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ORNL-2596
C-85 - Reactors-Aircraft Nuclear Propulsion Systems

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

PROGRAM 4700

AUGUST 1958

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C-85 Reactors - Aircraft
Nuclear Propulsion Systems

ORNL-2596

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OAK RIDGE NATIONAL LABORATORY
STATUS AND PROGRESS REPORT
PROGRAM 4700

August 1958

Date Issued: SEP 5 1958

OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee
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STATUS AND PROGRESS REPORT

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OAK RIDGE NATIONAL LABORATORY

STATUS AND PROGRESS REPORT

August 1958

This monthly report covers those AEC activities which fall under program 4700, categories C-84 and C-85, classified SECRET. Some of the topics are reported every month, but the majority are reported bimonthly.

PROGRAM 4700 - REACTOR DEVELOPMENT

AIRCRAFT NUCLEAR PROPULSION PROJECT

Lid Tank Shielding Facility (LTSF) Experiments

The investigation of secondary gamma-ray production in lead continued with gamma-ray measurements being taken in oil beyond lead thicknesses of up to 9 in. In order to determine the effect on the secondary production of suppressing the thermal-neutron flux beyond the lead, measurements were also made in a medium of borated water. The gamma-ray dose rates were reduced by a factor of 5 in the region close to the lead and by a factor of 13 approximately 120 cm beyond the lead.

A second group of measurements was made in which the spectrum incident on the lead was changed by the insertion of 4 in. of beryllium between the source and the lead. The configuration was kept dry in all cases.

Tower Shielding Facility (TSF) Experiments

The current series of tests intended to check and supplement information obtained at the TSF in the 2π experiment performed by GE-ANPD several months ago has thus far included measurements of the fast-neutron and gamma-ray dose rates and thermal-neutron fluxes in the GE crew compartment with all the tanks in the crew compartment empty except the rear shadow shield, which contained borated water. The reactor shield used was the GE reactor shield No. 1, which allows a relatively high neutron-to-gamma-ray leakage. The reactor shield was used in its normal orientation and also rotated 180 deg in the horizontal plane with and without its 2π shield. All measurements are being made as a function of altitude, and in most cases the measurements obtained agree with previous data.

Tower Shielding Reactor II (TSR-II) Experiments

The assembly of the eight central fuel elements of the TSR-II is complete. All the fuel plates for the annular fuel elements have been rolled and formed, and the elements are being assembled in a temporary manner. If a criticality study shows need for adjustment of the loading, some of the fuel plates can be changed before final assembly. After the lower central cylinder was completed and the central fuel elements were mounted in it, it was found that the variation in the water gap between the outer fuel plates and the cylinder was excessive. In order to eliminate this variation, 40 mils was machined from the inside of the cylinder and 20 mils from the outside, leaving the cylinder with a 1/16-in. wall thickness. Proper spacing all around the cylinder will be assured by spacer combs which will be used every 30 deg on the central fuel elements, which are assembled in 90-deg segments.

Studies of the speed of operation of the control mechanism were concluded when the bleed-down time of the system was reduced from 50 to 25 msec. The kinetic studies showed that this system is capable of reversing an 8-msec period with less than a 10^3 power overshoot. The control mechanism is now being fabricated. A further reduction in bleed-down time of the system is possible if the inertia of the electrohydraulic transducer which operates the control mechanism can be reduced. A more compact transducer design is nearly complete.

Initial studies and more recent data on the flow of fluid between parallel plates indicates the flow distribution problem to be more severe than anticipated. The new data show that higher flow rates are required for turbulent flow between parallel plates. To ensure turbulent flow in all channels a higher flow rate or a higher operating temperature or both are required. Both possibilities are being investigated. In addition, the test stand for observing the operation of the control mechanism under full flow conditions is being adapted to study the flow patterns in the central fuel elements and in the internal water reflector region.

The cubicle for the reactor controls was inspected at the vendor's plant and found to be acceptable. Delivery is expected early next month. A decision was made to use multipin connectors at the reactor for quick control cable disconnects. Vendors were contacted and an order will be placed soon.

The 1/8-in.-thick hemispherical shells for the lead-boral shield were received, inspected, and accepted. It was previously reported that the 3/4-in.-thick hemispherical shell for the reactor pressure vessel had been shipped to ORNL; however, the vendor states that the material was received only recently and that spinning of the hemisphere is now under way.

An experimental study of radiation heating in the lead-boral shield was performed with the use of the Bulk Shielding Reactor as a source and an insulated 1-ft^2 section of lead-boral shielding similar to that which will be used in the TSR-II. The reactor was operated at $\sim$0.75 Mw, and a water flow rate of 2 gpm was used to cool one surface of the lead. The water temperature rise and heat distribution in the lead-boral indicate that the assumed gamma-ray and neutron heat sources used in the TSR-II design are conservative.

Columbium Fabrication

The effect of heat treatment in the range 700 to 1000°C on the ductility of notched-bend specimens machined from a columbium casting was studied. In general, the ductility improved as the heat-treatment temperature was increased, but the scatter in the data observed in triplicate tests at each temperature indicated that grain orientation may be as important as the heat-treatment temperature.

The unclad columbium tubing extruded at ORNL and drawn at Superior Tube Company was found by nondestructive testing to have 0.003- to 0.004-in.-deep cracks extending from both the inner and outer surfaces. Similar cracks were found in unclad tubing purchased from the Fansteel Metallurgical Corporation.

A new duplex tube billet design was prepared which permits evacuating the billet, preheating it, and extruding it without using a core material. The vacuum is not broken until the actual moment of extrusion. A test extrusion of a type 310 stainless-steel-clad vanadium duplex tube blank showed the new design to be satisfactory.

