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USE OF CASCADE-DEPLETED URANIUM

- References:
1. HW-38558, Same Subject, AB Greeninger, August 9, 1955.
 2. HW-38463, LM Lang, to be issued.
 3. HW-38810, "Application of Depleted Uranium in New Production Reactors," JR Triplett, September 12, 1955.
 4. HW-39044, "The Irradiation of a Novel Fuel Element for U-233 Production," HW Woodruff and GW Stuart, September 10, 1954.
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CG-PR-2, 9-11-92
By JE Savely 8-13-93
Verified By PM ELL 8-13-93

In Reference 1 was summarized our consideration of the use of 0.3 per cent U-235 in Hanford loadings involving present slug geometry and present pile operating limits. This reference, which was based on reference 2, indicated that additional study was being given to the possible use of cascade-depleted uranium for plutonium production in loadings involving new slugs or new pile designs. For the additional study computations were made by G. W. Stuart, reference 3 was issued by J. R. Triplett, and the present summary letter was drafted. While the letter was being reviewed, we were informed orally by the AEC that new programs had reduced the interest in depleted uranium. Consequently, it was decided to issue this letter internally for the record rather than addressing it to the AEC.

New types of slugs which, if successfully developed, would be applicable in present Hanford piles have been considered quantitatively, though briefly. Only qualitative remarks have been included with regard to other types of piles. The following conclusions are in addition to those listed in reference 1:

1. No way has been found to use large tonnages of cascade-depleted uranium in present Hanford reactors without sacrificing production or efficiency, although small scale consumption (perhaps 20 to 100 tons annually) is attractive where excess pile reactivity and separation capacity are available.

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Another design has been frequently mentioned in the pebble-bed design. Assuming the most favorable situation, 70 per cent of the slug volume would be depleted (0.3 per cent U-235) pebbles and 30 per cent would be a dispersion of U-235 in moderator. The matrix would contain 0.610 grams of U-235 per cm of length.

It seems that the most serious difficulties were encountered in fabricating the thin (0.001 cm) U-235 alloy (Al, U-235 alloy) material, 85 per cent by weight U-235, having a thickness of 0.001 cm. In the transition from the alloy to the U-235 layer, the U-235 inventory would be small (0.001 cm per cent in each).

Reverend designs that could use cascade-depleted uranium in present Hanford piles have been studied. A composite target-lens slug that would contain natural uranium in reactivity with enriched U-235 (0.00272 cm thick) bonded to a solid depleted uranium core (0.3 per cent U-235) 1.70 cm in radius. This slug would contain 0.516 grams of U-235 per centimeter in the fuel and a comparable amount in the core. There would be a total of 1.031 grams of U-235 per centimeter of slug length, as compared with 1.236 grams per cm in a natural uranium slug. Although this would reduce physical inventory of U-235 about 15 per cent, the nominal dollar value would be increased. The conversion ratio for this composite element would be approximately one per cent less than for natural uranium. (Detailed calculations of the long-term changes of reactor parameters with irradiation have not been made. A rough idea of trends may be obtained from reference to the fuel element described here.) Without spacers would be high, running perhaps 80 per cent above natural uranium in two-thirds of the U-235 burned per slug from the alloy and one-third from the depleted core. In addition, development and fabrication costs for the composite slug would be well above those for normal uranium. Also, separation plant problems of slug dissolution and segregation would need to be resolved.

DISCUSSION

1. In the event additional plutonium production reactors are needed, consideration should be given to designs which use depleted uranium. An example is the fast plutonium breeder.
2. Successful development of a composite target-lens slug (layer of alloy surrounding core of depleted uranium) would permit a significant reduction in the U-235 inventory at Hanford with only a slight decrease in conversion efficiency. The dollar value of the U-235 inventory would be increased, however, and the economics of this mode of operation are not attractive unless there is a strong incentive for using cascade tails and for reducing U-235 inventories.
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while the pellets would contain 0.365 grams, resulting in a total of 0.975 grams per cm. This represents a 20 per cent reduction in U-235 inventory (compared to natural uranium), but the conversion ratio would be 12 per cent less than for solid natural uranium to which the reactivity of the matrix slug was matched. Burnout charges would be even higher than in the case of the composite slug and the additional fuel development and fabrication and separation plant problems would still be present.

In briefly reviewing other possible applications of depleted uranium, mention is made first of new thermal reactors. Only slight differences from present piles would be needed to accommodate a composite fuel assembly in which a small, internally cooled, enriched core was surrounded by a thick depleted envelope. The fast effect would be improved and the enrichment inventory kept within reason. The reactor would not be a breeder, however, and it is not clear whether the improved neutron economy would compensate for the enrichment costs.

A second type of thermal production reactor would segregate enriched uranium fuel and depleted target elements in separate coolant channels. This would permit fuel element designs and discharge schedules to be optimized, and could be advantageous where high specific power was desired. Separation of fuel and target would reduce the fast fission contribution and enrichment requirements would be high.

Fast plutonium breeders may ultimately use large quantities of depleted uranium. While the initial inventory of a fast reactor core might contain some depleted uranium along with the fuel, the major potential utilization of depleted uranium would be in the blanket. Here, efficiency would be greater for highly depleted than for slightly depleted uranium. A large inventory would be required and with a high breeding gain the consumption rate would be relatively large. Extraction of weapons-quality plutonium would require frequent reprocessing of the blanket. Projects now underway or proposed will establish the quantitative aspects of plutonium production and costs by this route.

One other reactor type which incorporates many of the advantages of the fast breeder, and might also utilize depleted uranium in substantial amounts, is the fast-thermal hybrid. This reactor is basically an enriched homogeneous reactor into which a close-packed lattice of depleted uranium rods has been inserted. This lattice has a very high fast effect and may provide modest breeding gains.

Usage of depleted uranium for control rod and shielding material has been suggested occasionally, but appears impractical due to the fission of plutonium formed. A possible exception would be a fluid breeding blanket and shield from which plutonium and fission products were removed continuously.

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