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Design and Evaluation of Processes for Fuel Fabrication: Quarterly Progress Report #4

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QUARTERLY PROGRESS REPORT #4

UNLV AAA University Participation Program

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Design and Evaluation of Processes for Fuel Fabrication

Summary

The fourth quarter of the project covered the following:

- Literature Search: The process of evaluating the pertinent literature continued. Results are summarized below.
- Mr. Richard Silva developed a simulation model with a Waelischmiller hot cell robot. Rich will continue to develop detailed 3-D process simulation models as his M.Sc. thesis project. Rich is employed with Bechtel at the Yucca Mountain project.
- Dr. Mauer visited CEA Cadarache and CEA Marcoule in France, the institute for transuranics in Karlsruhe, and the Framatome manufacturing plant in Lingen, Germany.
- Concepts and Methods for Vision-Based Hot Cell Supervision and control (Ph.D. Student Jae-Kyu Lee)

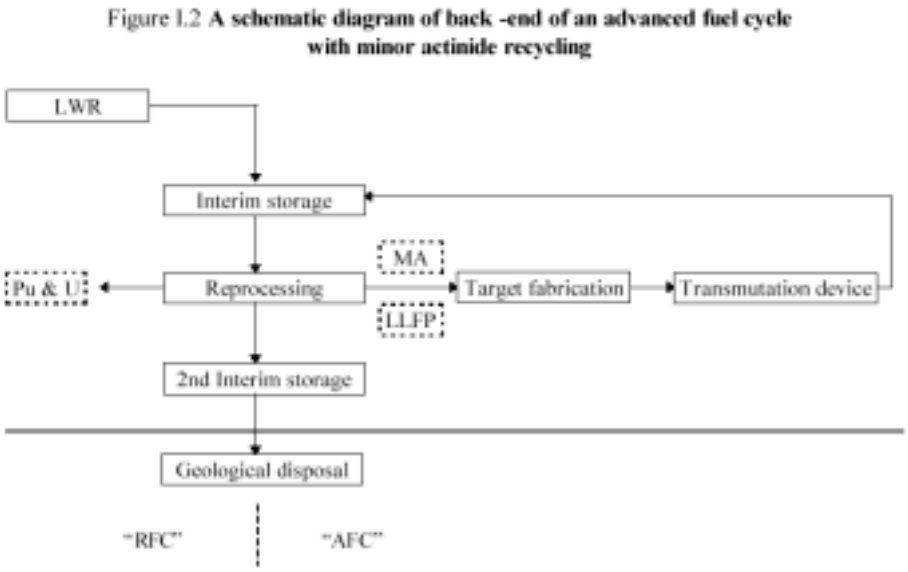


Figure 1 Concept for Fuel reprocessing (NEA, 1999)

1. More on Partitioning and Transmutation (P&T) Concepts (Literature Survey)

P&T concepts are discussed widely in pertinent publications and conference proceedings. Additional literature obtained during the reporting period include two reports published by the European Commission published in 1997 and 2000, respectively. Both reports summarize European research findings for their respective reporting periods on the issues of Partitioning and transmutation. European research efforts are largely being conducted by CEA (Commissariat à l'Energie Atomique) in France, by FZK in Germany, as well as in other labs.

Plant Visits – G. Mauer visited hot cell and diagnostic facilities at CEA Cadarache (Dr. Silvie Pillon) and CEA Marcoule (M. Louis Donnet). The Marcoule center is in the process of manufacturing a fuel rod containing Americium pellets. The rod will be inserted into the Phénix reactor for transmutation experiments. The pellets themselves are being manufactured at the Institute for Transuranics in Karlsruhe. The pellets are being produced by the sol-gel method developed in Karlsruhe and described earlier.

At the Institute for Iransuranics in Karlsruhe, Drs Rudy Konings and Didier Haas guided me through their labs. A new hot cell facility is under construction there which will also comprise a number of robotic and other automation tools. Since the facility is not yet operational, I was able to inspect all equipment in the new cell closely. The Karlsruhe hot cell comprises small robots which will be used to automate some operations. Sensitive electronic components for the robots will be located outside the hot cell. It appears that some electronic equipment, such as electronic laboratory balances, have functioned without problems in several installations in both France and Karlsruhe. ITU Karlsruhe will manufacture the AM pellets using the Sol-Gel process developed there. Figures 3 and 4 illustrate the process (also reported in Report 3 of June 2002.)