Further studies were made of the purification of columbium wire by vacuum annealing. Chemical analyses of samples vacuum annealed at temperatures ranging from 1400 to 2000°C for 30 min showed definite purification at the higher temperatures. For example, vacuum annealing for 30 min at 1800°C reduced the oxygen content from 390 to 110 ppm, the carbon content from 290 to 98 ppm, the nitrogen content from 50 to 38 ppm, and the hydrogen content from 15 to 11 ppm.

Efforts are being made to determine the oxidation and nitriding rates of pure columbium over the temperature range 800 to 1600°C and the pressure range 1×10^{-5} to 0.1 mm Hg. Specimens heated in pure nitrogen at a pressure of 0.5 to 3 μ for 1 hr at 1300°F showed no significant weight changes but thin transparent films formed on the surfaces. The preliminary tests thus indicate that the effect of nitrogen is small, although there may be a critical pressure below which absorption occurs without formation of a nitride film. Specimens containing various concentrations of oxygen (61 to 5000 ppm) were prepared by heating in an

evacuated furnace at 850°C under an oxygen partial pressure of 2 μ for periods up to 16 hr. These oxygen-containing specimens are being used to study the effects of oxygen contamination on the corrosion of columbium by lithium.

Columbium and Molybdenum Welding and Brazing

Hardness measurements were made on joints prepared as described previously (ORNL report 2547, p 4) by various welding techniques in several environments and then exposed to lithium for 100 hr at 1500°F. The data obtained indicate that the heavy attack of columbium welds and heat-affected zones can be attributed primarily to oxygen or nitrogen pickup. The hardness of the columbium increases during welding in an impure atmosphere and, upon exposure to lithium, the hardness decreases in the areas contaminated during welding. The lithium apparently getters one or both of the contaminants. The specially prepared samples containing oxygen and nitrogen, described above, are being used to determine which of the contaminants is responsible for the corrosion of columbium welds by lithium.

Additional molybdenum and columbium T-joints were made with zirconium-base brazing alloys in order to study brazing temperatures, wettability, flowability, and fillet characteristics. In general, the refractory-metal-base alloys show good wettability and flowability on both columbium and molybdenum when brazed in vacuum.

Mechanical Property Tests of Molybdenum

An initial test of an apparatus for carrying out creep and tensile tests at temperatures above 2000°F in controlled environments showed that an excellent temperature gradient could be achieved. The initial test of a specimen at a stress of 9000 psi and a temperature of 2000°F had to be terminated after 24 hr when an air leak occurred. A second specimen has now been under stress for 115 hr, and a creep rate of 0.034%/hr has been measured.

Yttrium Hydride Production

Methods for purifying hydrogen, especially with respect to oxygen and nitrogen are being evaluated. The method being studied at present consists of hydriding uranium, decomposing the product, and collecting the hydrogen. The analysis of the gas collected from the first run indicated that the hydrogen was ~99.8% pure. Special care will be used in future runs to outgas the system more completely and the decomposition temperature will be varied.

The major construction work on the yttrium preparation facility was completed. Shakedown tests are being conducted, and the minor repairs or alterations indicated are being made. It is now anticipated that the first reduction run will be attempted during the first week of September.

Fabrication of Boron-Containing BeO Bodies

The developmental work on boron-containing BeO bodies for GE-ANP was completed. The irregularity previously observed in a hot-pressed 3 x 3 x 1-in. BeO-ZrB_2 block was eliminated on subsequent blocks by using iron-free ZrB_2. This pure ZrB_2 was obtained either by preparation of the boride in the laboratory or by leaching commercially available boride with HCl. The preparation of six BeO-ZrB_2 blocks will complete this phase of the program.

Heat Transfer Studies

Additional data were obtained in the study of surface thermal-stress cycling of Inconel in a pulse-pump apparatus. A study of the time history of crack propagation at a thermal stress cycle frequency of 0.1 cps was completed. The test section was a heavy-walled Inconel tube 0.5 in. ID and 1.5 in. OD. In the final test of the series, operation was such as to generate a temperature fluctuation of ±122°F at the inside wall with a mean fluid temperature of 1410°F. The run was terminated after 25 hr (9000 cycles), and the test section was examined metallographically. No evidence of cracking was found. After another test at 1.0 cps for 100 hr (36,000 cycles) with a temperature fluctuation of ±76°F around a mean of 1415°F, the 0.147-in.-wall, 0.485-in.-ID Inconel test section similarly showed no evidence of cracking.

Stress Analyses

Basic studies are under way of the elastic behavior of five structural configurations commonly used in reactor design. The configurations being analyzed are a flat circular plate, a tapered circular plate, a cylindrical shell, a conical shell, and a spherical shell. The stress and displacement formulas and tables of numerical values for all the functions involved are being obtained. The study of the conical shell, which has been completed, provides for analyses of a conical shell with a combination of axisymmetrical loads. The loads may include membrane forces and uniform pressure, in addition to edge moments and shear forces.

Bearing and Seal Tests

The centrifugal pump rotary assembly that is being operated under gamma irradiation in the MTR canal continued to function satisfactorily. The region of the oil-lubricated lower seal and journal bearing had accumulated on August 19, 1958, a gamma-ray dosage of 8.9×10^9 roentgens

during 3950 hr of operation. The corresponsing estimated accumulated dosage to the bulk oil is 2×10^8 roentgens.

A centrifugal pump with a bellows-mounted shaft seal has operated for more than 7400 hr with NaK at 1200°F, a shaft speed of 2500 rpm, and a flow rate of 1200 gpm. Operation continues to be satisfactory.

Edited by A. W. Savolainen

Approved by Alvin M. Weinberg, Director

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