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A STUDY OF THE WORKABILITY OF URANIUM BY MEANS OF TENSILE-IMPACT, HARDNESS, AND DROP-HAMMER EVALUATIONS AT ELEVATED TEMPERATURES

PROPOSAL TO

NATIONAL LEAD COMPANY OF OHIO

SOUTHERN RESEARCH INSTITUTE

2000 9th Avenue S   Birmingham 5, Alabama

A STUDY OF THE WORKABILITY OF URANIUM BY MEANS OF TENSILE-IMPACT, HARDNESS, AND DROP-HAMMER EVALUATIONS AT ELEVATED TEMPERATURES

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Southern Research Institute
Birmingham, Alabama
January 30, 1963
Proposal No. 2152

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INTRODUCTION

This proposal is for an extension of National Lead Company of Ohio's program to investigate the hot-workability of uranium by means of laboratory studies after various thermal and processing treatments. The hot-workability would be studied by means of tensile-impact, hardness, and drop-hammer evaluations at temperatures from 885 to 1235° F with other possible evaluations at 70 and 1305° F.

The initial phase of the program consisted of elevated-temperature tensile evaluations from 885 to 1235° F of uranium in six starting conditions; (1) as-cast, (2) cast-and-beta-treated, (3) as-extruded, (4) extruded-and-beta-treated, (5) rolled, and (6) rolled-and-beta-treated. This phase of the program was recently completed by Southern Research Institute.

The purpose of the entire program is to obtain hot-workability and mechanical-property data from laboratory evaluations that can be translated into optimum working conditions for production of different uranium components. Forging, extruding, rolling, and piercing are used to produce the different uranium parts and shapes.

Laboratory studies are being used to an increasing extent to evaluate many of the material and processing variables associated with hot- and cold-working of metals and alloys. This approach offers several advantages over trial-and-error methods of establishing optimum working conditions for use on production or full-scale equipment. Laboratory studies are generally more economical and can be more suitably controlled to investigate the working variables singly or in combination. At the same time, it must be realized, laboratory procedures usually do not precisely duplicate production conditions; therefore, judgment must be exercised in applying laboratory-developed information to production processes.

Both material and processing variables can be studied and evaluated by laboratory methods. Examples of material variables are composition, impurities, grain size, and anisotropy. Examples of processing variables are thermal and mechanical processing prior to working, working temperature, time at temperature, deformation rate, severity of deformation, and mode of deformation.

A number of different laboratory tests can be used to evaluate the hot-workability of metals (1)[1]. Perhaps the most widely used method is the hot-tensile test (2, 3, 4, 5, 6, 7, 8). A tensile machine with a wide strain-rate capability, up to 50-60 in. /in. /min, is desirable because, in addition to temperature and other variables, the effect of strain rate can be studied (6, 8). Other standard laboratory methods used for workability investigations include hot-torsion (2, 3, 4, 5, 9) and hot-bend (3, 4, 5) tests. Elevated-temperature upset tests, in which a cylindrical specimen is forged in a press or hammer, are also used to study the workability of metals and alloys (1, 10, 11). Specialized tests, often designed to simulate a particular hot-working method, have been used by different companies and laboratories (10, 11, 12). Often, several of the methods discussed above are utilized in workability evaluation programs.

SCOPE

The proposed program would include hardness, tensile-impact and drop-hammer evaluations at elevated temperatures on reactor grade uranium after six different thermal and processing treatments. The number and orientation of specimens for each material are summarized in Table I. Duplicate evaluations would be conducted at 885, 955, 1025, 1095, 1165, and 1235° F for each material, orientation, and type-evaluation shown in the table. Additional evaluations would be conducted at any of these temperatures where inconsistent results were obtained or at 70 and 1305° F.

National Lead of Ohio would machine and supply specimens for the hardness, drop-hammer, and tensile-impact tests as shown in Figures 1, 2, and 3 respectively.

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[1] Numbers in parentheses refer to the Bibliography.

EQUIPMENT AND PROCEDURES

A. Hot-Hardness Evaluations

A Rockwell hot-hardness tester would be furnished by National Lead of Ohio and returned at the conclusion of the program. Southern Research Institute would furnish any auxiliary equipment that would be needed for use with the apparatus.

