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Design and Economic Study of a Gas-Phase
Chemonuclear Ozone Process

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MASTER

A gas-phase ozone process utilizing fission fragment energy is presented which offers the promise of being competitive with conventional ozone-generating systems.

The reactor chosen for the system is externally-moderated, with graphite serving as reflector material. The high volume ratio of gas to fuel dictated by fission fragment energy deposition considerations makes it desirable to eliminate moderating material from the core and to rely strictly upon the reflector for neutron energy degradation. Table 1 summarizes the reference design characteristics, which are based on a G-value of 15 for the formation of O_3 from O_2 . The oxygen stream acts as reactor coolant, chemical reactant, and process medium. Fuel consists of a 20 wt % dispersion of highly enriched uranium in 2.5 μ -thick palladium foil fabricated in a honeycomb configuration within each fuel subassembly. Spacing of the honeycomb is such that the fission fragment energy

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deposited within fuel and structural material is minimized. For the oxygen conditions of Table 1, a spacing of 0.11 cm is required. The thin, unclad fuel foils permit the deposition of 43% of the total fission fragment energy into the oxygen stream. For a G-value of 15, approximately 8% of the total reactor power is consumed in forming the chemical product and 92% is removed as waste heat by the coolant. The extremely low average coolant temperature and the high coolant flow rate are necessary to maintain the stability of the ozone product. The reactor is controlled by inserting absorbing rods axially into the radial reflector at the location of the thermal flux peak which is characteristic of externally-moderated assemblies. The temperature coefficient is positive but acts very slowly due to the gross separation of fuel and moderator materials.

The reactor feed is 300 psi oxygen gas from an air separation plant. Reactor waste heat is removed by recycling reactor gas through a Freon-12 refrigeration system. The O_3 and Xe are adsorbed in Freon-22 cooled silica gel beds at -80°C , and the O_2 leaving the beds passes through a molecular sieve trap to remove Kr and some Ar. It is then warmed to -5°C through heat exchange with incoming gas, and returned to

Table 1. Reference Design Characteristics

Total reactor power	39 MW(t)
Chemical production rate	100 tons O_3 /day
Core diameter	8.5 ft
Core height	8.5 ft
Reflector-moderator	graphite, 4.25 ft thick
Uranium enrichment	93.5%
Fuel loading	100 kg. U^{235}
k_{eff} (clean, control rods out)	1.104
Operating time per core	635 full-power days
Maximum burnup of U+Pd	3.44 at.%
Working pressure	300 psig.
Coolant inlet temperature	-4°F
Coolant outlet temperature	32°F
Coolant flow rate	1.45×10^7 lb/hr.
Average coolant velocity	40 ft/sec.
Reactor pressure drop	20 psi.
Peak-to-average power density	1.43
Temperature coefficient of reactivity	$+3.66 \times 10^{-5}/F^\circ$
Structural material	Aluminum
Subassembly size	3 in. x 3 in.; 0.04 in. wall thickness

the reactor. The O_3 and Xe are desorbed from the silica gel by heating, and fed to a packed distillation column where Xe is separated from O_3 along with the NVFP which have passed through the initial decontamination filters.

The estimated cost of producing 100 T/D O_3 from a conventional ozonizer plant is 15¢/lb. O_3 from a chemonuclear reactor can be produced for 11¢/lb at a G value of 15, and for 15¢/lb at a G value as low as 9. Steady-state reactor concentrations ranging from 2-10% O_3 were examined, and show relatively little effect on the plant economics. Based on available radiation chemistry data it is expected that these yields can be realized using fission fragment energy.