Summary

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INTRODUCTION

A new type of spent-nuclear-fuel (SNF) cask is being investigated for storage, transport, and disposal, as well as for use as a multipurpose cask. The cask body is made of a depleted uranium dioxide (DUO_2)–steel cermet, which consists of DUO_2 particulates embedded in steel with clean layers of steel on both sides of the cermet. This cask has potentially major economic and other advantages over current designs.

- *Capacity*. Cermets provide better gamma shielding than steel because DUO_2 (10.9 g/cm^3) has a higher density than steel (7.8 g/cm^3). Typically half the cermet is DUO_2. Because of the high oxygen content associated with the DUO_2, which moderates neutrons, cermets also have better neutron shielding capabilities than steel. As a consequence of the superior shielding performance, the SNF cask capacity can be increased for the same given cask size and weight constraints.

- *DUO_2 disposal*. The use of DU in storage, transport, and disposal casks would avoid the storage and disposal costs for this material.

- *Security*. Traditional tank armor is made of cermets. Cermet casks may provide a more robust cask, which, in turn, can reduce other security requirements.

The key question is the cost of manufacturing cermet casks. If low-cost manufacturing methods can be developed, cermet casks could become an enabling technology for multipurpose casks[1], where SNF is loaded into the cask at the reactor and the cask is subsequently used for SNF storage, transport, and disposal. The multipurpose cask then becomes an enabling technology for an advanced integrated once-through fuel cycle.

ECONOMICS

Historically, cermets have been very expensive to fabricate because they are extremely difficult to weld, machine, and bend. This difficulty is evident from the traditional applications of cermets: tank armor, machine cutting tools, and vehicle brakes. A new manufacturing process (Fig. 1) avoids these operations and thus has the potential to radically change the manufacturing economics. The new process[2] consists of the following steps.

- *Preform fabrication*. A preform slightly larger than the final annular cask body is constructed of steel and serves as the outer layer of clean steel in the final cask. The preform consists of the inside, outside, and top surfaces of the final cask body but excludes the cask bottom.

- *Preform filling*. The preform is filled with a particulate mixture of DUO_2, other ceramics, and steel powder.

- *Welding, heating, and gas evacuation*. After the preform is filled, an annular ring is welded to the preform to create a loaded, sealed annular preform. The preform is then evacuated while being heated, which removes gases in the void spaces in the particulate mixture.

- *Forging.* The preform is heated and compressed to (1) eliminate all void spaces and (2) weld the metal particles together to form a continuous, strong steel matrix containing various ceramic particulates, thus creating a near-final-form cask. There are two mainline forging options.

  – Traditional forging. With traditional forging, a cylindrical anvil, the size of the interior of the final cask, is placed inside the preform. The forge then strikes the exterior to consolidate the particulate mixture.

  – Ring-rolling forging. The hot loaded preform can be placed in a ring-rolling machine and rolled into its final form.

- *Finishing*. The cask bottom is welded onto the cylindrical cask body. After completion of this step, a vertical boring mill is used to obtain the final dimensions and to drill holes in the top of the cask for the lid bolts. No welding, cutting, or bending of the cermet is required.

The characteristics of this manufacturing process create the potential for low costs: steel powder is inexpensive ($600/ton), the process involves very little labor, and the forging process produces a near-final-form cask with minimal machining. However, three major uncertainties are associated with the process.

- *DUO_2 costs*. In France, DUF_6 is converted to a mixture of DU_3O_8 and DUO_2 for long-term storage, and the same chemical conversion is planned in the United States. The DU must be fully converted to DUO_2 before cermet fabrication. Several process options to complete this conversion are available.

- *DUO_2 credits*. If credits for avoided disposal costs of DUO_2 are included, the DUO_2 has a negative cost (i.e., the fabricator is paid to "dispose of" the DU). Under these circumstances, the economics become very favorable.

- *Forging costs*. Forging can be conducted in a specially built facility or in a general forging facility. (The preform is welded shut with clean exteriors.) For smaller production runs, the use of existing general forging facilities is highly desirable; however, regulatory and commercial issues are associated with the process.

CONCLUSIONS

Depending upon the specific underlying assumptions, cermet casks can become highly competitive. The cost implications of different assumptions and methods are described in the paper. Submittal of a full paper is contingent on successful completion of cost analysis this summer.

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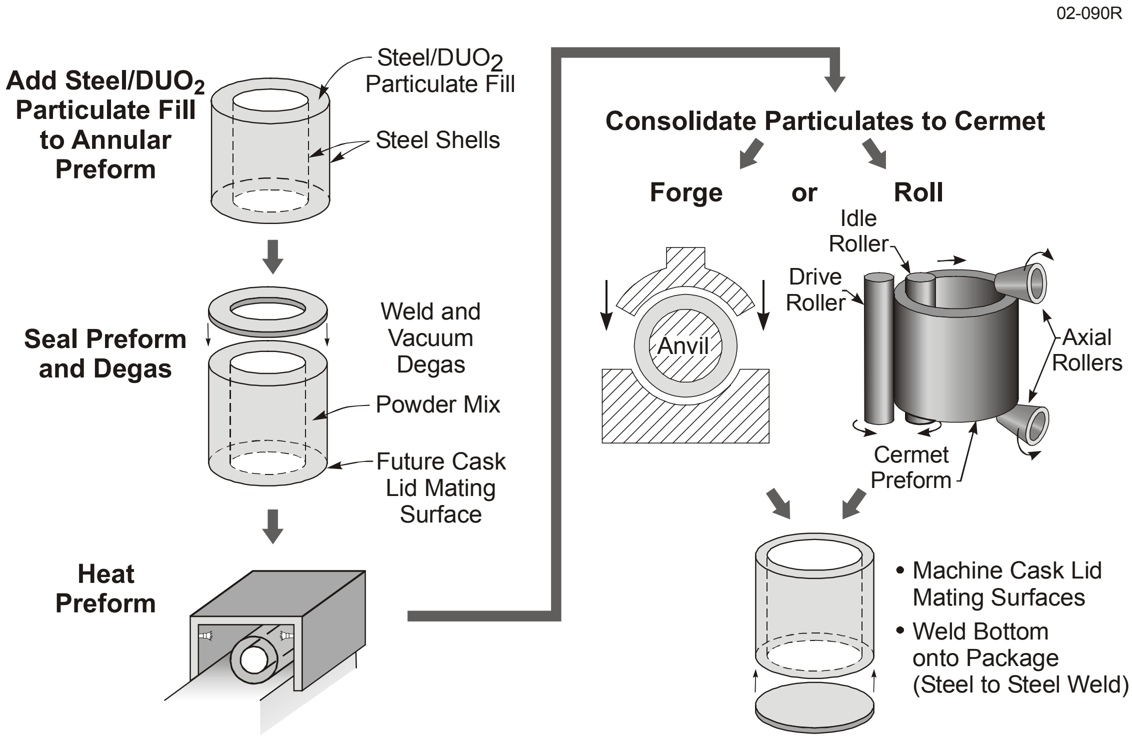

Fig. 1 New Method for Cermet Cask Fabrication