Heating-rate curves and calibration of the furnace temperature to the specimen temperature would be established for the different evaluation temperatures prior to hardness measurements. The temperature of the specimen, as indicated by a thermocouple welded to the specimen, and the furnace temperature, as indicated by the control thermocouple, would be recorded at frequent time intervals during heating and for 10 minutes after the specimen reached the control temperature. Heating-rate curves for the different temperatures would be constructed from these data. The heating-rates for subsequent hot-hardness evaluations would be the same as those established at the different temperatures during the heating-rate determinations. High-purity argon gas would be used to protect the specimens from oxidation. The specimens would be held at temperature for 10 minutes, and a minimum of four hardness impressions would be made for each specimen.

B. Drop-Hammer Evaluations

The 200 ft-lb drop-hammer apparatus would be furnished by National Lead of Ohio, but Southern Research Institute would provide the base for the apparatus and any related equipment that would be required.

A chloride salt bath, maintained at the different temperatures by means of an immersion thermocouple, would be used to heat the specimens. The chloride salt would be furnished or specified by National Lead of Ohio. The specimens would be held at temperature for 10 minutes, transferred to the drop-hammer anvil, struck within 2 seconds after removal from the salt bath, and water quenched.

After the specimens are cooled, any remaining salt would be removed, and the percentage reduction in height would be determined from measurements of the specimen before and after evaluation. The appearance of the specimen would also be recorded.

C. Tensile-Impact Evaluations

Our Sonntag Universal Impact Machine, Model SI-1, would be used for the tensile-impact evaluations. Although this machine is equipped with a tensile-impact attachment, it requires threaded specimens. We, therefore, propose to use National Lead's tensile-impact attachment for this part of the program. Specimens would be heated in a chloride salt bath, which would be controlled at the different temperatures by means of an immersion thermocouple, and held 10 minutes before evaluation. The temperature of the salt bath would be maintained at a temperature higher than the nominal evaluation temperatures so that the specimen would be at temperature, ±15° F, at impact. The required temperature correction for the salt bath would be established at the different temperatures by measuring the temperature drop of a specimen during transfer from the salt bath until the specimen is fractured. A thermocouple, welded to the specimen, would be used to measure the decrease in the specimen temperature during transfer at the different temperature levels. The transfer time would be maintained constant for each evaluation temperature. The specimens would be water quenched after impact.

The impact energy would be recorded from the 0-50 ft-lb range of the machine, and the elongation, in one inch, and the reduction of area would be determined from the fractured specimens.

REPORTS

Progress reports would be prepared at monthly intervals during the performance of the work, and a final report would be prepared at the conclusion of the program. The progress reports would include a description of the work performed and data obtained in each report period. The final report would include a description of the equipment and procedures, all of the data, and a discussion of the results of the program. An example of the type of final report that would be prepared is our final report on the tensile-evaluation phase of the program conducted under Purchase Order H-26624.

QUALIFICATIONS OF SOUTHERN RESEARCH INSTITUTE

Southern Research Institute is qualified to undertake the proposed program because of our past experience on similar programs and our understanding of the techniques that would be used during the proposed work.

In addition to conducting the elevated-temperature tensile evaluations on uranium for National Lead of Ohio during the first phase of the present program, we have conducted two hot-workability investigations for Wyman-Gordon. At the present time we are conducting a program on the hot-workability of titanium alloys for General Electric. Several years ago we investigated the true-stress, true-strain characteristics of a uranium alloy up to 1250° F for the Atomic Power Development Associates. Any of these companies may be contacted with regard to the work performed for them.

We are familiar with the special safety precautions and handling procedures that are required for uranium metal, having used these precauations and procedures in our previous work on uranium. We currently have an AEC "source material" license for specified work on natural uranium and have applied for a modification of this license to permit unspecified physical and mechanical testing of natural and depleted uranium.

The Metallurgy Division at SRI is directed by J. R. Kattus, a metallurgical engineering graduate from Purdue University, who has had charge of the metallurgical work at SRI for 15 years. Mr. C. L. Dotson, an engineering-physics graduate from Auburn University, would have technical responsibility for the program. He has a total of 8 years' research experience at the U. S. Steel Fundamental Research Laboratory, the Youngstown Sheet and Tube Co., Cameron Iron Works, Inc., and Southern Research Institute. He has conducted programs at Cameron Iron Works and SRI on the hot-workability of metals and alloys (1, 6, 7, 8, 10, 11) and was in charge of the first phase of National Lead's program on the workability of uranium, i.e., the elevated-temperature tensile evaluations.

Mr. J. A. Hamilton would serve as project engineer. He has a degree in Metallurgical Engineering from the University of Alabama and was the project engineer on the elevated-temperature tensile evaluations on National Lead's project at SRI. He has also participated in other programs in high-temperature metallurgy at SRI during the past two years.

