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Hot Forging of Graphite-Carbide Composites

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This project was aimed at hot shaping of titanium carbide/graphite and vanadium carbide/graphite composite materials by heating them to above 2000 degrees celsius and pressing into an electrographite die. The sample was to be a preformed cylinder of powdered graphite mixed with powdered titanium or vanadium, lightly sintered. The preform would be heated in a hot press and the titanium or vanadium would react with some of the graphite to form titanium or vanadium carbide. The remaining (excess) graphite would form a composite with the carbide, and this could then be deformed plastically at temperatures well below the onset of plasticity in pure graphite. There were to be two major thrusts in the research: In the first, an electron beam furnace at Sandia Laboratory was to be used for rapid heating of the sample, which would then be transferred into the press. The second thrust was to be entirely at Alabama A&M University, and here we intended to use a heated, controlled atmosphere press to forge the graphite/carbide preforms at a steady temperature and measure their viscosity as a function of temperature.

The Department of Energy granted the contract on 15 June 1992, and work began at once on purchase and installation of the necessary hot press at Alabama A&M University. Dr. Jenkins would lead the project and arrange the work at Sandia, while Dr. Holland was responsible for the technical work at Alabama. Dr. Jenkins had arranged for the preforms to be made by Dr. Haskell Scheinberg of Los Alamos National Laboratory for both thrusts.

The Alabama hot press was designed and the contract for its construction was let on 24 September 1992. The furnace system was fabricated by Materials Research Furnaces (MRF) of Suncook, New Hampshire. The base price was \$89,869, and there were two change orders for \$1,642 and \$650, which were to improve the physical sensing and data recording systems. The hot press system was finally installed and activated in January of 1993, somewhat behind schedule.

Late in 1992 Dr. Jenkins was incapacitated by a health problem, and it became necessary for him to return to Great Britain temporarily. Meanwhile problems arose with respect to securing the preform samples from Los Alamos. A no cost extension was requested and granted, and finally Dr. Holland took over the project in February of 1994. Still hoping that Dr. Jenkins would be sufficiently recovered to finish the work, a second extension was requested to the end of 1994. Unfortunately the preform samples were never forthcoming, and Dr. Holland considered it too dangerous to work with finely divided titanium or vanadium in the facilities available in Alabama. Both of these metals can react violently with air, and there is substantial explosion hazard.

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At this time, Dr. Jenkins is in Great Britain, and it appears he is unlikely to return to Alabama. Dr. Holland and Dr. Sheinberg have both retired. The necessarily disappointing but inescapable conclusion is that a new generation will have to take over this work if it is to be completed, and at this time those who might be willing and able are nowhere to be seen.

On the positive side, Alabama A&M University has a unique and excellent controlled atmosphere hot press in its high temperature laboratory. This press has a maximum force of four tons, and the high density graphite rams are circular in section with a diameter of 29 millimeters. The maximum temperature is 3000 degrees celsius, which must be derated linearly to 2500 degrees celsius at the maximum force of four tons. A recording system keeps track of both temperature and applied force. Control is by a combined thermocouple (type G, up to 1700 celsius) and optical pyrometer (Ircon) from 1700 celsius to 3000 celsius.

Much of the infrastructure of the high temperature laboratory itself has either been installed or enhanced thanks to this support from DOE, and several graduate students have received training and support in this project. In particular, Drs. Hossein Maleki, William Andrew Hollerman, and Jonathan Fisher have all used these DOE supported facilities for their thesis research.