The last visit was to the Framatome manufacturing plant in Lingen, Germany. The plant produces UO_2 commercial reactor fuel from Uranium heaxafluoride. The UO_2 powder is pressed into pellets and sintered for 18 hrs. at approx. 1800 ^{o}C. The sintered pellets are ground automatically to their specified diameter, arranged in long rows, and automatically inserted into fuel rods. According to the Lingen plant's safety engineer, material losses are kept below 0.1%. The manufacturing automation in Lingen was largely developed locally. Lingen operates without shielding such as glove boxes or hot cells. Nevertheless, all plant modifications must undergo a laborious approval process which takes approximately two years. Fig. 2 show the manufacturing process schematically, augmented by translations of some captions into English.

Figure 2 Lingen UO2 Plant Schematic (Framatome)

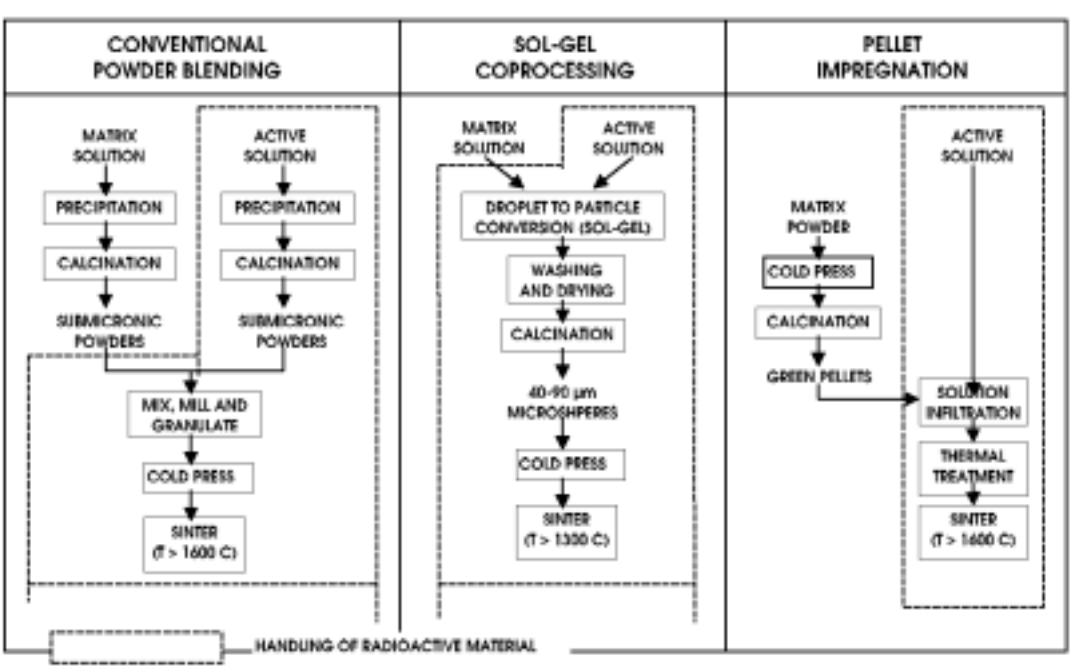


Figure 3 Three processes for Americium Fuel Fabrication (Haas et al., 1998)

