and medium active technological waste[1].

The operational results demonstrate clearly that the objectives fixed at design stage have been fully reached, and in most of the cases far over the expectations :

- Very high plant availability demonstrated through the reprocessing of more than 12000 tons of oxide fuels since the start-up of UP3 (see fig.2),
- Very quick start up (only a few months to reach full capacity for UP2 800 in 1994)
- Very high and stable process performances,
- Drastic reduction of dose to operators, of release to the environment and of volume of final waste.

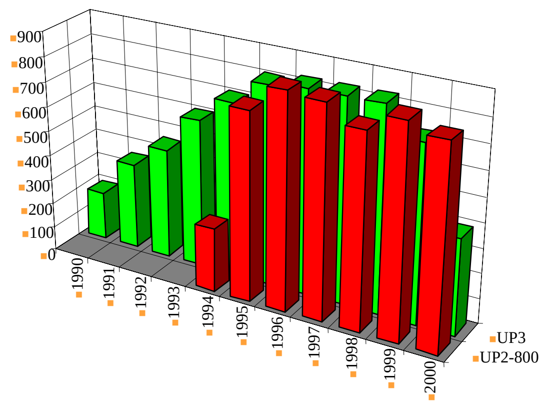

Fig. 2 UP3 and UP2 800 production record

La Hague plants : 15 years of improvements thanks to lessons learned and continuous R&D

After the successful start-up of new La Hague plants, R&D effort has been pursued and numerous advances have been made possible thanks to it. It is worth noticing that the strong co-operation between R&D, engineering and operators has played a key role in the success.

Some examples of the most significant improvements are given hereafter.

Core of the chemical process: decontamination of uranium

At design stage, two extraction cycles were foreseen to decontaminate uranium from neptunium, plutonium and fission products after its separation from plutonium in first extraction cycle. Immediately after active start-up of the plant it appeared that decontamination (for plutonium in uranium and for fission products) performances of first cycle was far over the expectations. The decontamination factor for neptunium in uranium cycle was also higher than expected, but still too low to reach neptunium specification with only one cycle. Operation was then optimised and additional R&D was launched. The plant flowsheet has been improved and consequently and the decontamination factor for Np is over 1000, and thus today only one cycle is used to purify uranium.

Vitrification facility [2] [3]

There are two vitrification facilities on La Hague site: R7 entered in active operation in June 1989 and began to treat the 1200m3 stock of HLW solutions produced by UP2 plant since its start-up in 1966 and

T7 facility is devoted to treat the HLW solutions produced by UP3 plant. It entered in active service in July 1992, 3 years after its "twin" facility R7.
Several significant improvements have been brought since active start-up:

- Addition of an in-cell washable pre-filtering device on the ventilation of main hot cells (vitrification, pouring, dismantling) in order to protect HEPA filters from contamination;

- Modification of the cranes to improve the reliability of some components and to reduce the need for their maintenance;

- Iimprovement of the canister decontamination device (higher water pressure and throughput);

- Optimisation of glass homogenisation;

- Increase of service life of melting pot through optimisation of material and operating conditions (fig. 3).

Most of these improvements have been implemented while facilities were in active operation, demonstrating the flexibility of the design.

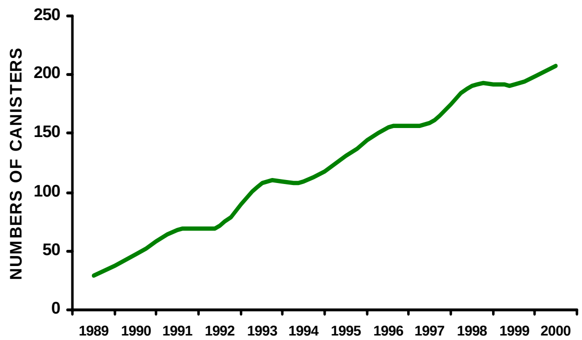

Fig. 3 Number of canisters produced with a single melter

New liquid waste management

Active operation of UP3 was started in 1989. The initial liquid waste management led to the production of two types of solid waste : glass canisters containing the bulk of activity and bitumen drums.

