Design and Evaluation of Processes for Fuel Fabrication

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The research work was divided into several tasks and subtasks:

**Methods and Processes** – A literature survey and detailed analysis of the research and development pertaining to candidate processes for transmuter fuel manufacture continued. Industry standards were used to refine equipment, instrumentation, and control specifications, and assessed the reliability and safety of operations.

**Simulations** – This task modeled manufacturing processes to generate a realistic assessment of plant layout, size, feasibility, and technology development required for large-scale remote fabrication of fuel. Modeling of the candidate fuel manufacturing processes was initiated using the MSC Visual Nastran and ProEngineer simulation software tools.

**Process and Equipment for Autonomous Manufacturing** – This task attempts to develop an understanding of the cost and capability of current generation remotely operated equipment suitable for use in radiation environments. Monitoring of the market for equipment and components with regard to suitability for automated manufacturing under hot cell conditions continued.

**Sensors, Controls, and Operational Safety** – This task determines the adequacy of current technology and the need for suitable sensor technology development for deployment in hard radiation environments. A means to identify the precise location and spatial orientation of all parts in the robot’s work envelope were implemented. The ability to position and handle materials along with troubleshooting techniques were evaluated. Radiation hardened vision systems appear to be promising technologies.

**Cost, Feasibility, and Large Scale Deployment** – This task develops the database necessary to provide cost estimates and differential cost for various fuel manufacturing options. Efforts began to tabulate and quantify estimates regarding projected cost, reliability, and plant life.
RESEARCH ACCOMPLISHMENTS

A simulation model with a Waelischmiller hot cell robot was developed and coupled with MatLab control software. MatLab provides the interface with the robot and is used to control the system. This renders a realistic simulation of the forces and torques present during robot motion. Efforts began to develop the 3-D manufacturing process simulation using CAD models. Results exist in the form of movies, data sets, and images. Simulations for several robot types were developed and their proper kinematic configuration was verified.

While the simulation process generally worked flawlessly, the simulation time rose considerably as more details were added to the simulation. Options were investigated to increase the speed, especially since researchers anticipate adding significantly more complexity to the simulation as the project progresses.

Efforts began to develop a vision-based methodology for locating and identifying objects within the robot’s workspace and included the development of an Artificial Intelligence (AI) algorithm for object identification.

Another accomplishment involved the development of algorithms for knowledge based pattern recognition using IF (a set of conditions is satisfied) THEN (a set of consequences can be executed) routines. Other simulation variables established included pattern matching using clustered indexing vectors containing information about an object and feature vector indexing, where a 3-D object is segmented into a set of simple geometric features. Each feature is stored with its vector segmentation and geometry information (magnitude, inner angle, etc.).

HIGHLIGHTS

- PhD. Student Jae-Kyu Lee presented his dissertation proposal to the doctoral advisory committee and passed the preliminary examination.
- Dr. Mauer visited CEA Cadarache and CEA Marcoule in France, the institute for transuranics in Karlsruhe, and the Framatome Manufacturing Plant in Lingen, Germany.

FUTURE WORK

Further efforts will be devoted to increasing data and knowledge regarding the cost and feasibility of automated fuel manufacture in a hot cell. Artificial intelligence concepts will be further developed with respect to object identification and hot cell dynamics simulations. Following completion and testing of the operation of a single robot, multiple robots will be placed into a hot cell and controlled simultaneously by a supervisory program.

The simulation environment will enable designers to create a virtual mock-up environment in which possible scenarios can be executed and analyzed at any desired level of detail. Normal operations and failure scenarios will be investigated, analyzed, and simulated. The results of the simulations will be used by AFCI program personnel to perform sensitivity studies on the impact of different fuel types on transmutation system operation. Conceptual designs of the fuel fabrication processes will allow evaluations of issues related to maintainability, robust design, and throughput rate, and lead to identification of areas where improvements in technology are required to meet the goals of the transmutation system.

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Interactive graphical user interface process simulation of moving a part from one place to another.