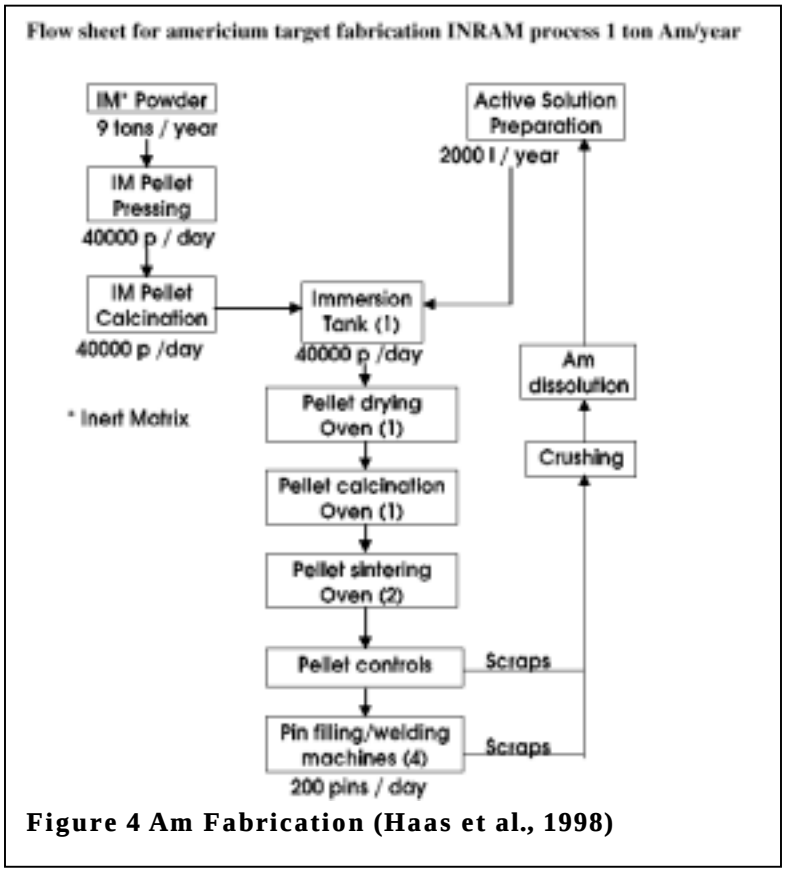


Figure 4 Am Fabrication (Haas et al., 1998)

Manufacturing Automation – The goal here is to develop simulations of manufacturing processes to allow for plant sizing and to determine adequacy of current generation sensors and robotics and the need for development of new technology in this area. The progress reports # 1 through #3 for this project contain an assessment of generic equipment needs and a survey of commercially available manufacturing and robotic handling equipment. The candidate fuel manufacturing processes are being modeled using the MSC Visual Nastran and ProEngineer simulation software tools (see also the appendix.) One graduate student working on the project, Mr. Richard Silva, is developing the 3-D manufacturing process simulation CAD models. A hot cell robot model (Waelischmiller) has been created and its correct performance has been verified.

Accurate process supervision will be essential for the reliability and safety of the fuels manufacturing process. This will likely be accomplished by a combination of process sensors and visual supervision. Machine vision can detect and analyze situations automatically and without physical contact, and camera images can be transmitted directly to supervising personnel. In addition, calibrated vision systems can perform and document automated dimensional and surface quality measurements on the completed pellets as well as the completed fuel pins.

