FUSION REACTOR FUEL PROCESSING*

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ABSTRACT

For thermonuclear power reactors based on the continuous fusion of deuterium and tritium the principal fuel processing problems occur in maintaining desired compositions in the primary fuel cycled through the reactor, in the recovery of tritium bred in the blanket surrounding the reactor, and in the prevention of tritium loss to the environment. Since all fuel recycled through the reactor must be cooled to cryogenic conditions for reinjection into the reactor, cryogenic fractional distillation is a likely process for controlling the primary fuel stream composition. Another practical possibility is the permeation of the hydrogen isotopes through thin metal membranes. The removal of tritium from the ash discharged from the power system would be accomplished by chemical procedures to assure physiologically safe concentration levels. The recovery process for tritium from the breeder blanket depends on the nature of the blanket fluids. For molten lithium the only practicable possibility appears to be permeation from the liquid phase. For molten salts the process would involve stripping with inert gas followed by chemical recovery. In either case extremely low concentrations of tritium in the melts would be desirable to maintain low tritium inventories, and to minimize escape of tritium through unwanted permeation, and to avoid embrittlement of metal walls.

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D. M. Gruen (ed.), The Chemistry of Fusion Technology
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INTRODUCTION

Although the most critically difficult problems to be solved before fusion power can become a practicable possibility are those concerned with the plasma physics of fusion reactions and with the maintenance of the materials of construction, there are also difficult problems involved in the processing of the fuel. In what follows we identify these problems and possible solutions for them.

CONCEPTUAL POWER MACHINE

Based on our present knowledge and speculation the likely first fusion power device will be a continuous toroidal machine burning a 50-50 mixture of deuterium and tritium in its reactor and breeding tritium in a blanket containing lithium in some form. However, regardless of the particular type of reactor or the particular fusion reactions which predominate, the principal problems involved in the processing of the fuels are essentially the same. These problems arise in two different contexts, one the reactor system and the other the blanket system. For purposes of illustration and without sacrificing the generality of the discussion we shall describe the relevant features of a typically visualized fusion power machine, the Princeton Reference Design Model (18).

This model is a hypothetical design for the purpose of providing a basis for testing the feasibility and practicability of the various aspects of fusion reactor technology. As such it is subject to continual updating and revision, and although the properties of the design are presented in specific, quantitative terms, they should be regarded only as providing a frame of reference and not an absolute description of an actual or even a possible machine.

REACTOR SYSTEM

The principal characteristics of the Princeton Model are listed in Table I, and an elevation cross section of one half of the machine is shown in Figure 1. The reactor itself is an empty tube, 4.5 m mean diameter, in the shape of a torus with a centerline diameter of 17.7 m. Its wall, the