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C-85 - Reactors-Aircraft Nuclear
Propulsion Systems

AEC RESEARCH AND DEVELOPMENT REPORT

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SPECIAL PROGRESS REPORT

PROGRAM 4700

JANUARY 1958

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SPECIAL PROGRESS REPORT

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OAK RIDGE NATIONAL LABORATORY

SPECIAL PROGRESS REPORT

January 1958

PROGRAM 4700 - REACTOR DEVELOPMENT

AIRCRAFT NUCLEAR PROPULSION PROJECT (AEC Activity 4701)

Shield Design

Gamma-ray heating calculations, for which the Auslender Monte Carlo Oracle program was used, were completed for several GE-ANP shield configurations. The results, which give the heating and dose rates throughout the shield as a function of energy and angle of incidence upon the shield, are now being coupled with the results of a Bulk Shielding Facility reactor leakage calculation.

Calculations were made of the spectrum of the gamma rays (from neutron inelastic scattering in air) which should have reached the detector in the recent TSF secondary gamma-ray experiment. The spectral shape and magnitude are in fair agreement with the experimental results for the contribution believed to come from inelastic scattering.

Tower Shielding Facility (TSF)

The Convair Aircraft Shield Test Reactor (ASTR), which was flown in the Nuclear Test Airplane, was installed at the TSF in order for experimental data to be obtained, which, when compared with that obtained in the Nuclear Test Airplane, will show the effects of the airplane structure. Two reactor runs for reactor instrumentation and reactor cooling system checks were made. Additional checks on completed systems are in progress. It is expected that shortly after February 1 regular runs will begin.

Tower Shielding Reactor-II (TSR-II)

The contract for installation of the water-cooling system for the TSR-II is to be let during February and work should be started by March 1. An analysis of the tower loading due to the water hoses indicates that if there is no deviation from the method prescribed by the architect-engineer for suspending the reactor load it will be extremely difficult to keep the beam of radiation from the reactor in the vertical midplane of the facility as the reactor is raised or lowered. In order to minimize the problem, the inlet and outlet hoses to the reactor will be suspended from opposite tower legs. This will be done subsequent to installation of the water system by the contractor.

The first full-scale control mechanism is being fabricated and should be available for testing in mid-March. The test stand for studying water flow through the fuel channels is scheduled for completion in February.

[redacted]

PROGRAM 4700 - REACTOR DEVELOPMENT (Continued)

Nuclear calculations are under way to determine the location of a boral shell in water outside the reactor core which would permit the reactor to operate with the same fuel loading but without the lead-boral reflector or a water-boral reflector. The purpose of the boral in either case would be to reduce the reactivity coupling between the core and various shields.

The nuclear calculations for determining the core loading and available control are complete except for the determination of the excess loading required for temperature compensation. Nuclear calculations will be continued to supply information for kinetic analog studies. A preliminary investigation of the water system for analog studies was started.

Metallurgy - Yttrium Production

Several runs were completed in the modified yttrium-magnesium alloy production apparatus to which both the yttrium-containing fluoride mixture and the lithium reductant are added in the molten state. The alloys produced in the first few runs separated into magnesium-rich and yttrium-rich layers. In subsequent runs a considerable excess of lithium was used, and no segregation occurred. Experiments are being carried out for determining the best operating conditions.

Experiments are continuing in order to obtain the data needed for correlating the tensile properties of yttrium with the impurity concentration. Several tensile specimens were machined from finger castings and were tested. A preliminary investigation showed that there might be a correlation between yield strength and impurity concentration. One finger casting was swaged to a diameter of 0.365 in. (27% reduction in area) without noticeable cracking. A tensile specimen was machined from this swaged finger casting and was tested. This specimen, along with several others, is presently being examined metallographically.

Metallurgy - Niobium-Lithium Systems

All five niobium-lithium thermal-convection loops (loops 52, 54, 55, 58, and 59) have failed as a result of lithium penetration of the longitudinal tube welds. All the loops showed heavy attack in the weld areas and, in several cases, heavy intergranular attack of the base material. Loop 59 (hot leg at 1500°F; cold leg at 1300°F; operated 115 hr), the most recently examined loop, gave results that were quite similar to those reported previously for these unclad loops, which are fabricated of sintered tubing with a section of arc-cast seamless tubing inserted in the hot leg. The arc-cast tubing in loop 59 was attacked to a depth of 16 mils, while the sintered tubing was attacked to a depth of 12 mils. Intergranular attack (up to 11 mils) was also detected in the weld zone of the cold leg of loop 59. It is believed that the attack observed in these loops is due to grain-boundary impurities, possibly carbides, oxides, or nitrides. Tests are planned for studying the effects of impurities.

Electron micrographs of the as-received tubing used in the fabrication of loops 52, 54, and 55 revealed a very minute grain-boundary phase, which may or may not have been attacked by the lithium.

Work was continued on the problem of finding protective coatings for niobium. Long-time oxidation tests were run on two Coast Metals brazing alloys, and one (alloy 53) showed some promise. Tests are presently being run in which lithium is being circulated in niobium tubes coated on the outer surface with alloy 53.

Chemistry

Conversion of Y_2O_3 to YF_3 in 2-lb batches by treatment of the solid oxide with gaseous HF is being accomplished satisfactorily. It was found that the product obtained by treatment at 1100°F is at least as good as that obtained by treatment at 1400°F. Treatment for 12 hr with 132 liters of HF per hour is adequate, and it appears that a 6-hour treatment may suffice. Oxide contamination has been below 1.5 wt % O_2 in all runs, and in most preparations it has been below 0.5%.

A similar method for converting MgO and $Mg(OH)_2$ to MgF_2 appears to be satisfactory. The $Mg(OH)_2$ is more readily converted than MgO and yields a better product.

The test apparatus used for these preparations is very similar to the large equipment formerly used for the conversion of $ZrCl_4$ to ZrF_4. It appears, therefore, that equipment for conversion of 250-lb batches of Y_2O_3 to YF_3 is available.

The hydrogenation-hydrofluorination fuel-processing method was applied to the production of ten 5-lb batches of $LiF-MgF_2-YF_3$ mixture. Fluorides prepared as indicated above were used. No oxides were detected in these batches by x-ray diffraction or chemical microscopy.

Experimental Engineering

An ART fuel pump has operated in the cavitation region for a period of 2800 hr, and operation has been satisfactory in all respects. This test will be continued until at least 3000 hr of operation has been accumulated.

Testing of the 20-tube semi-circular fuel-to-NaK heat exchanger was interrupted by a radiator-heat-dump failure after 194 of a proposed 300 thermal cycles were completed. A new radiator was installed and startup was initiated. During the startup procedure, it was found that a leak had developed in the semi-circular heat exchanger. The test was therefore terminated. A metallurgical examination will be made of the heat exchanger, and the results will be reported.

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Tests of the improved NaK dump valve were successfully completed. The valve accumulated 1500 hr of operation, including 67 opening and closing cycles. The valve was operated at 1000°F with a 50-psig pressure across the seat. The maximum opening force required was 84 psig. The leakage rate at the end of the test was less than 0.2 cm^3/hr. This performance was better than that required by the specifications.

The one-fourth-scale shell-buckling test was completed. The shell buckled after 111 hr at 1500°F and a 52-psig buckling pressure. This test of a complete core shell indicates that the result obtained previously for one-half of a shell with the ends blocked off was overly optimistic. The half shell did not buckle until after 200 hr at the same conditions.

Edited by A. W. Savolainen

Approved by Alvin M. Weinberg, Director

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