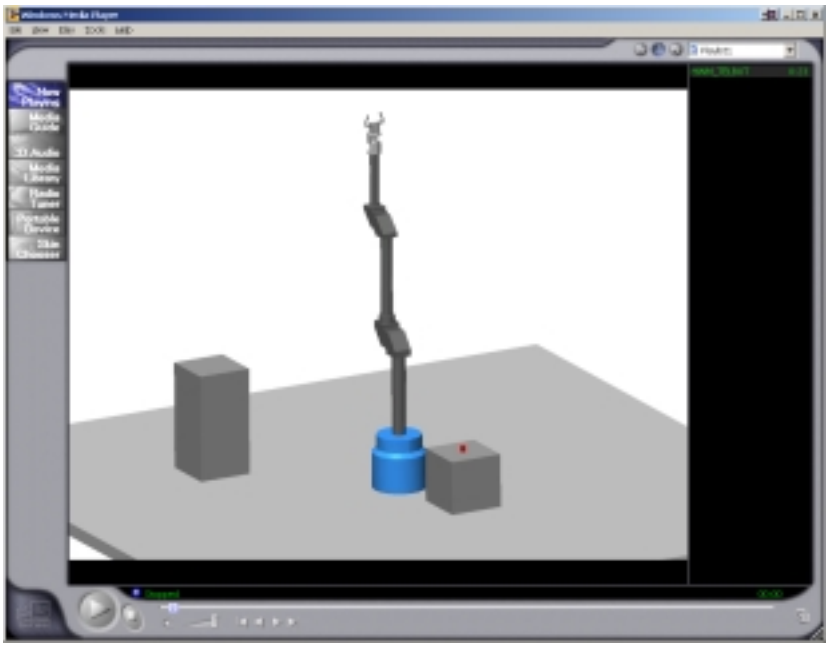
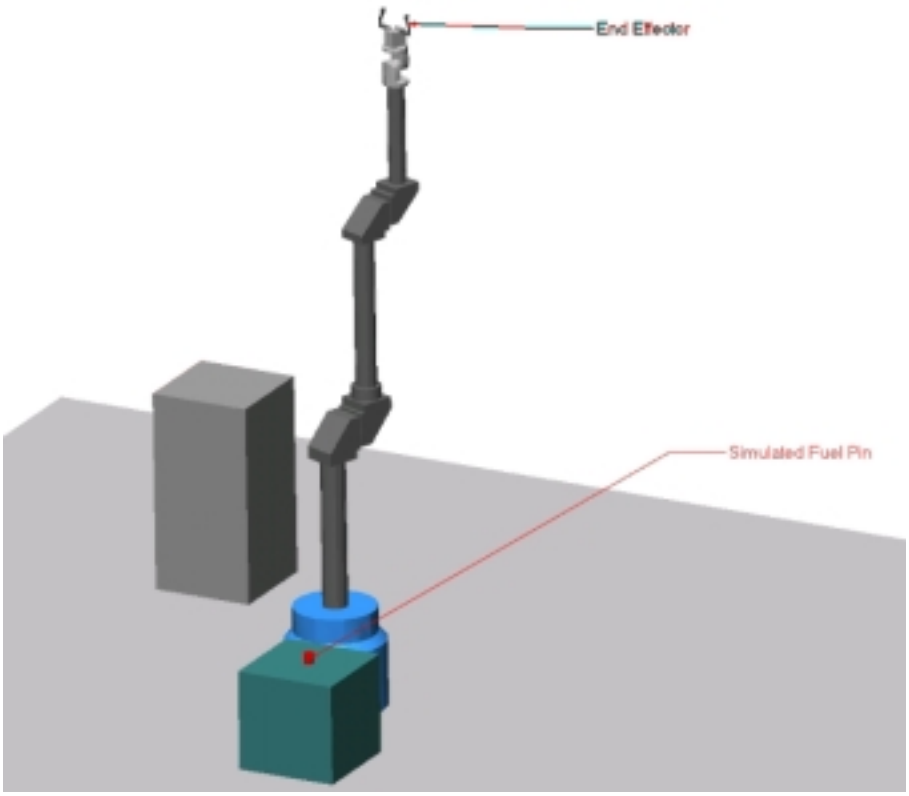
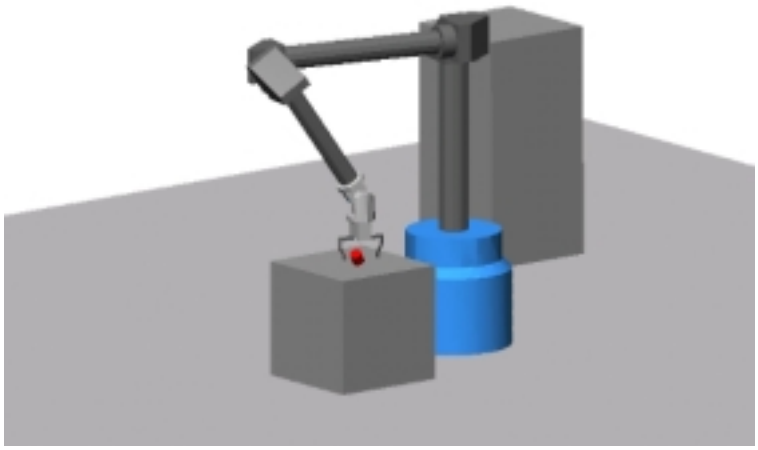


Figure 5 Interactive GUI process simulation: Hot Cell Robot (Waelischmiller.) Created by Grad. Student Richard Silva with Visual Nastran. The robot base (shown in blue color) contains all mechanical parts and can be placed outside the ionized region. The cylindrical pipe would form a conduit through the hot cell wall.