The very good decontamination performances of first extraction cycle gave the opportunity to modify liquid waste management in order to delete production of bituminised waste. Main features of this new management are:

- All salt free acidic waste and some of the salt bearing waste are concentrated by evaporation and concentrates are routed towards vitrification,

- Most of the salt bearing waste have an activity low enough to be released to sea, after activity checking and filtration,

- Three new evaporation units and a specific unit for treatment of laboratory waste, for which specific r&d has been conducted,

- New piping and vessels to perform waste transfer to the new units.

The provisions taken into account in the original design have allowed to perform these modifications with extremely low dose rate to the personnel and within short duration, while the plant remained in active operation.

Light robotic equipment for in cell exceptional operations

R&D is pursued also in this domain. A recent example of application is the repair of the shear chute of R1 (head-end facilities of UP2-800 plant). A small hole, caused by wear was discovered in February 2001. A repair has been conducted as early as April, taking advantage of the ongoing R&D for light robotic.

The third generation plant

Last generation facilities in COGEMA : R4 and ACC

Two new facilities on La Hague site entered commercial service in 2002: The plutonium finishing facility R4 [4] and hulls and end-pieces super-compacting facility ACC [5].

R&D and early involvement of operators from previous facilities played key role in design of R4, which is characterised by:

- Use of a single extraction cycle for plutonium purification and concentration, validated by specific R&D and UP3 feed-back,

- Technological innovations, such as centrifugal extractors, supported by extensive R&D program,

- Extensive use of in-line measurement, allowing short response time and decreasing analytical workload and effluents,

- Significant investment cost reduction.

The waste volume reduction is the main goal of ACC facilitiy. Compared to direct cementation, volume of final waste is divided by 4. The main other characteristics of ACC are:

- Standardisation of package through use of universal canister (UC),

- Accommodation of technological waste,

- Innovative nuclear measurement devices.

These two facilities are a first step towards a new generation of reprocessing plants.

Present R&D's main objectives

The R&D under way in COGEMA follows several objectives, the most significant being :

- Reprocessing of high burn-up fuels, both uranium oxide and mixed oxide, and RTR fuels;

- Increase of storage pools capacity and of flexibility of head-end process through use of burn-up credit;

- Development of light robotics for in-cell inspection and repair after exceptional incident, such as in the case of shear chute mentioned here above;

- Extraction process: further simplification with a single extraction cycle including neptunium barrier;

- Evaluation of partitioning of actinides and other long life nuclides;

- Simplification of vitrification facilities through development of cold crucible melter which could be used also for other incineration purposes;

- Liquid waste management: although a drastic decrease of release has already been achieved since second generation plants start-up, R&D is still performed to develop complementary technologies such as ultrafiltration;

- Solid waste management: minimisation of generation of waste, recycling of equipment after repair, decontamination of waste prior to disposal, best appropriate conditioning process

CONCLUSION

As a conclusion, we have presented the different steps from the beginning of industrial reprocessing in COGEMA in the 70's up to now.

The first generation plant has proven the efficiency of the hydrometallurgical process, although production rate was limited.

The second generation plant has demonstrated clearly the reliability of equipment, the process performances, the ability of operators to produce with high standard of safety and quality, the very low impact on the environment, the personnel exposure reduction, the minimisation of final waste volume.

The first steps to the third generation plant are a reality with our new facilities, started in 2002.
Further improvements are expected.

This was obtained thanks to three key factors :

- Huge R&D effort performed by COGEMA and CEA to develop and qualify processes and equipment,

- Accumulation and analyses of feedback experience during operation,

- Very close collaboration between the three main actors of any industrial project : R&D people, designers and operators.

Taking into account our 30 years industrial experience, we plan continuous improvements in La Hague, but also some very efficient improvements for the next generation plant, both in term of investment and operating cost while keeping a high standard of safety and quality.

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