ESTIMATED TIME AND COST

We estimate that the proposed program could be completed in 5 to 6 months at a cost of $12,780. To insure completion by September 30, we suggest a starting date any time during February or March. A contract similar to the one for the previous program (P. O. H-26624) for National Lead would be satisfactory. Mr. W. R. Pittman, Manager of Contracts, or Mr. Andrew Wyper, Business Manager, would negotiate the contractual considerations.

National Lead's project leader would be welcomed at anytime during the performance of the contract.

Birmingham, Alabama
January 30, 1963
Proposal No. 2152
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Table 1

Summary of Evaluations for Uranium after Different Thermal and Processing Treatments

Evaluation	Orientation	Processing and Thermal Treatment					
		As-Cast	Cast and Beta Treated	Extruded	Extruded and Beta Treated	Rolled	Rolled and Beta Treated
Hot-Hardness	Long	20	20	20	20	20	20
	Radial	20	20	20	20	20	20
	Tang	20	20	20	20	–	–
Drop-Hammer	Long	20	20	20	20	20	20
	Radial	20	20	20	20	20	20
	Tang	20	20	20	20	–	–
Tensile-Impact	Long	16	16	16	16	16	16
	Tang	16	16	16	16	–	–

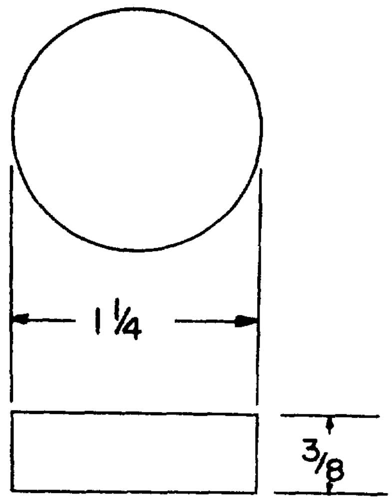

Figure 1. Hot-hardness specimen

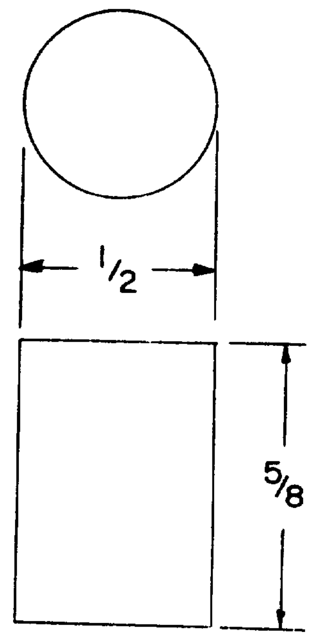

Figure 2. Drop-hammer specimen

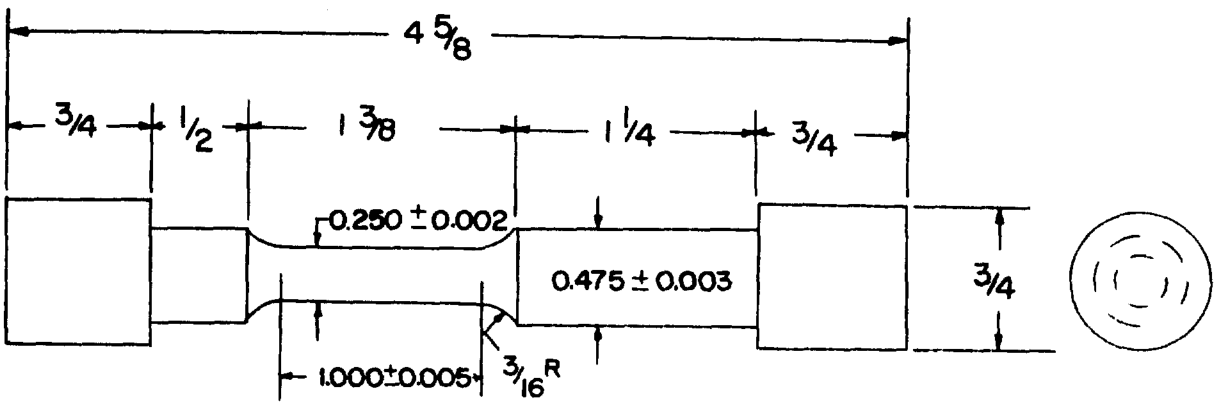

Figure 3. Tensile-impact specimen