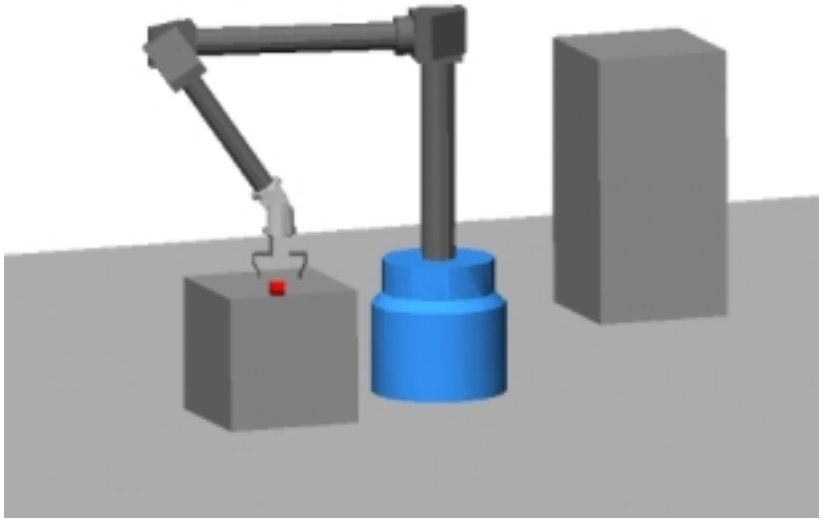


(a) Initial Position

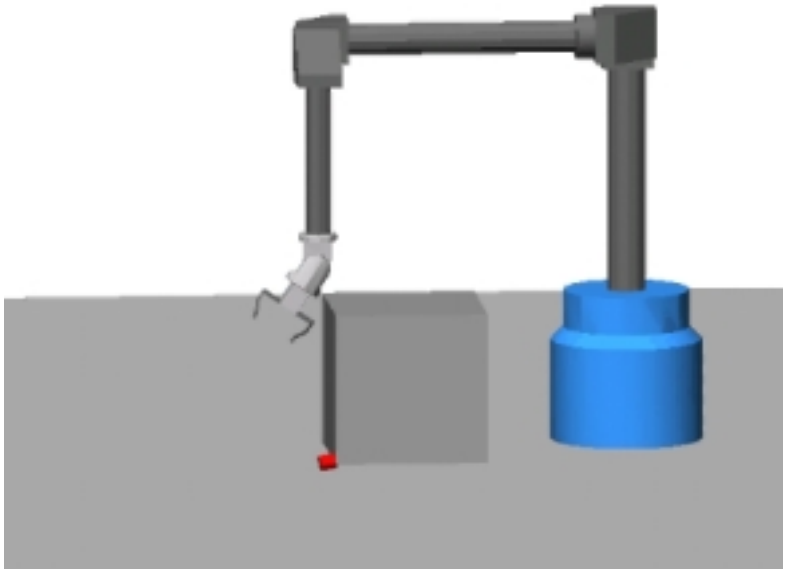


(b) Approaching the Pin

Figure 6 Work Cell Robot Screen Shots



(c) Trying to grasp Manually



(d) .. and missing

Figure 6 (Screenshots Continued)

Graduate Student Progress

Ph.D. student Jae-Kyu Lee presented his dissertation proposal to the doctoral advisory committee and passed the preliminary examination.

Conclusion

During the fourth quarter, project needs and issues were detailed further. Dr. Mauer's visits to four laboratories and plants provided insight into current practices and ongoing R&D. The present effort is focusing on crating detailed manufacturing simulation models, and on collecting more detailed information on the cost and space requirements for powder processing equipment. Matlab software, another essential part of the plant simulation was received. Matlab will provide a control interface for the workcell simulation. We expect the simulations to become more realistic with the addition of Matlab.

Management Issues: Expenditures were generally as planned in the proposal. Ph. D. student Jae-Kyu Lee was funded throughout the reporting period. An undergraduate engineering student, Mr. Timothy Atobatele, has been recruited on an hourly basis to provide support services.

Publications

Two conference papers were submitted and accepted for publication:

1. G. Mauer "Design and Evaluation of Processes for Transmuter Fuel Fabrication," accepted for ANS Winter conference, November 2002

2. Jae-Kyu Lee and Georg F. Mauer "Object Recognition over an expanded range of viewing Angles using indexing methods," accepted for presentation at CAINE 02 Conference, November 2002.

References

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